Handbook for the Ceylon Farmer

BY AGRICOLA

A STUDIO TIMES PUBLICATION

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This book is dedicated to the Island we love.

FOREWORD

The food problem in Sri Lanka is not merely a matter of supply and demand but rather a manifestation of the ever-increasing pressure of population on land. Our population, already 13 million, is increasing annually at the rate of 1.7 per cent while our food production, amongst other essential needs, does not show a corresponding increase.

The amount of food available per capita thus diminishes and under-nutrition becomes inevitable. There is, in addition, the problem of malnutrition. This stems from two complementary factors. The dietary habits of our people seem to favour cereals to protein-rich food. In addition, such foods (milk, eggs and other animal proteins and pulses) are not widely consumed either because of their scarcity or due to high cost.

It is evident therefore that the main problems on the question of food production are not difficult to identify. In formulating the solutions to these problems several factors have to be taken into account.

The Government is now engaged in a reappraisal of our approach to agriculture and of the process of diversification in order that a continuing increase in the production of our basic food requirements — in terms of quantity and quality — can be ensured.

To my mind, such a goal can be reached by the intelligent adaptation of our traditional methods of agriculture and animal husbandry to modern scientific principles in this field.

In our enthusiasm to achieve our goal we must be ever vigilant that we do not take any measures which would, sooner or later, by interfering with the quality of the environment, defeat the very purpose of our endeavours. Along the road to the attainment of self-sufficiency in food any denudation of our natural forests, which are essential for the normal climatic cycles, or the unrestrained use of chemicals would be inimical to the environment. Therefore, these are two dangers which have to be consciously avoided as they would escalate the ever-continuing undeclared war on nature by the irresponsible application of the fruits of man's scientific achievement.

Relevant to this question is the necessity to dispel the misconcepts that agriculture is only for the affluent and that it requires extensive tracts of land and an abundance of chemicals to be productive. Every family, be it in rural or urban area, can make its contribution to the over-all effort at self-sufficiency in food. It is in this context, in addition to many others, that the "Handbook for the Ceylon Farmer", which is soon to be available in Sinhala as well, makes an extremely valuable contribution. This book lays down clearly, for the farmer in Sri Lanka, whatever his stakes are, the practical application of the insights gained from numerous investigations into the many facets of agriculture and animal husbandry.

J. R. JAYEWARDENE

13.10.1977

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PART I

SOIL AND WATER

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SOIL

There are two ways to study soil. One is the purely pedalogic aspect which is concerned with the origin and geographical distribution of soils. The other is the utilitarian edaphic point of view which is concerned with the faculty of the soil to produce different crops. The agriculturist is concerned with both aspects. He must know the location and distribution of the different types of soils, their nutrient status and their different physical and chemical properties, so that he can devise appropriate crop schedules, tillage operations and fertilizer practices that will make the best use of the land.

I. Fertility Characteristics of Soil

Farmers are primarily interested in the agricultural potential of their soils, or their inherent fertility or productive capacity. Inherent fertility is determined both by the physical and chemical properties of the soil.

Of the physical properties, the colour and depth of soil, its texture and drainage, structural stability and consistence are important. Soil reaction, the organic matter and nutrient status, and cation exchange capacity are important chemically.

SOIL COLOUR. Generally brown, brownish-red and red soils are more productive than yellow, grey and white soils because they contain (i) more organic matter or humus and (ii) are well drained.

The red colour of a soil indicates the presence of unhydrated iron oxide which can only exist in well drained conditions. In imperfectly drained soils, on the other hand, the soil takes on a yellow colour because of the presence of hydrated iron oxide.

Poorly drained soils, or soils that are deliberately submerged for rice cultivation, are brownish grey or grey in colour—because the ferric iron has been reduced to ferrous.

Light grey and white soils indicate a very low content of organic matter and iron. At the other extreme black soils indicate a very high organic matter content.

SOIL DEPTH. Depth is important from the point of view of root penetration, moisture storage and supply of plant nutrients. Shallow soils are less than 20 inches deep from surface to decomposing rock. Moderately deep soils have a depth of 20 - 36 inches and deep soils over 36 inches.

SOIL TEXTURE. The relative proportions of sand and clay determine texture. If there is more than 80 percent sand and less than 20 percent clay the soil is usually coarse. Fine-textured soils have less than 60 percent sand and more than 20 percent clay.

In between are the moderately coarse and moderately fine-textured soils with a clay fraction of 20 — 40 percent.

The more clay there is in a soil the more difficult it is to plough. More power is required to pull a plough through fine and moderately fine soils than through coarse and moderately coarse soils. Coarse soils are therefore said to be "light" in contrast to fine soils which are referred to as "heavy".

'Heavy' soils can be made more easy to work if lime and organic matter are incorporated.

SOIL STRUCTURE. Structure is defined by the way the particles or 'crumbs' cling together. If they cling together fairly persistently and do not break down easily on cultivation, the soil is said to have a stable structure (and *vice versa*).

The erodibility of a soil, or its capacity to be washed away during heavy rains, is closely related to its structural stability. Soils which are highly erodible have a poor structural stability.

SOIL CONSISTENCE. This is the way the soil behaves under wet and dry conditions. Soils that tend to get sticky when wet and very hard when dry are difficult to cultivate. They also have a limited range of moisture conditions, tending to dry out quickly. Soils which are friable in the dry state (*i.e.*, they break up easily) and non-sticky in the wet state have the most desirable consistency: they can be easily worked under a wide range of moisture conditions.

SOIL REACTION. Soil reaction is expressed in pH values. A neutral soil has a pH of 7. pH values below 7 signify increasing acidity and above 7 increasing alkalinity. Soils in high rainfall areas (wet zone) are usually acid, while soils in low rainfall areas (dry zone) are usually alkaline.

In areas of high rainfall when the water moves through the soil the hydrogen ions in the water replace the calcium and magnesium ions. This base exchange renders the soil acid in reaction. Acid soils therefore need to be amended periodically by the addition of crushed dolomitic limestone, which contains both calcium and magnesium.

In areas of low rainfall however most of the rain water that enters the soil is rapidly evaporated or transpired by the plants. Thus there is not much base exchange between the hydrogen ions and the calcium and magnesium ions. Consequently the soils remain neutral or alkaline. Should the soils become strongly alkaline however owing to excessive irrigation in very dry areas (e.g. Mannar District) — the soil tends to become impregnated with salts causing the plants to "burn" and die — then remedial action has to be taken by 'flushing' the surface salts away with copious quantities of fresh water and by the addition of gypsum.

A crude test of soil reaction can be made by the use of litmus paper. A wet litmus paper when pressed against a moist soil will turn red if the soil is acid and blue if the soil is alkaline. There will be no colour change if the soil is neutral.

SOIL ORGANIC MATTER. This is decomposed plant and animal residues in the soil. It forms 'humus' which improves the "crumb" structure and water-holding capacity of the soil. It also gives the soil a brown or black colour depending on the quantity of humus: the greater the quantity the blacker the soil.

SOIL NUTRIENTS. Carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur are the most important plant foods.

Carbon, oxygen and hydrogen are supplied from the air and water, so there is no need to worry about these elements.

Usually sufficient supplies of calcium, magnesium and sulphur are available in the soil. Where there is a shortage of calcium and magnesium this can be cheaply supplied by finely crushed dolomitic limestone. There is no need to worry about sulphur as fair quantities are supplied by rain.

Nitrogen, phosphorus and potassium (NPK) however are required in fairly large quantities which the soil cannot supply. Supplementary applications of these elements have therefore to be made from time to time in the form of organic manures and fertilizers. What quantities are applied will depend on the NPK status of the soil.

CATION EXCHANGE CAPACITY. Since fertilizers are highly soluble in water there is a general fear that they will be washed out of range of the crop. This is prevented however by the mechanism of cation exchange.

When ammonium sulphate $(NH_4)_2$ So_4, for instance, is applied to the soil the ammonium cation $(NH_4)^+$ is exchanged for the calcium ion (Ca^+). The calcium ion combines with the sulphate $(So_4)^-$ to form calcium sulphate which is leached, while the ammonium is retained until it is absorbed by the crop.

Similarly the potassium ion of muriate of potash (potassium chloride) gets fixed on the exchange complex and is held thus till it is slowly used by the plant.

In general the more clay there is in a soil the higher its cation exchange capacity. And the higher the cation exchange capacity the more effective the fertilizer programme.

II. Soil Groups and their Agricultural Potential

Figure I shows the principal soil groups. In the dry zone are the: (1) Reddish - Brown Earths (2) Non - Calcic Brown Soils (3) Immature Brown Loams (4) Red - Yellow Latosols (5) Calcic Red - Yellow Latosols (6) Black Clay Soils (7) Alkaline and Saline Soils and (8) the Sandy Regosols. And in the wet zone: (9) Red - Yellow Podzolic Soils (10) Reddish - Brown Latosolic Soils and (11) Swamp Soils. (12) Alluvial Soils and Low - Humic Gley Soils are scattered all over the dry zone and the wet zone.

Legend according to key from top to bottom. (*Fig. 1.1*)

(1) Reddish Brown Earths
(2) Red Yellow Podzolic Soils
(3) Reddish Brown Latosolic Soils
(4) Red Yellow Latosols
(5) Swamp Soils
(6) Regosols
(7) Alluvial Soils
(8) Alkaline and Saline Soils
(9) Calcic Red Yellow Latosols
(10) Black Clay Soils
(11) Non-Calcic Brown Soils
(12) Immature Brown Loams

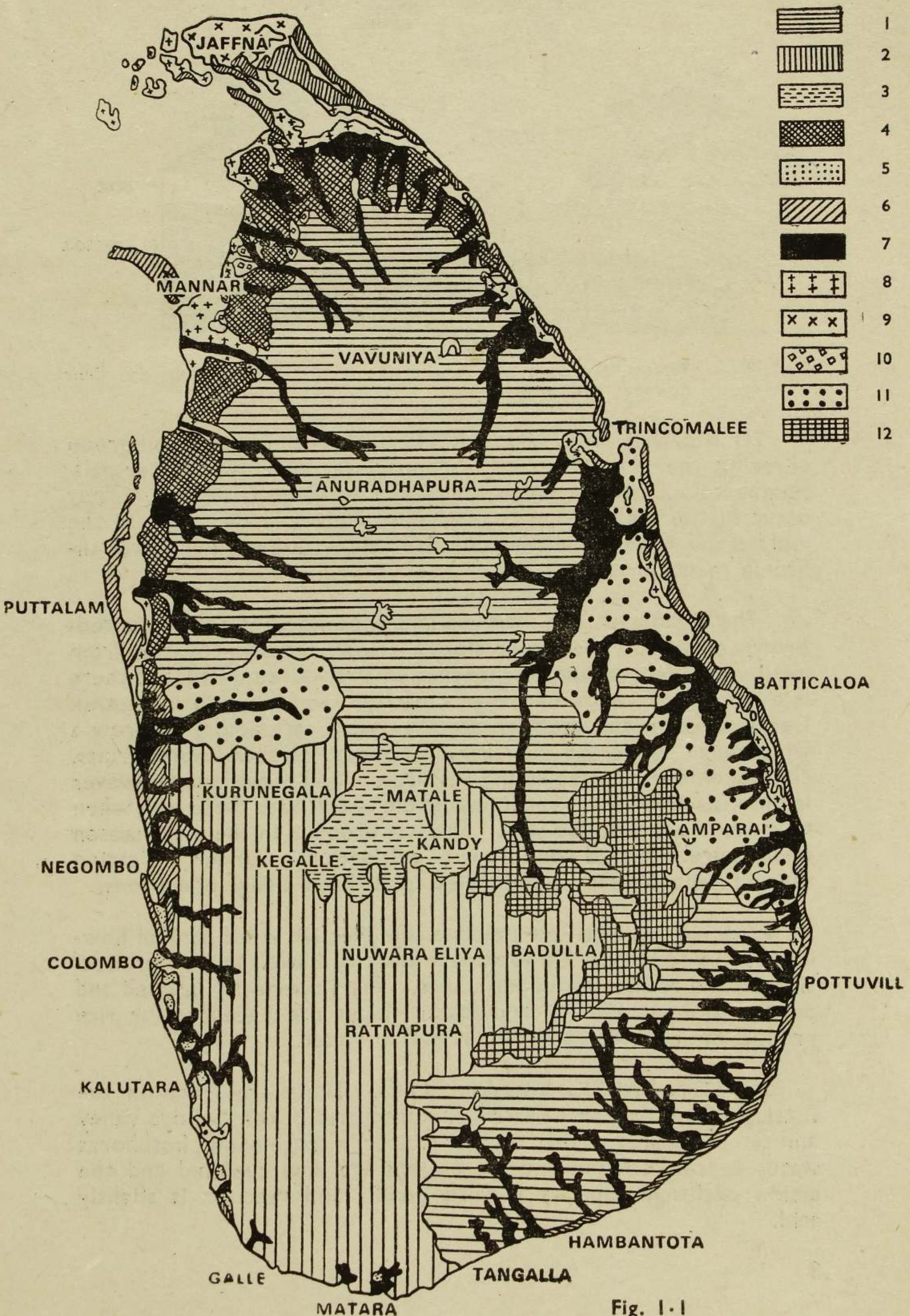
JAFFNA
MANNAR
VAVUNIYA
TRINCOMALEE
ANURADHAPURA
PUTTALAM
BATTICALOA
KURUNEGALA
MATALE
KANDY
KEGALLE
NEGOMBO
AMPARAI
COLOMBO
NUWARA ELIYA
BADULLA
POTTUVILL
RATNAPURA
KALUTARA
HAMBANTOTA
TANGALLA
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Fig. 1·1

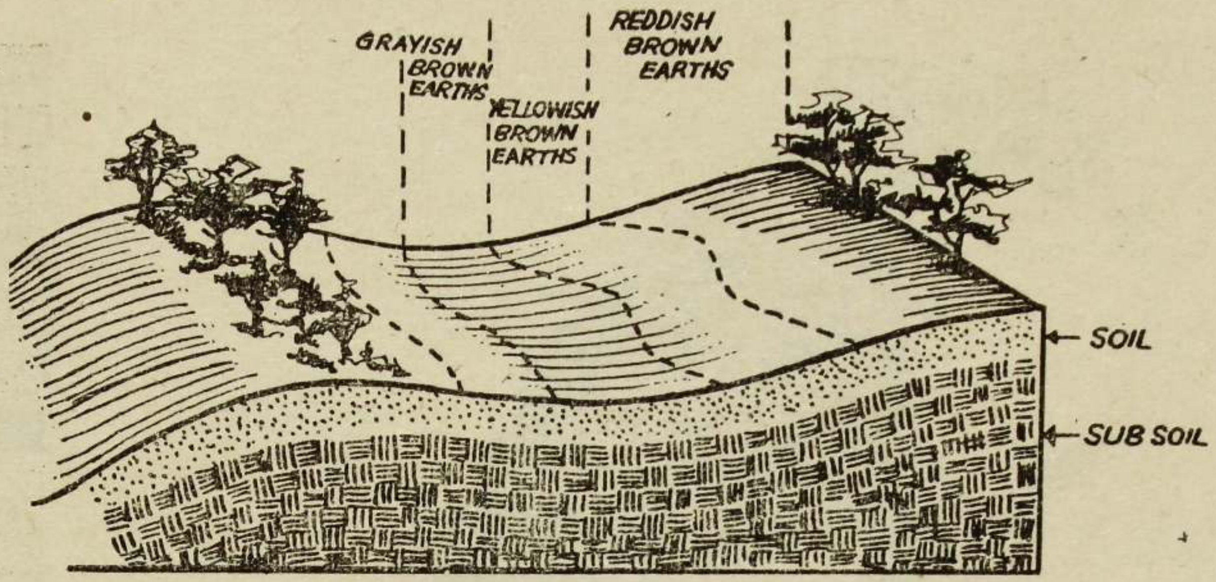


Fig. 1·2 — Typical Dry Zone soil showing the reddish-brown earths and their drainage associates.

(1) REDDISH-BROWN EARTHS. This is the largest soil group covering the Anuradhapura, Polonnaruwa, Vavuniya, Moneragala, Hambantota Districts and parts of the adjacent Districts. They occur in the higher aspects of the undulating landscape. On the middle and lower relief the soils are yellowish-brown and greyish-brown in colour (Fig. 1·2).

The organic matter, nitrogen and phosphorus status of the red-brown earths on the upper slopes is low, potassium varies from medium to high, calcium and magnesium are well supplied, and there is a very good cation exchange capacity. Soil reaction is neutral. Depth, texture and drainage are also quite satisfactory to grow a wide range of crops *viz.*, cereals, pulses, oil-seed, fibre, fruits, chillies, onions, vegetables and pastures. Soil consistency however is unsatisfactory: it is almost impossible to cultivate these soils when they are too dry or too wet. This is a problem in the *maha* season under purely rainfed conditions of cultivation. Under irrigation the soil moisture can be controlled to facilitate tillage operations.

With correct fertilizer practice and effective weed control however it should be possible to achieve sustained levels of high production on the red-brown upper slopes. The imperfectly drained and poorly drained middle and lower slopes are excellent for rice production, provided there is irrigation water.

(2) NON-CALCIC BROWN SOILS. These are found in the Batticaloa and Amparai Districts, some parts of the Gal-oya Valley and the Maho area. Their organic matter, nitrogen and phosphorus status is low, calcium and magnesium are well supplied and the cation exchange capacity is fairly good. Soil reaction is slightly acid.

Physical fertility however is poor as the soils are shallow, coarse and poorly structured. Erosion is therefore a fairly serious hazard.

The agricultural potential of these soils is decidedly inferior to that of the reddish-brown earths, although the same range of crops may be cultivated under rainfed or irrigated conditions. Since the soils dry-out faster they should be irrigated more often than the red-brown earths.

(3) IMMATURE BROWN LOAMS. These soils are neutral in reaction, rather shallow and eroded. The organic matter, nitrogen and phosphorus status is low, but potassium, calcium and magnesium are well supplied. The cation exchange capacity is good.

Moderately deep soils may be used in the same manner as the reddish-brown earths. But the shallow soils which occur on steep slopes and rock outcrops have little or no agricultural value.

(4) RED-YELLOW LATOSOLS. This group extends for nearly 1,000 sq. miles north of Puttalam through Mannar across to Mullaitivu on the east coast. The red latosols are found on the higher slopes and the yellow latosols on the lower.

Their organic matter, nitrogen, phosphorus, potassium, calcium and magnesium status are very low, and they also have a low cation exchange capacity. Soil reaction is slightly acid. Drainage and porosity however are good. So also is consistence. As a result these soils can be worked under a wide range of moisture conditions. Even in prolonged rainy weather they remain well drained and aerated.

This condition is particularly advantageous for growing orchard crops like citrus and cashew which cannot tolerate "wet feet" even for a short spell. Where irrigation water is therefore available during the dry season these crops may be grown to advantage. Irrigation would preferably have to be by sprinkler rather than by basin or furrow-flood systems which are wasteful consequent on the high infiltration rate of the latosols.

Although the rainfall in this area is poor, geological conditions favour the storage of underground water, which can be brought to the surface from depths of 200 ft. by "tube" wells. If these underground supplies could be proved and successfully exploited as the Department of Irrigation has done at Vanathuvillu and Mannar, it should be possible to bring some of these soils under intensive lift irrigation.

(5) CALCIC RED-YELLOW LATOSOLS. These soils are a sub-group of the Red-Yellow Latosols. They are confined exclusively to the Jaffna Peninsula. Although low in organic matter and nitrogen, these soils are fairly well supplied in phosphorus and potassium and extremely rich in calcium and magnesium. The soil reaction is alkaline.

These soils also have excellent physical fertility. Consequently they are one of the most intensively cultivated areas in this country. Liberal seasonal applications of organic manure however are necessary to maintain the fertility owing to the very high rate of mineralization of organic matter.

(6) BLACK CLAY SOILS. These are found around Tunnukai in the south of the Jaffna District and Murunkan in the north of the Mannar District. Neutral to slightly alkaline in reaction these soils are poor in organic matter, nitrogen and phosphorus but are well supplied with potassium, calcium and magnesium and have a high cation exchange capacity. Soil consistence however is a problem making tillage operations difficult. In the circumstances rice is perhaps the best crop to grow: high yields can be expected.

(7) SALINE AND ALKALINE SOILS. These soils occur along the coast in the northern province. Their organic matter, nitrogen and phosphorous status is low: potassium, calcium and magnesium are well supplied and the cation exchange capacity is good. But owing to an excess of sodium, which is distinctly harmful to crop growth, these areas are not of much agricultural value. They are presently used for grazing livestock. The fine-textured soils however may be reclaimed for rice production by repeated applications of gypsum and flushing with water.

(8) SANDY REGOSOLS. Found as coastal strips they have a moderately acid to neutral reaction. Organic matter, nitrogen and phosphorus are low, but potassium, calcium and magnesium are fairly well supplied. The cation exchange capacity is moderately good.

Although coarse with a high infiltration rate, the presence of an underlying fresh water layer makes it possible to grow cashew profitably on the flatter parts of the relief, avoiding the sand dunes. Coconut too is a good crop for these areas.

The sandy regosol stretch south of Chilaw, which has been developed on the older sands is excellent for coconut. Owing to the presence of an underlying impervious layer however at a depth of 5 - 6 feet, it is necessary to construct drains to dispose of the excess water.

(9) RED-YELLOW PODZOLIC SOILS. This is the largest group of soils in the wet zone. The organic matter and nitrogen status ranges from low/medium at the lower elevations to medium/high at the higher elevations. Phosphorus and potassium are poorly supplied.

Calcium and magnesium supplies are also low, but this does not seriously affect tea and rubber which are the main crops grown in this region. Orchard crops and vegetables however would require periodical applications of dolomitic limestone to 'sweeten' the soil.

The cation exchange capacity of these soils is high, so that even under high rainfall conditions there is a satisfactory retention of chemical fertilizers.

Depth, texture and drainage are generally satisfactory except where the laterite (cabook) is exposed. Consistence is good, permitting the soil to be worked easily under a wide range of moisture. Structure is also good so that erosion is not a serious hazard, except on the steeper slopes where soil conservation measures are necessary.

These soils have already been exploited for plantation agriculture (coconut, rubber and tea) and some orchard crops. Certain areas however still remain to be developed *e.g.*, the *patanas* and the *kekilla* region. Pasture production and plantation forestry may be recommended as two lines of development.

(10) REDDISH-BROWN LATOSOLS. These soils are found in the Kandy and Kegalla Districts and also in the south-west part of the Matale District. They occur on hilly and sharply rolling terrain. The organic matter, nitrogen and phosphorus status is low, while potassium, calcium and magnesium are fairly well supplied. The cation exchange capacity is also satisfactory. Soil reaction is moderately acid.

Depth, drainage, texture, structure and consistency are also good. These soils can be easily worked under a wide range of moisture conditions. They do not erode easily, but anti-erosion measures should be provided if the steep slopes are brought under cultivation.

These soils have been more or less fully exploited for permanent agricultural crops like tea, rubber, pepper, cardamom, cloves, cocoa, coffee and fruits. With improved soil management and the greater use of fertilizers however, substantial increases in productivity are possible. Spice crops, pasture and fodder grasses could profitably replace some of the uneconomic tea in this region.

(11) SWAMP—or BOG SOILS. They occur chiefly in low areas in the Colombo, Kalutara and Galle Districts. They are strongly acid in reaction. The organic matter and nitrogen status is very high, but potassium, calcium and magnesium are poorly supplied. These soils have a very good cation-exchange capacity.

Frequent flooding is a major drawback to the agricultural development of this area. The only crop that can be recommended is rice. In places where the water table is low—about one foot below the surface— *keerai* crops may be cultivated successfully.

(12) ALLUVIAL SOILS AND LOW-HUMIC GLEY SOILS. These soils are found scattered all over the island, the former in the valleys and flood plains of the streams and rivers and the latter in the lowest slopes of the land associated with the reddish-brown earths and non-calcic brown soils in the dry zone and the red-yellow podzolic soils in the wet zone. They comprise the major rice-growing regions.

III. Maintenance of Soil Fertility

Soil is a living, working factory, almost as alive as any animal. It must have food if it is to do its job properly. The produce you get from your land can only be as good as the soil in which it is grown. Good soil means strong healthy plants, while poor soil is associated with poor crops.

Much of the success which can be achieved in raising food crops therefore depends on the maintenance of soil fertility. Since the crops themselves remove a good portion of the nutrients from the soil every time they are cultivated (see table) particular attention must be given to the use of organic manures and fertilizers in rebuilding the soil from season to season. But since the question of which is better to use—organic manure or fertilizer — is a debatable point, a brief discussion on the merits and demerits of both types will not be out of place.

ORGANIC MANURES *vs.* FERTILIZERS. The commonest forms of organic manure are cattle dung and compost. These manures have all the plant nutrients, but unfortunately they are not available in a concentrated and easily absorbed form as in the case of fertilizers. In other words you might say that despite its bulky nature organic manure is really a watered down or dilute form of fertilizer. Consequently you have to use fairly large quantities—about 10 tons to an acre—to get the same effect as 5-6 cwt. of fertilizer.

Ten tons of cattle dung or compost would contain about 130 lb. of nitrogen (N) 90 lb. of phosphoric acid (P_2O_5) and 130 lb. of potash (K_2O). But since only half the nitrogen and potash and about one-sixth of the phosphoric acid are made available to the crop—the balance being too complex to be broken down during the growing period of the crops—we must for all practical purposes assume that 10 tons contains only about 75 lb. nitrogen, 15 lb. phosphoric acid and 75 lb. of potash. This is the equivalent of about 3¾ cwt. of ammonium sulphate (or half that quantity of urea), nearly ½ cwt. of superphosphate and about 1¼ cwt. of muriate of potash. The deficiency in phosphate may be corrected by the addition of ½ cwt. conc. superphosphate to every 10 tons of compost.

We can take it then that organic manure applied in fairly large quantities (10 tons) and supplemented with superphosphate is as good as any average fertilizer mixture. But it has other advantages too. In addition to applying the essential plant foods, organic manure also improves the physical condition of the soil. The humus content of this material helps to produce a crumbly soil, which is well drained and well aerated. The water-retentive capacity of such a soil is also improved. As a result crops grow more vigorously.

TABLE

Nutrients removed by some commonly cultivated crops

CROP	AGE (Days)	YIELD Kg/ha	PLANT Part	Kg/ha N	P	K	Ca	Mg	S
Rice (Bg 11-11)	130	5,000	Grain	58	12	10	2	7	3
			Straw	37	5	135	24	15	5
			Husk	5	1	6	1	1	1
			Total	100	18	151	27	23	9
Maize (Thai Composite)	105	4,000	Grain	64	7	13	2	2	6
			Other	54	4	142	30	23	7
			Total	118	11	155	32	25	13
Sorghum (IS-2941)	100	4,000	Grain	68	8	16	3	6	2
			Other	33	5	92	14	8	3
			Total	101	13	108	17	14	5

CROP	AGE (Days)	YIELD Kg/ha	PLANT Part	Kg/ha N	P	K	Ca	Mg	S
Soyabean (T.K. 5)	90	1,800	Grain	103	10	34	6	4	3
			Other	5	1	13	10	5	2
			Total	108	11	47	16	9	5
Green Gram (MI-2)	90	1,200	Grain	49	2	13	1	1	2
			Other	9	1	13	9	4	1
			Total	54	3	26	10	5	3
Black Gram (MI-1)	90	1,500	Grain	55	4	17	1	3	2
			Other	16	1	26	15	5	2
			Total	71	5	43	16	8	4
Cowpea (MI-35)	75	1,200	Grain	42	3	15	1	3	1
			Other	6	1	17	6	4	1
			Total	48	4	32	7	7	2
Cowpea (Arlington)	90	1,500	Grain	50	4	19	3	2	2
			Other	10	1	17	8	4	2
			Total	60	5	36	11	6	4
Dhal (MI-10)	135	1,500	Grain	47	4	23	2	2	2
			Other	24	1	21	15	4	2
			Total	71	5	44	17	6	4
Manioc (M.U. 10)	180	45,000	Yam	62	10	164	12	22	3
			Other	140	22	122	119	86	12
			Total	202	32	286	131	108	15

CROP	AGE (Days)	YIELD Kg/ha	PLANT Part	Kg/ha N	P	K	Ca	Mg	S
Sweet Potato (Jewel)	100	15,000	Tuber	31	6	15	10	4	2
			Vine	58	11	136	34	22	11
			Total	89	17	187	44	26	14
Gingelly (MI-3)	75	1,000	Pod	39	3	4	7	2	2
			Other	12	1	32	12	6	2
			Total	51	11	36	19	8	4
Chilli (MI-1)	180	2,000	Pod	41	4	55	3	3	3
			Other	23	2	29	7	6	2
			Total	64	6	84	10	9	5
Brinjal (Dept.Rec.)	150	39,000	Fruit	38	8	96	6	5	4
			Other	25	3	48	21	8	3
			Total	63	11	144	27	13	7
Bandakka (MI-5)	150	19,000	Pod	46	8	52	11	10	3
			Other	13	3	18	17	10	4
			Total	59	11	70	28	20	7
Knol Khol (E.W.Vienna)	120	8,000	Bulb	18	3	33	4	2	3
			Other	24	2	34	8	3	6
			Total	42	5	67	12	5	9
Carrot (Nantes)	90	6,000	Root	17	4	30	3	2	2
			Other	14	2	22	4	2	2
			Total	31	6	52	7	4	4

CROP	AGE (Days)	YIELD Kg/ha	PLANT Part	Kg/ha N	P	K	Ca	Mg	S
Beet	100	13,000	Root	42	5	60	4	6	2
(Crimson			Other	21	2	36	5	10	2
Globe)			Total	63	7	76	9	16	4

Other = Balance plant material excluding marketable commodity.

lb/ac. = Kg/ha $\times$ 0.89

P_2O_5 = P $\times$ 2.29

K_2O = K $\times$ 1.20

(*Source:* Department of Agriculture — Research Station, Maha Illuppallama)

These physical benefits however are restricted only to upland soils and do not apply to the puddled and flooded conditions obtaining in paddy fields. In the circumstances, the maximum benefits of cattle dung and compost are achieved on upland soils rather than in paddy fields (*For organic manures in paddy fields see pp. 18 - 21.*)

In addition to being a soil conditioner, organic manure is also a crop conditioner in the sense that it produces a hardier crop than one cultivated with fertilizers only. Take chilli for instance. If only artificials are used, then the plants tend to become very succulent and consequently more susceptible to the dread leaf curl disease. But on the other hand, if you use a combination of organic manure and fertilizer it produces a hardy crop which is more resistant to pests and diseases: such crops have been known to yield 25-30 percent more.

Yams are another example. If they are produced by the application of artificials alone, then the tubers enlarge and mature too quickly with the inevitable result that there is a much quicker break-down of the tissues during storage. On the other hand, if organic manure, or a combination of organic manure and fertilizer is used, the yams produced will store well for longer periods.

Even in rice production, in countries like Japan, the steady use of fertilizers alone over a long period has been found to reduce the yield. This trend, Japanese scientists have found, can be corrected by the combined use of fertilizers and organic manures.

The concensus of opinion therefore favours the combined use of organic manure and fertilizer — the former to improve both the physical and chemical condition of the soil, and the latter to supplement the nutrient status in an easily assimilable manner to the crop. In fact, the presence of an adequate quantity of organic manure in the soil facilitates the absorption of nitrogen from fertilizers like urea and ammonium sulphate and phosphoric acid from the slowly acting rock phosphates like saphos and apatite.

CATTLE MANURE is the dung and urine mixed with varying amounts of straw, grass and other such roughage. It is estimated that 75-90 percent of the nitrogen and phosphorus and about 95 percent of the potash present in the original cattle food reappears in the dung and urine. Nitrogen and potash are distributed fairly equally in the dung and the urine, while the phosphorus which is not used by the animal is voided completely in the dung. It is important therefore to conserve the urine along with the dung if the best value of the cattle manure is to be realised. This is usually achieved by allowing the animals to stand on a bedding of straw, dry grass, dead leaves or sawdust.

This manure should be collected everyday and arranged in layers to form a heap. It should not be allowed to become too dry or too wet as this would interfere with the fermentation process. If well managed, about 4 tons of manure could be produced from a single animal in one year.

COMPOSTING: THE INDORE METHOD. The Indore method is the most widely practised way of preparing compost. It is called by this name after the place where it was first put into practice successfully in India. This method can be used to prepare compost in pits or heaps. The material that is used is composed of crop residues, weeds, grass, etc. Any fresh green material that is collected like grass and tree loppings must be wilted for a day or two before it is used.

PITS 30′ × 15′ × 2′, are arranged in an E-W direction as shown in the accompanying diagram. The waste material is spread on the bottom of each pit to a height of about 6-8 inches and to a length of 25 ft., leaving 5 ft. at one end as turning space. (All green material should be wilted for a day before it is used).

This layer is then sprinkled with a slurry made up of the following:—

> One bucket fresh cattle dung, two handfuls of wood ash, 8-10 gallons water—and also, if available, one basket of urine—earth scraped from floor of cattle shed and one basket of decomposing material from a compost heap 10-15 days old.

Such a slurry is necessary to provide the micro-organisms with the energy-material they require to live and work. If, however, cattle manure is not available, the compost can still be prepared by incorporating green leaves like wild sunflower, glyricidia, cassia etc. up to one third the waste material used to form each layer. These green materials provide the energy food for the micro-organisms responsible for the decomposition. But to ensure speedy decomposition be sure to add some wood ash and some earth.

The charge is then watered. The watering is repeated in the evening and the next day if necessary. Excess watering should be avoided.

The process of charging the pit and applying slurry in this sandwich fashion is continued till the heap is 2½ ft. high. Filling should be over in about one week. The heap is then watered periodically as required to keep it moist but never too wet.

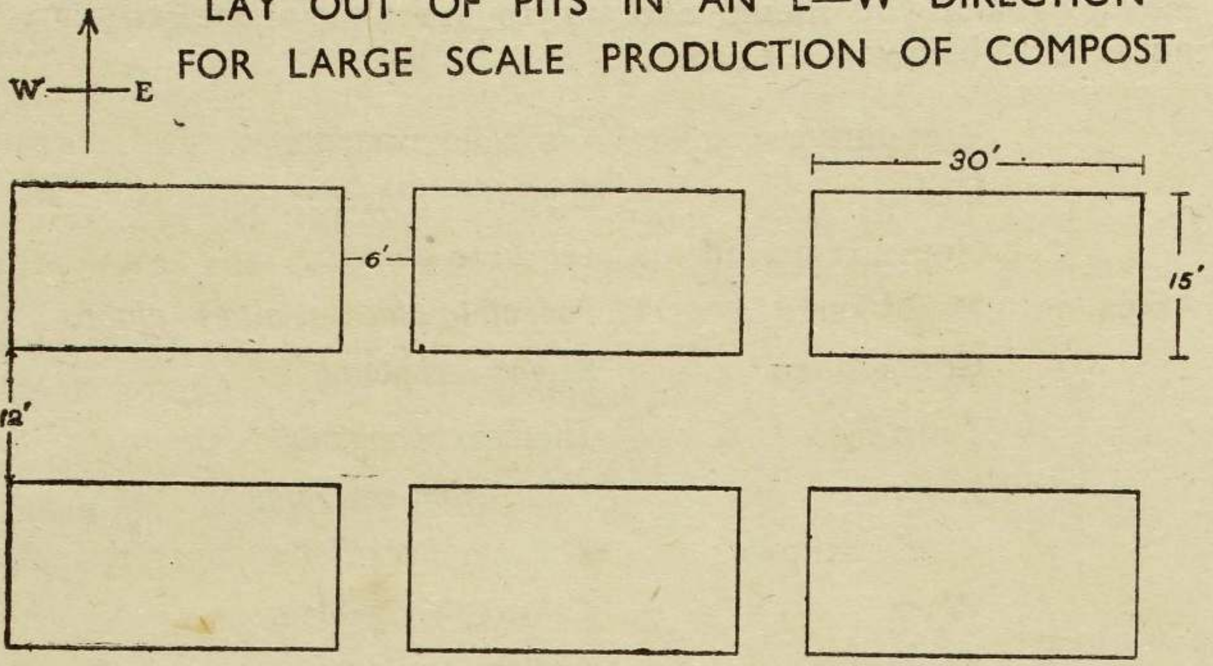
The next operation is turning. In this process the top-most layers are placed at the bottom and the bottom-most layers at the top. Regular turning is necessary to provide aeration for the micro-organisms to do their job of decomposition properly, and also to ensure uniform decomposition. The first turning is done 15 days after filling the pit to a height of 2½ ft., the second turning 15 days later and the third 30 days after the second. To hasten the process of decomposition one or two baskets of decomposing material may be added from a heap about 30 days old. Watering should be done regularly. One month after the third turning the compost should be ready.

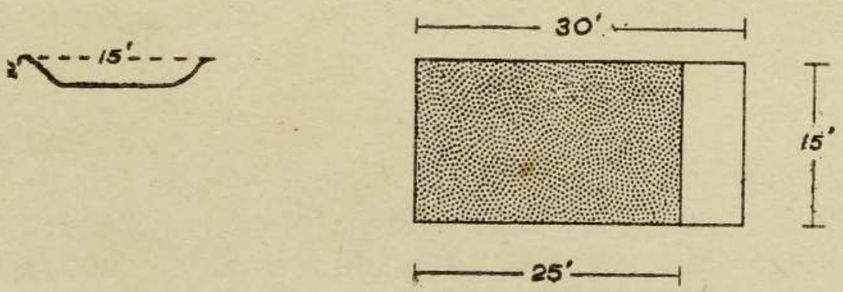
HEAPS. Instead of pits, heaps (above ground) of the same dimensions can be prepared. They are charged, watered and turned in the same manner (*see diagram on page 19*).

OUTPUT. The output of a single pit or heap 30 × 15 × 2 ft. should be about 5 tons compost. Two such heaps or pits are necessary to provide enough compost for a single acre. If the management of the compost throughout has been correct, it should be ready for use 3 months after the process is begun. At this stage it should look like well rotted cattle manure.

GREEN MANURING IN PADDY FIELDS. Green manure is one of the cheapest sources of nitrogen and other important plant nutrients. Any green leafy material may be used. Even the weed growth in paddy fields when turned in is in effect a small-scale green

LAY OUT OF PITS IN AN E—W DIRECTION FOR LARGE SCALE PRODUCTION OF COMPOST





Above left : Cross section of pit. The pit is 15 ft wide at the top and the sides taper inwards to the bottom. Pit is dug $1\frac{1}{2}$ ft deep and the earth piled up on the sides to make a total height of 2 ft.

Above right : Pit is filled to 25 ft leaving a turning space of 5 ft at one end.

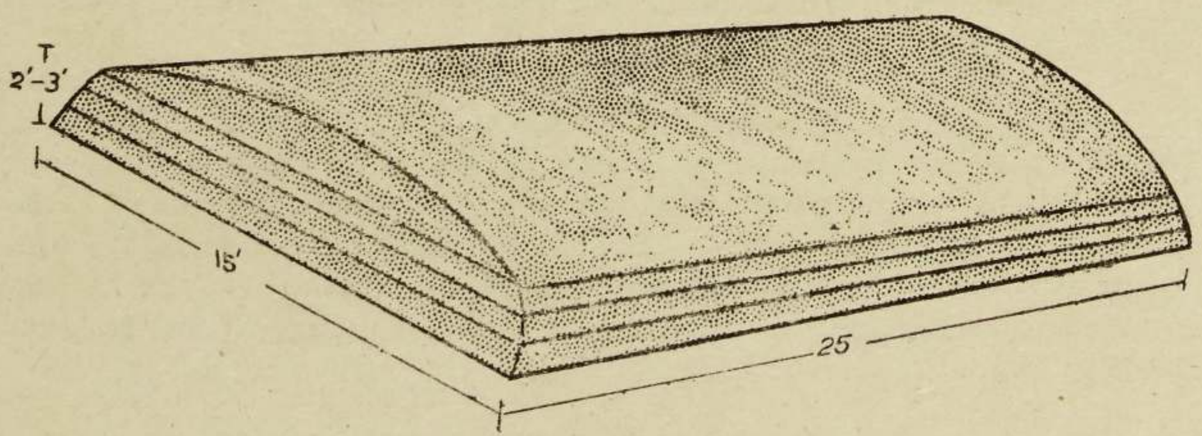


Fig. 1·3

Heap method of composting. Note the sandwiched layers of waste material and slurry.

manuring, but you should also try to use some of the green manures listed below:—

Wetahiriya	*Gliricidia maculata*
Dadap	*Erythrina lithosperma*
Horse Tamarind	*Leucaena gluaca*
Magul karanda	*Pongamia pinneta, also P. glabra*
Gon kaduru	*Rejona dichotoma*
Tulip tree	*Thespesia populnea*
Kekuna	*Cannarium zeylanicum*
Wild sunflower	*Tithonia diversifolia*
Wara	*Calatropis gigantea*
Keppetiya	*Croton lacciferus*
Aththora	*Cassia alata*
Petitora	*Cassia tora*

Wetahiriya (*Gliricidia*) and Gon Kaduru (*Rejona*) may be planted along the boundaries of paddy fields as a hedge plant. Aththora (*Cassia*) grows well along banks and streams in the wet zone. Suriya (Tulip Tree) is more suitable for the dry zone, especially, the sandy tracts. Loppings of these crops may be used as green manure at the rate of 1-2 tons per acre. Wild sunflower (*Tithonia*) is the most useful green manure crop: it should be grown as a thick hedge and frequently lopped. Five tons of wild sunflower is the equivalent of about 3 cwt. of ammonium sulphate or 1½ cwt. urea in nitrogen value.

It is best to turn the green material into the soil with the first ploughing *i.e.* 25-30 days before sowing or transplanting. Once it is turned in, the field should be kept adequately wet, preferably under water.

In the alternative a green manure crop like Sunn-hemp (*Crotalaria juncea*) may be cultivated in paddy fields during the off season and turned in when preparing the land for the next paddy crop. By sowing about 80 lb. seed you should be able to produce 3-5 tons of green material. The nitrogen content in Sunn-hemp is highest when the crop is six weeks old and this is the best time to turn it into the soil.

A neutral soil reaction is most favourable for rapid decomposition of the green material. It is desirable therefore to add a small quantity of lime or wood ash along with the green material.

WARNING. Do not apply green manure to the boggy, ill-drained paddy fields that are found in the Colombo, Kalutara and Galle Districts. These soils already have an excess of organic matter and any further addition would be harmful to the rice crop.

STRAW IN PADDY FIELDS. Paddy straw can be used as a manure for the replacement of potassium and silica. About 90 percent of the total potassium that is removed by the rice crop from the soil is found in the straw. This is more than six times the quantity of potassium that is recommended in the form of muriate of potash. Therefore by returning only a part of the straw—about one sixth of the total quantity back to the field you can supply the potassium requirement of the next rice crop without using any fertilizer at all.

Straw may be added to the fields in the burnt or unburnt form. Burning the straw however before adding it to the fields is preferable as the bulky unburnt material is difficult to handle and also takes a long time to decompose. The straw may be burnt on the threshing floor and the ash spread uniformly over the field. There is no loss of potassium in burning.

Another advantage of adding burnt straw ash is that it returns about 75 percent of the silica removed by the paddy crop in a season. In the silica-deficient rice soils of the Kalutara and Colombo Districts, therefore, it is a desirable agronomic practice to use burnt straw ash in this manner.

UREA. This is a very concentrated nitrogen-fertilizer containing 45 percent nitrogen. The ordinary crystalline form is hygroscopic and difficult to store, but a water-repellant form is also available on the market: even this should be stored in tight polythene containers in very humid areas. The commercial product is a fine, pearly grained substance.

When urea is added to the soil it is converted to ammonium carbonate which is not easily leached. The immediate soil reaction is alkaline, but on the subsequent nitrification of the ammonium the soil turns acid.

AMMONIUM SULPHATE. The commercial product contains 20.6 percent nitrogen. It is a fine white, crystalline salt, easy to store and handle because unlike urea it does not absorb moisture easily. Like urea it is freely soluble in water.

When ammonium sulphate is added to the soil, the sulphate is not generally utilized. It gets converted into sulphuric acid and therefore tends to make the soil acid much faster than urea.

SUPERPHOSPHATE. This fertilizer is marketed in two grades. Ordinary superphosphate contains 16-20 percent soluble phosphate, while concentrated superphosphate (also called Triple superphosphate) contains 40-45 percent. Although about 85 percent of the phosphate contained in superphosphate is soluble in water it is not easily leached. On the contrary it is held in the soil; about 25 percent is absorbed and the balance is soil-bound.

ROCK PHOSPHATE. There are two forms *viz.* saphos phosphate which is imported and apatite which is produced locally. Saphos contains 28-30 percent P_2O_5. It looks like a brownish-grey cement powder. It is very slow-acting and is therefore best used with permanent plantation crops, and since it performs best in moist acid soils it can be used to advantage with crops like tea, rubber and coconut which are planted in the red-yellow podzolic soils of the wet zone. Similarly with apatite.

MURIATE OF POTASH. This is the most widely used potash fertilizer. It is potassium chloride and contains 50 or 60 percent potash as K_2O. The colour of the commercial product which comes in fine grained crystals is white to pink. Muriate of potash is slightly hygroscopic and it is apt to cake in the bags on prolonged storage.

SULPHATE OF POTASH: More expensive than muriate this fertilizer is used mainly for tobacco because the muriate has an adverse effect on the quality of the tobacco leaves. The sulphate is a powder making it easier to handle and store. It contains 45 percent potash.

LIME: Although lime adds calcium to the soil it is not considered a fertilizer so much as a 'soil amender' because it makes 'sour' soils 'sweet' and this helps the plants to absorb minerals like phosphorus which would otherwise be unavailable to the crop. Lime also helps to 'open' a clay soil, making it more permeable to air and rain. This facilitates tillage practices and encourages the growth and multiplication of soil organisms which are responsible for breaking-down organic matter into plant foods.

Ground limestone is the most effective liming material for local soil conditions. It must be ground finely so that all the particles are less than one-eighth inch in diameter and about half can pass through a 100 mesh sieve. Ground limestone may be prepared either from dolomitic limestone or coral limestone.

Frequent liming however has an exhausting effect on the soil, specially in the absence of organic manure. Therefore care should be exercised in its use. As a rule liming could be done with advantage in the black soils and the clay soils. A moderate application of 12-15 lb. per 1,000 sq. ft. every 3 years should suffice.

IV. Soil Conservation

EROSION. The fruitful top soil as we know it has taken centuries to form from underlying sub-soil and rock and the decayed remains of plants and animals. As long as this soil is protected by nature's dense blanket of forests and other vegetation it remains fairly stable.

But when the land is cultivated the life-giving top soil is exposed to the beating action of the rain. In time the structure breaks down so that everytime rain water moves across bare land it carries away some soil. The steeper the land the faster the rain water runs off it and the more soil it carries away along with important plant foods. This type of erosion is going on around us all the time.

Paradoxically the solution to soil erosion appears to lie in water conservation. If we can arrest or slow down the movement of water across cultivated land we shall not only be able to check the fertile top soil from being washed away from the fields and deposited as useless sediment in drains and streams, but we shall also be able to promote maximum storage of water in the soil for use by crops during drought. The deeper the soil the greater the amount of stored water. Fertile top soil and the right amount of water in the soil are the two main things which make land productive.

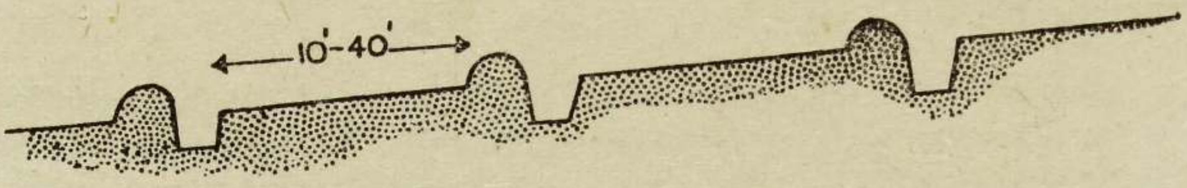
There are many ways to check surface run-off. On the large scale this would include such measures as reservations of forest areas, preservation of vegetation on water sheds and the protection of stream banks. These measures are usually taken by Government at the State level.

There are other measures however that the farmer can adopt in his own land. On hill slopes for instance in the wet zone a combination drain-bund system or terraces are useful mechanical measures to adopt.

CONTOUR DRAINS AND BUNDS. Contour drains and bunds are sited on the contour against the slope of the land. A contour is a line which connects spots of the same height on the land. A bund or drain constructed on such a line is called a contour bund and drain.

The distance between these combination bunds and drains will depend on the slope of the land. As a general rule on steep land they are placed 10 ft. apart, on moderately steep land 20 ft. apart and on gentle slopes 40 ft. apart. The drain should be at least 2 ft. wide and 1½ ft. deep to prevent rapid overflow in areas of heavy rainfall. The excavated soil from the drain is heaped on the *lower* side to form the bund.

The drain entraps the flowing water and allows it to gradually seep into the soil instead of running off the land and causing floods. Should the drain fill, the bund on the lower side prevents the water from spilling over; the soil wash collected in the drains may be periodically removed and spread over the land again.



Section of sloped land showing arrangement of contour drains and bunds.

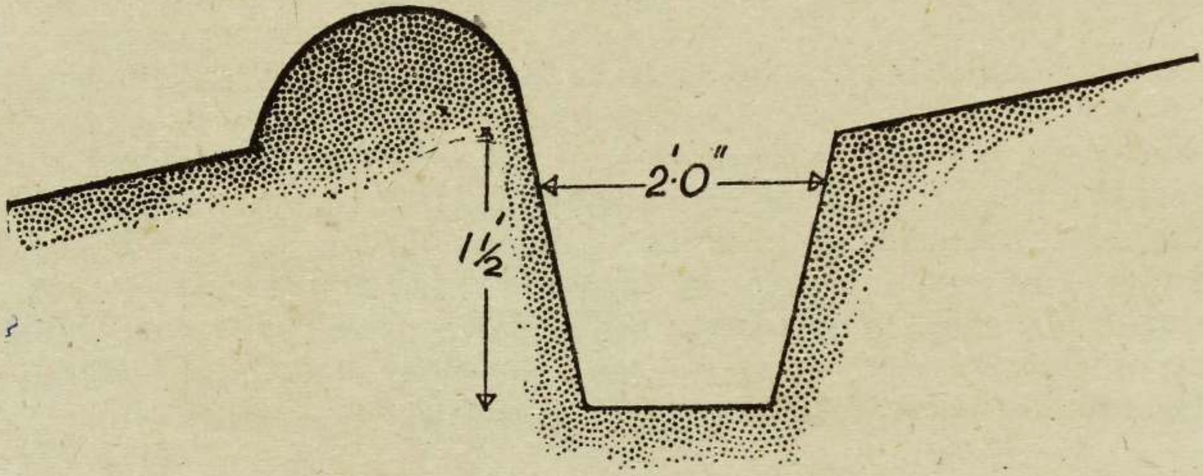


Fig. 1·4 *Cross section of contour drains and bund.*

BENCH TERRACES. In steep land where the space between two adjoining contour bunds and drains is so small that there is an abrupt vertical drop between one bund and the next it is better to construct bench-like terraces. The terraces should be sloped back to collect water and the vertical banks turfed to prevent erosion.

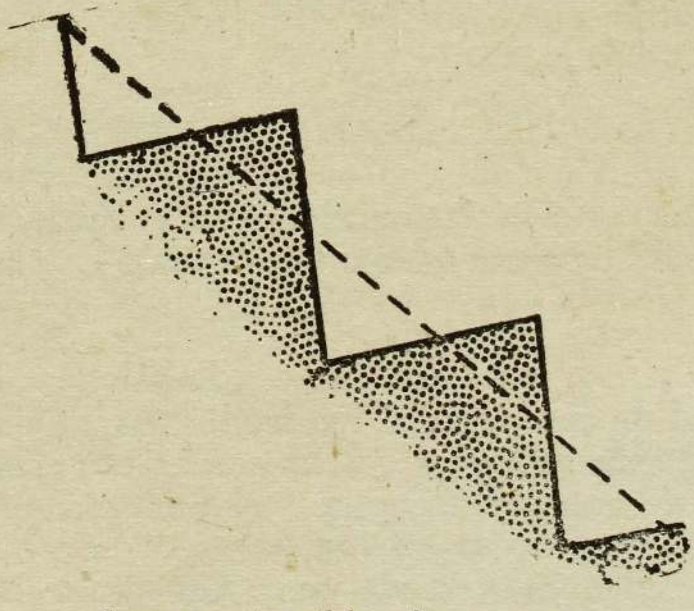
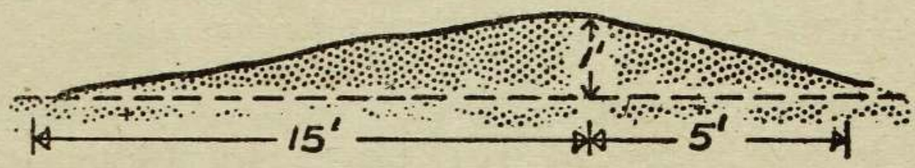


Fig. 1·5 *Cross section of bench terraces*

BROAD-BASED BUNDS. On slightly undulating topography which is typical of the dry zone broad-based bunds should be constructed to hold back the water. These bunds too are constructed on the contour about 40-60 ft. apart. The highest point or crest of the bund is on the contour. From here the bund slopes down fairly sharply to about 5 ft. away on the upper side, and slopes down more gently to a point 15 ft. away on the lower side. When rammed down hard these bunds can take tractor traffic moving from one field to another. They have to be strengthened anew each season.

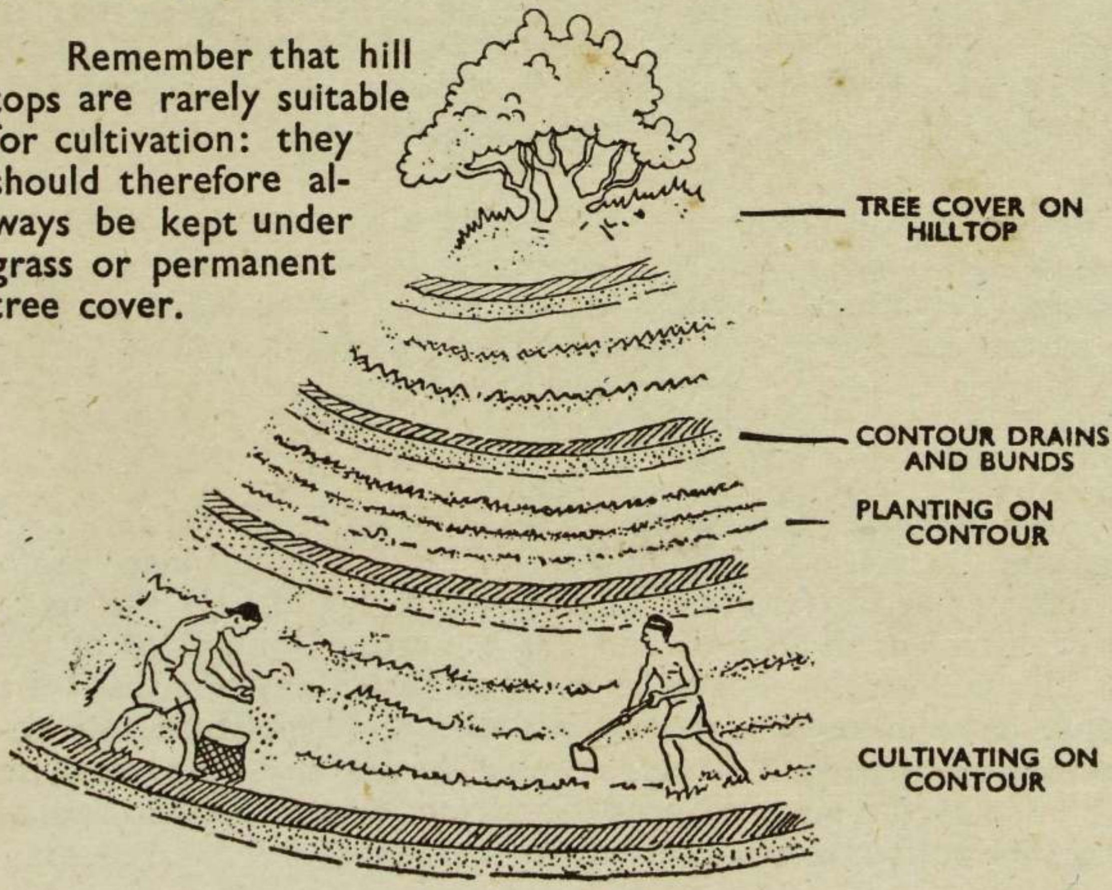


Cross section of a broad-based earth bund. Fig. 1·6

OTHER MEASURES. Other important measures of control are to plant row crops along the contour rather than in rows up and down the hill, and to carry out all ploughing and cultivation on the contour too.

Some crops protect the soil against erosion more than others by reason of their close spacing or good foliage cover; examples of such crops are sugar-cane and millets like kurakkan. Others permit more than average erosion because of their wide spacing; examples are cotton, tobacco and maize—these should be planted on the gentler slopes only.

Remember that hill tops are rarely suitable for cultivation: they should therefore always be kept under grass or permanent tree cover.



Soil conservation on hilly land showing mechanical and agronomic measures of control. Fig. 1·7

V. Highland Irrigation

Highland agriculture in the dry zone is a hazardous venture (except in the rainy *maha* season from October-December) unless the farmer is assured of irrigation water. A rainfall distribution that is nearly ineffective for 8 months of the year makes this so.

Water for irrigation must come from rivers, streams, 'tanks', irrigation channels or wells. If these sources of water are above the land to be irrigated 'gravity' irrigation would be possible. In the alternative the water will have to be lifted by pump.

SPRINKLERS. The flexibility of sprinkler equipment combined with the efficient control of water makes sprinkler irrigation the most effective method in practice today—the efficiency of water application being about 95%. The water is sprayed into the air and falls on the land in a uniform pattern like rain. Light applications for seedlings and small plots can be made more efficiently than by any form of surface irrigation. Furthermore, land is not wasted in the construction of ditches.

The parts of a sprinkler system consist of a pump to provide the needed pressure, main pipelines, laterals and sprinkler heads. Each sprinkler head applies water to a circular area, and a certain amount of overlap is provided in siting the sprinklers on the lateral lines so as to ensure uniform wetting. Double-nozzle, revolving head sprinklers spaced 40 feet apart on portable quick-coupled aluminium lateral lines are the norm for the irrigation of most food crops (exclusive of orchards e.g. citrus, which require low sprinklers with stationary or fixed heads).

Power requirements are high because high pressures (40-60 lb. per sq. inch) are required to operate the sprinklers. Turbines or horizontal centrifugal pumps are best — the former being used to pump from relatively deep sources of ground water, and the latter from surface water or shallow wells with suction lifts of less than 15 feet.

Good design is essential to the successful operation of sprinkler irrigation. It is a job for an engineer. But for the engineer to do his job properly the farmer should be able to tell him (1) the moisture requirement of his crop and (2) the rate of infiltration of the soil. This will enable the engineer (1) to design a system that has a capacity large enough to meet the peak period moisture requirement of the crop and (2) to apply water at a rate that does not cause run-off during the normal operating period, or cause water stagnation on the surface after the sprinkler line is shut off.

As a general rule it may be said that the infiltration rate in the reddish brown earths (dry zone) is one - inch per hour. And most dry zone crops like chilli, maize, beedi-tobacco, require 3½-4 acre feet of water per crop (exclusive of rainfall) or half this quantity of water if there is rain as usual.

FURROWS AND BASINS. Yet the high capital cost and foreign exchange component of sprinkler equipment forbids its widespread use in this country. In the circumstances, surface irrigation techniques must continue to be the vogue e.g. furrows and basins.

Basin irrigation is common in the Jaffna and Vavuniya Districts. It is best illustrated by the cultivation of onion. Shallow, flat basins about 3 ft. × 3 ft. are prepared. Water is allowed into them. The soil puddled and the onions planted. They are irrigated every 3-4 days by letting in water from the channel to the basins.

In furrow irrigation the crop e.g. (chilli) is planted on ridges spaced 3 feet apart and the furrows in between are used to 'channel' the water. The furrows are 18 inches wide at the bottom widening to 24 inches at the top. They are six inches deep and have a gradient of about 3 inches in 100 feet. If the water moving in the furrows is clear it is an indication that the gradient is alright. If the water is seen to carry suspended soil particles the gradient is too steep.

The present open channel and furrow system adopted by farmers is too wasteful of water. An improved system, claimed to be 70% efficient, has consequently been evolved at the Maha Illuppallama Research Station. Known as the "lined channel and graded furrow" system it is designed to fit the undulating topography of the dry zone landscape, and cater to the porous nature of the reddish-brown earths which constitute the predominant soil group in this area.

Briefly the lay-out of the system is as follows: Distribution channels from the main irrigation channel are run along the headlands at a 1% gradient. These channels are lined with concrete using four-foot sections which are previously turned-out in a mould.

The land on either side of the headland is now terraced by levelling and smoothening operations. Graded furrows or small channels with a uniform slope in the direction of irrigation are then constructed in straightlines broadside to the lined channel. The difference in height between the bed of the lined channel and the beginning of the furrow should be a minimum of ¾ foot to permit siphoning the water through rubber tubes.

Because the reddish-brown earths are susceptible to extreme erosion during periods of intense rainfall that occur in the *maha* season, the gradient or slope of the furrows should not exceed 2% —0.5 to 0.7% gradients are ideal. Furrow lengths should be 200 ft.

Furrows serve not only to carry irrigation water to the crop, but also to dispose of surplus rain water into storm drains which are specially constructed in the natural depressions of the landscape. Unless such storm drains are provided good drainage cannot be achieved in the low-lying regions of the landscape.

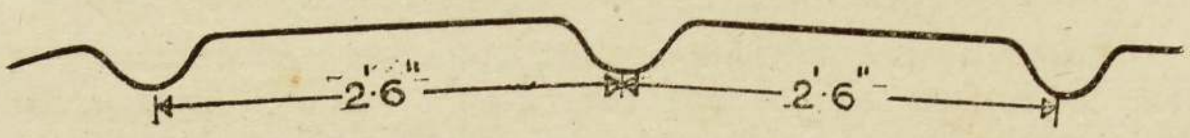


Fig. 1·8 *Raised bed and small furrows.*

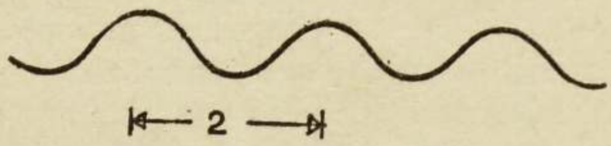


Fig. 1·9 *Rounded ridges and small furrows.*

Furrows should be separated by slightly raised beds (2½ ft. wide) which may be used for the cultivation of close-spaced crops like onions, pulses and groundnut. Lateral seepage has been found to be quite satisfactory in the reddish-brown earths when bed widths of up to 2½ ft. are used.

In the case of chillies however rounded ridges are recommended the chilli plants being spaced 2 ft. apart along the ridges.

The water from the lined channel is siphoned off into the furrows through rubber tubes of one-inch diameter. If the furrows are carefully constructed at the recommended gradient, the water will take 20 minutes to flow to the end of a 200 feet long furrow. In this time the quantity of water discharged should be sufficient to irrigate the plants in the row. The usual practice is to allow the water to cover about 170 ft. of furrow and then to remove the rubber tube and fix it at another furrow. If the flow of water in the lined channel is adequate it should be possible to use about 40 such rubber tubes at one and the same time.

The water requirement, irrigation interval and number of irrigations required per crop under this system in the *yala* season are shown below:—

		Total water Requirement	*Total No. of irrigations*	*Interval between irrigations*
Onions (60 days)	...	24 inches	16	3 days
Chilli (150 days)	...	48 ,,	28	4 ,,
Groundnut (105 days)	...	28 ,,	13	7 ,,
Soyabean (90 days)	...	28 ,,	12	6 ,,
Cowpea (90 days)	...	28 ,,	12	6 ,,
Green Gram (85 days)	...	28 ,,	12	6 ,,
Green Gram (55 days)	...	14 ,,	6	6 ,,

PART II

CEREALS, YAMS AND PULSES

Rice — Maize — Sorghum — Kurakkan — Meneri — Thana Hal — Manioc — Sweet Potato — Large-Leaved Yams — Dioscoreas — Elephant Yam — Edible Canna — Jerusalem Artichoke — Green Gram, Black Gram and Cowpea — Soya Bean — Groundnut.

RICE — OUR STAPLE FOOD

Why have we failed to be self-sufficient despite the adoption of high-yielding varieties?

That there is a desperate need to produce more rice goes without saying because this staple accounts for 50 percent of the calorie and protein requirements of the people; yet, despite production having expanded at the annual rate of 6 percent, we still continue to import 30 percent of our requirement.

Per-acre yield increases have been mainly associated with the adoption of high-yielding varieties (HYV). Surveys have revealed that the rate of adoption is as high as 70 percent, but the average yields at the national level are still disappointing. Our farmers obtain only one-third to one-half the achievable potential of these HYV. Why?

Seed of doubtful quality...

One reason is that farmers do not use the best seed material available. In the adoption of HYV it is important to obtain seed of good quality, since the genetic viability of the seed is known to last only a few seasons. Many farmers, however, do not renew their seed paddy every 2 - 3 years, as they are expected to do from certified institutional sources like the Department of Agriculture. Instead they go on using their own stocks, and in recent times because of recurrent drought they have been compelled to obtain seed from other non-certified sources.

Clearly, therefore, the use of seed material of doubtful quality has been the root cause of poor performances. There are other reasons too. In the adoption of HYV it is a necessary concomitant that fertilizers should be used appropriately to obtain the desired results. But although the use of fertilizers continues to expand, it is very evident that it is rarely used in the amounts recommended.

Inadequate fertilizers . . .

The main constraint precluding the application of the recommended amounts is financial. In the circumstances farmers very often neglect to apply the basal mixtures and use only the top-dressings as these show immediate and visible results. In the long run, however, if denied regular basal applications of fertilizer, the crop loses vigour and produces small earheads with lighter grain. There is much scope, therefore, for improvement in fertilizer practice.

Unsatisfactory weeding . . .

Control of weeds is another essential cultural practice, since yields could be very adversely affected in the new varieties which are short and erect. Because of their stiff-strawed growth habit, weeds are not shaded out naturally as they are by the tall traditional types which tend to flop over.

There is no doubt that the majority of farmers weed their fields manually. But the weeding they do is rather sketchy and while this might have been sufficient for the tall traditional types it is obviously inadequate for the HYV.

The main reasons adduced by farmers for not weeding as intensively as they should are financial constraints and labour scarcity. While financial constraint is an acceptable excuse, it is difficult to accept the plea of labour scarcity. Perhaps the reason is not so much scarce labour as a lack of understanding that the new varieties are more prone to weed infestation than traditional types. There is room here for more farmer education along these lines.

Chemical and mechanical methods of weed control are not so popular. This is not surprising in respect of chemical methods which are relatively expensive. But the same reason cannot be attributed to mechanical means. After all, a hand-operated rotary weeder can be turned out quite cheaply and used quite conveniently.

A pre-requisite to the use of such a weeder, however, is row-sowing or row-transplanting. But for some reason seed-dibblers are not commonly used. Any even when transplanting is done the plants are usually planted at random and not in rows. Under these conditions the rotary weeder cannot be used.

It is necessary, therefore, to promote the use of seed-dibblers or encourage row-transplanting as a pre-requisite to rotary weeding, at least in those areas where labour is scarce or too expensive to be used effectively for the manual control of weeds.

Shallow transplanting . . .

In the establishment of a rice crop it is generally accepted that transplanting gives better yields than broadcast-sowing mainly because the weeds are better controlled this way. But most farmers who transplant do so because it is a traditional community habit with no real thought of its advantages as a cultural practice.

This is one reason why they transplant at random and not in rows. Similarly, without thinking, they often make the mistake of planting too deep. This precludes tillering and reduces yields. There is room for more farmer education in this respect too.

Indifferent plant protection . . .

Plant protection forms another integral part of modern rice technology. As in the case of fertilizers it is imperative to use the appropriate agro-chemicals at the appropriate times. But it is clear that most farmers adopt protection measures only when their crops are seriously threatened. Otherwise, they are prepared to suffer a certain amount of pest damage rather than incur further expenditure on crop inputs.

In regard to the effectiveness of crop protection measures, the location of different plots in a single 'yaya' makes it necessary to synchronise spraying and dusting operations to achieve the best results. But farmers obviously do not act together in this respect. If they act at all, they do so individually and at different times. And this makes one wonder—considering that most agro-chemicals aim at 50 percent kill at the recommended rates—whether these sporadic applications of pesticides often at sub-optimal levels, are not a waste of scarce financial resources. Indeed, the scope for improving the efficacy of plant protection methods is very wide — specially in regard to group action.

Until all these deficiencies are corrected, viz. the use of poor seed combined with poor management practices, we cannot expect to close the gap that now exists between the potential yield of 120-140 bushels of paddy per acre (4,000 sq. metres) that may be expected from HYV and what is actually achieved at present.

CEREALS

Rice *Oryza sativa*

TILLAGE: This may be done manually or with the aid of bullock-drawn or tractor-drawn implements. One ploughing with the onset of the rains, or when irrigation water is made available should be sufficient to bury the weeds. If green manure is used it should be ploughed in along with the weeds. The fields are then inundated for two weeks to allow the organic matter to rot.

After this the fields are ploughed again—and the soil is puddled, churned into a soft consistency. The Burmese Harrow (Fig. 2.1) is a very effective implement for this purpose. The same harrow with the wooden teeth withdrawn may be used as a levelling board. After the fields have been levelled by drawing the harrow (minus the teeth) several times over the soil, finer levelling and the construction of shallow drainage channels is achieved with the aid of a hand-levelling board or *athporuwa*. Fine levelling however will not be necessary if the crop is transplanted.

A basal dressing of fertilizer is usually applied at the time of second ploughing.

SEED: Seed rate depends on the method of sowing or planting. If the seed is broadcast the average seed rate is 2 bushels per acre for all varieties except BG. 11-11. If the seed is first sown in a nursery and the seedlings transplanted later the rate is one bushel. If the seed is dibbled with tube seeder (Fig. 2.2) the seed rate is $1\frac{1}{4}$ bushels.

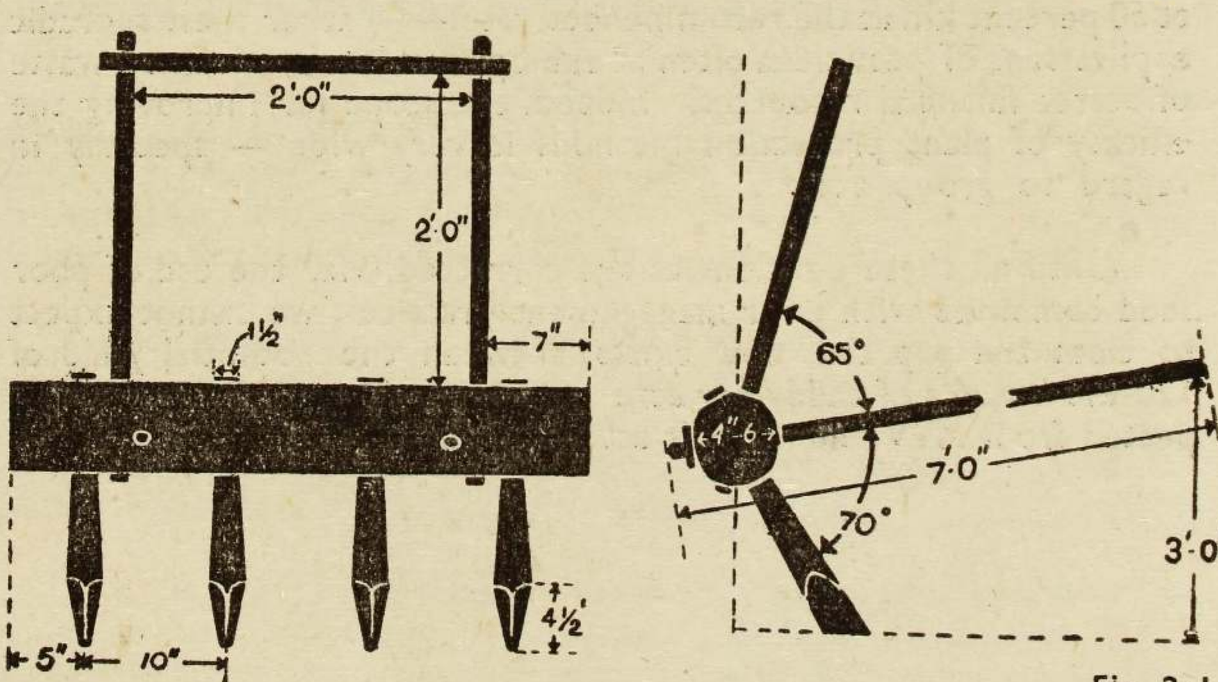
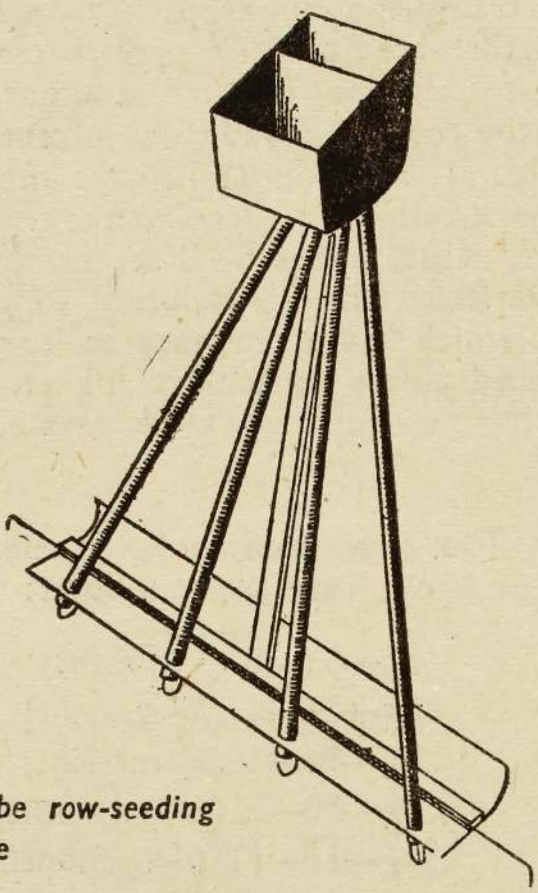


Fig. 2·1

Burmese Harrow



A popular four-tube row-seeding device

Fig. 2·2

In the case of BG 11-11 however because of its smaller size, you can use less seed in all three methods—1½ bushels for broadcast sowing, one bushel for dibbling and three-quarter bushel for transplanting.

The seed of the new BG varieties has a dormancy period of 4 - 5 weeks during which germination is poor. For this reason you should ensure that seed paddy is at least 5 - 6 weeks old after harvesting. The seed has to be prepared for planting by wrapping it in a gunny and soaking for 18 - 24 hours in water. After this it is kept under a weight for a further 24 hours before sowing. By then the incipient white roots would have emerged.

Seed disinfection is no longer thought to be necessary as the disease germs—if there are any—are carried inside the seed where they are immune to any superficial dusting or wetting with a disinfectant.

PLANTING: It was once thought that transplanting and row-dibbling were superior methods to broadcast-sowing because they gave slightly higher yields. But this is a debatable point as equally good yields have been obtained from crops that have been broadcast-sown thinly rather than thickly. Your decision as to which method to employ would therefore be dictated by personal preference and custom rather than scientific reason.

If you opt to transplant your crop, then you must make provision for a nursery (l/10th acre to raise enough seedlings to transplant one acre). Be sure also to "fertilize" the nursery crop as follows: 25kg (½ cwt.) of the recommended basal mixture followed by a top-dressing of 4½ kg. (10 lb) of urea 10 days after germination : and when you lift the seedlings in three weeks time see that they are transplanted fairly close, about 6 - 8 inches apart, because the new improved rice varieties are all 'tailored' to grow upright unlike the old varieties which had a tendency to 'sprawl'. As such they can be transplanted closer to achieve higher yields. This means that they might have to be lifted 5 - 6 days earlier than the usual three weeks.

VARIETIES: The new improved varieties recommended by the Department of Agriculture are as follows:

Bg—34—8 (3 months)
Bg—34—6 (3½ months)
Bg—94—1 (3½ months)
Bg—90—2 (4-4½ months)
Bg—11—11 (4-4½ months)
Bg—3—5 (5-6 months)

Given plenty of water these varieties will give high yields (over 100 bushels per acre) with heavy applications of fertilizer. Where irrigation is a problem and where the farmer is not in a position to adopt a high level of management it would be better to grow 'hardy' varieties like H4 and 62-355. H4 is a 4-4½ months variety and 62-355, a-3 months variety.

FERTILIZERS: A basal application of fertilizer is followed by one, two or three top-dressings, depending on the soil, climate and age of the rice variety.

The basal mixture is prepared by the Fertilizer Corporation and marketed as the V1, V2 and V3 paddy mixtures. It consists mainly of phosphorus and potassium fertilizer with a little nitrogen.

The nitrogen fertilizer is given later in the life of the crop when it is most required *viz.* at tillering and at primordia initiation (*heen-bundi*) when the earhead begins to develop at the bottom of the central shoot. It may be given in the form of urea or a mixture of nitrogen and potassium. The potassium is necessary to fill out the grains as they develop. The nitrogen and potassium mixtures are prepared by the Fertilizer Corporation and made available as the Top Dressing Mixture No. 1 (TDM 1) and the Top Dressing Mixture No. 2 (TDM 2).

The current fertilizer recommendations (per acre) for the Dry Zone *i.e.* the Anuradhapura, Polonnaruwa, Ampara, Moneragala, Jaffna, Vavuniya, Mannar, Trincomalee and Batticaloa Districts; the Bintenne Division of the Badulla Districts; the Minipe Division of the Kandy District; North and East Divisions of the Matale Districts; Puttalam Pattu, Gravets, Kalpitiya, Kumarawanni and Rajawanni Divisions in the Puttalam District; and Magam Pattu and Giruwa Pattu East Division in the Hambantota District are as follows:

3-3½ MONTHS VARIETIES

Fertilizer	*Time of application*	*Quantity*
V I	At second ploughing or before sowing or transplanting.	75 kg (1½ cwt)
Urea	2 weeks after sowing or transplanting.	25 kg (1/2 cwt)
Urea	6 weeks after sowing or 4 weeks after transplanting.	37.5 kg (3/4 cwt)

4-4½ MONTHS VARIETIES

Fertilizer	*Time of application*	*Quantity*
V I	At second ploughing or before sowing or transplanting	75 kg (1½ cwt)
Urea	2 weeks after sowing or transplanting.	25 kg (1/2 cwt)
Urea	6 weeks after sowing or 4 weeks after transplanting.	25 kg (1/2 cwt)
Urea	10 weeks after sowing or 8 weeks after transplanting.	37.5 kg (3/4 cwt)

The recommendations for the Wet Zone *i.e.* Kegalla and N'Eliya Districts; Kandy District except Minipe; Matale South in the Matale District; Badulla District except Bintenne; North and South Pitigal Korale and Wennappuwa in the Puttalam District; and Giruwa Pattu North and South in Hambantota District are:

3-3½ MONTHS VARIETIES

Fertilizer	*Time of application*	*Quantity*
V 2	At second ploughing or before sowing.	75 kg (1½ cwt)
Urea	2 weeks after sowing.	12.5 kg (1/4 cwt)
TDM 1	6 weeks after sowing.	50 kg (1 cwt)

4-4½ & 5-6 MONTHS VARIETIES

V 2	At second ploughing or before sowing or transplanting.	75 kg (1½ cwt)
Urea	2 weeks after sowing or transplanting.	12.5 kg (1/4 cwt)
Urea	6 weeks after sowing or 4 weeks after transplanting.	25 kg (1/2 cwt)
TDM 2	10 weeks after sowing or 8 weeks after transplanting for 4-4½ months varieties.	50 kg (1 cwt)

There are some problem paddy soils too for which special rations have been designed. The ill-drained soils of the low-country Wet Zone, for instance, Colombo, Kalutara, Galle and Matara Districts and Ratnapura District except Attakalam and Kolonne Korales, should be treated as follows:

3-3½ MONTHS VARIETIES

Fertilizer	*Time of application*	*Quantity*
Pellet Fertilizer or Compound Mixture	Before sowing.	100 kg (2 cwt)
Urea	6 weeks after sowing.	25 kg (½ cwt)

4-4½ and 5-6 MONTHS VARIETIES

Fertilizer	*Time of application*	*Quantity*
Pellet Fertilizer or Compound Mixture	Before sowing or transplanting.	100 kg (2 cwt)
Urea	4 weeks after sowing or 3 weeks after transplanting.	25 kg (½ cwt)
TDM 2	10 weeks after sowing or 8 weeks after transplanting for 4-4½ months varieties, 16 weeks after sowing or 14 weeks after transplanting for 5-6 months varieties.	37.5 kg (3/4 cwt)

The phosphate deficient soils of the Kurunegala District (at Hiriyala Hathpattu, Dewamaddi Hathpattu and Wanni Hathpattu) and the Ratnapura District (Attakalam Korale and Kolonne Korale) should be treated as follows:

4-4½ and 5-6 MONTHS VARIETIES

Fertilizer	*Time of application*	*Quantity*
V 3	At second ploughing or before sowing or transplanting.	100 kg (2 cwt)
Urea	2 weeks after sowing or transplanting.	25 kg (½ cwt)
Urea	6 weeks after sowing or 4 weeks after transplanting.	25 kg (½ cwt)
Urea	10 weeks after sowing or 8 weeks after transplanting (In the Ratnapura District and Wanni Hathpattu only).	37.5 kg (3/4 cwt)
TDM I	10 weeks after sowing or 8 weeks after transplanting for 4-4½ months varieties,	50 kg

Fertilizer	Time of application	Quantity
	16 weeks after sowing or	(1 cwt)
	14 weeks after transplanting for 5-6 months varieties. (In Hiriyala and Dewamaddi Hathpattus only).	

3-3½ MONTHS VARIETIES

V 3	At second ploughing or before sowing.	100 kg (2 cwt)
Urea	2 weeks after sowing.	25 kg (½ cwt)
Urea	6 weeks after sowing (Ratnapura Dist. and Wanni Hathpattu only).	37.5 kg (3/4 cwt)
TDM I	6 weeks after sowing (Hiriyala and Dewamaddi Hathpattus only).	50 kg (1 cwt)

The balance soils in the Kurunegala District i.e. in the Weudawili, Dambadeni and Katugampola Hathpattus should be treated as follows:

3-3½ MONTHS VARIETIES

Fertilizer	Time of application	Quantity
V I	At second ploughing or before sowing.	75 kg (1½ cwt)
Urea	2 weeks after sowing.	12.5 kg (1/4 cwt)
TDM I	6 weeks after sowing.	50 kg (1 cwt)

4-4½ and 5-6 MONTHS VARIETIES

V I	At second ploughing or before sowing or transplanting.	75 kg (1½ cwt)

Fertilizer	*Time of application*	*Quantity*
Urea	2 weeks after sowing or transplanting.	12.5 kg (1/4 cwt)
Urea	6 weeks after sowing or 4 weeks after transplanting	12.5 kg (1/4 cwt)
TDM I	10 weeks after sowing or 8 weeks after transplanting for 4-4½ months varieties, 16 weeks after sowing or 14 weeks after transplanting for 5-6 months varieties.	50 kg (1 cwt)

The above fertilizer recommendations have been calculated for an average level of management and an average yield of about 75 bushels of paddy per acre. With assured irrigation, however, and a high level of management greater quantities of fertilizer may be applied to achieve yields of over 100 bushels per acre. But since fertilizers encourage weed growth and cause plant succulence to attract a number of insect pests, it is imperative that the farmer should maintain a high standard of weed control and pest control.

WEED CONTROL: Weed control may be effected manually by hand-weeding and the use of the rotary weeder in between rows of dibbled or transplanted rice, or chemically by the application of weedicides. If manually attempted two good weedings are necessary, preferably just before the first two top-dressings of fertilizer. Manual weeding however is only partially successful because by the time the weeds have reached the stage for pulling they have already utilized valuable plant nutrients and crowded the fields at the expense of the rice crop. Chemical herbicides are more effective because they destroy the weeds when they are quite small.

Chemical herbicides are marketed as emulsifiable concentrations and granules. The former have to be sprayed while the latter are applied direct to the fields by hand. The emulsifiable concentrations are MCPA 40%; MCPA 60%; 3-4 DPA; Machete 50% and Saturn 50%.

The MCPA concentrations are not effective against grass weeds. They are sprayed 21-30 days after sowing or 15 days after transplanting. 3-4 DPA is sprayed 12-16 days after sowing or transplanting when the weeds are in the two to three-leaf stage. Fields should be drained before spraying to expose the weeds, and water impounded again 2-3 days later. Saturn 50% and Machete 50% are sprayed 5-7 days after sowing or transplanting.

Granules are applied to the standing water in the fields 5 - 7 days after sowing or transplanting. The best results are obtained when the fields are fairly level and contain one or two inches of water. You may use any one of the following: Machete 5% Saturn 6% or MCPA 3%. MCPA 3% is not effective against grass weeds.

IRRIGATION: Irrigation water should not be let into the fields for 2 - 3 days after sowing or planting. When it is let in it should be maintained at a height of 1 - 3 inches throughout the growing season, except when weedicides are sprayed, and just before harvesting.

Prior to spraying weedicides the fields are not irrigated for 2 - 4 days so that the water level drops to expose the weeds. After spraying, too, water should not be let in for another two days. One week prior to harvest the fields should be completely drained of water and allowed to dry to hasten the maturity of the paddy crop.

If is not necessary to reduce the level of the water in the fields when applying fertilizers, but do not let the water flow from *liyadda* to *liyadda* for at least a week after application to ensure that the fertilizer is not washed away.

PEST CONTROL: The most serious insect pests are leaf-rollers, brown hoppers, stem borers, gall midge, thrips and paddy bugs.

LEAF - ROLLERS: These are small greenish yellow caterpillars which chew the leaves, leaving whitish streaks on them. Later they will roll the leaves and continue feeding inside. These caterpillars are most active during the tillering stage of the crop. They are controlled by spraying Monocrotophos 60% EC (Azodrin, Nuacron and Movocron). or Fenthion (Baytex, Lebaycid). So are all other caterpillars.

BROWN HOPPERS (Fig. 2.3). These are small brown insects which are found crowding the lower stems of the rice crop. The outer leaves begin to yellow and die and soon the affected areas appear as brown patches in the field. To minimise crop damage control action must be taken long before the brown patches, or 'hopper burns' as they are called, appear. Apply Carbofuran

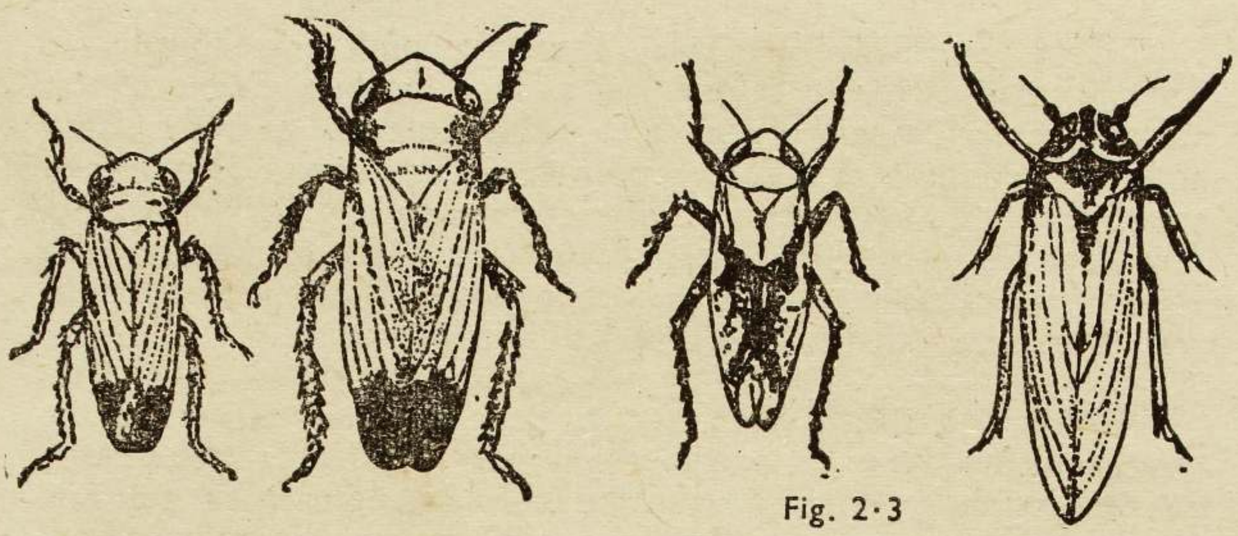
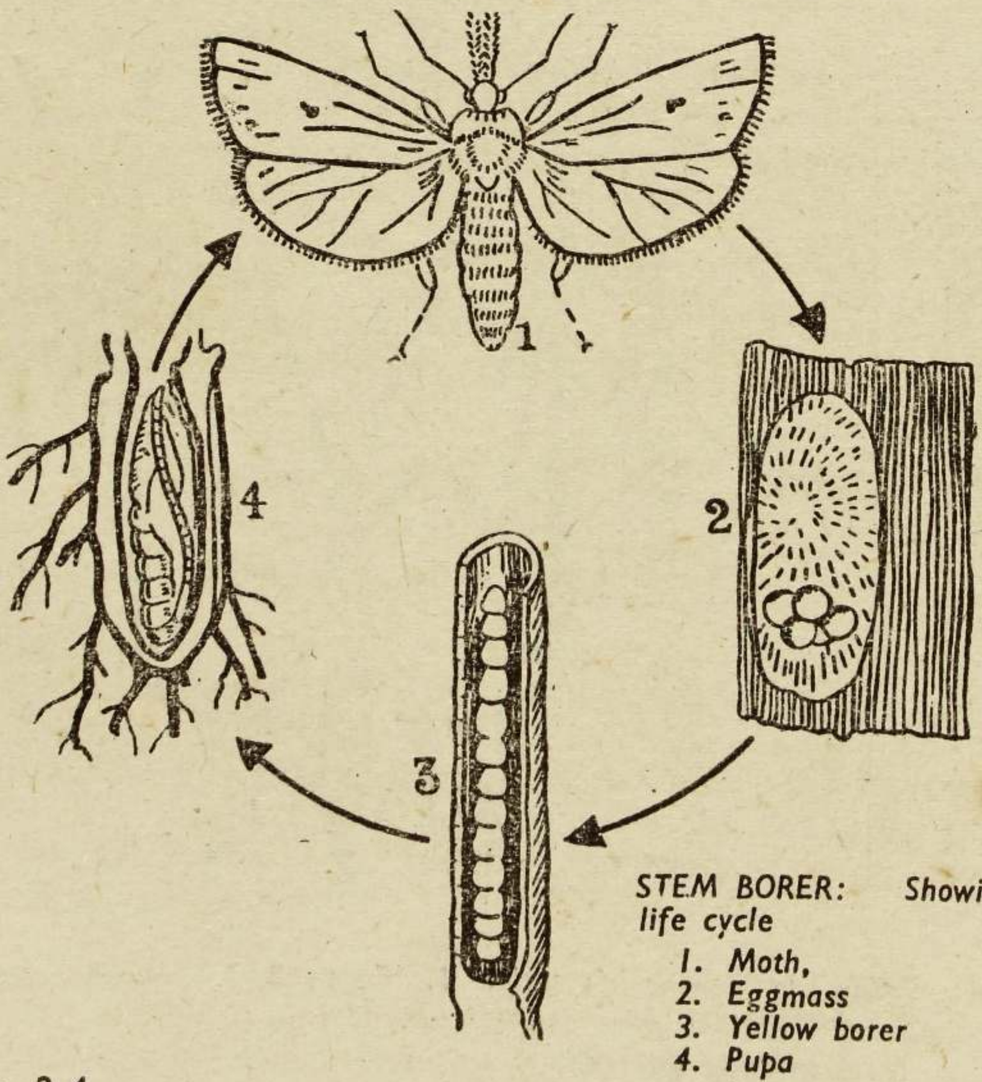


Fig. 2·3

PADDY HOPPERS : (Left) Male and female green leaf hoppers and (Middle) greyish white zig-zag hoppers who eat the leaves should not be confused with brown stem hopper (right) which is a serious pest today (greatly enlarged)

(Furadan, Currater) or Propoxur (Undane) granules to moist soil or half-inch of standing water (not more). In the alternative use a power sprayer to apply BPMC 50% EC. (Bassa).



STEM BORER: Showing life cycle

1. *Moth,*
2. *Eggmass*
3. *Yellow borer*
4. *Pupa*

(Approx. twice life size)

Fig. 2·4

STEM BORERS (Fig. 2.4): These are pink or yellow larvae about three-quarter inch long. They feed inside the base of the stems causing the central shoots to yellow and die in young plants and white empty earheads to appear in mature plants. Preventive action should be taken at the early stage by applying Carbofuran 3 G (Furadan, Currater) or Diazinon 10G (Basudin) granules to the water in the nursery. In a broadcast sown crop the same insecticides will have to be added to 1 - 2 inches of standing water.

GALL MIDGE: This is an orange-bodied mosquito-like insect which lays its eggs on the rice plants. The larvae which hatch out feed at the growing point in the base of the plant. A tubular, onion-like, silvery shoot develops. Infestation generally occurs from nursery to *heen-bundi* stage. Use the same insecticides recommended for stem borer.

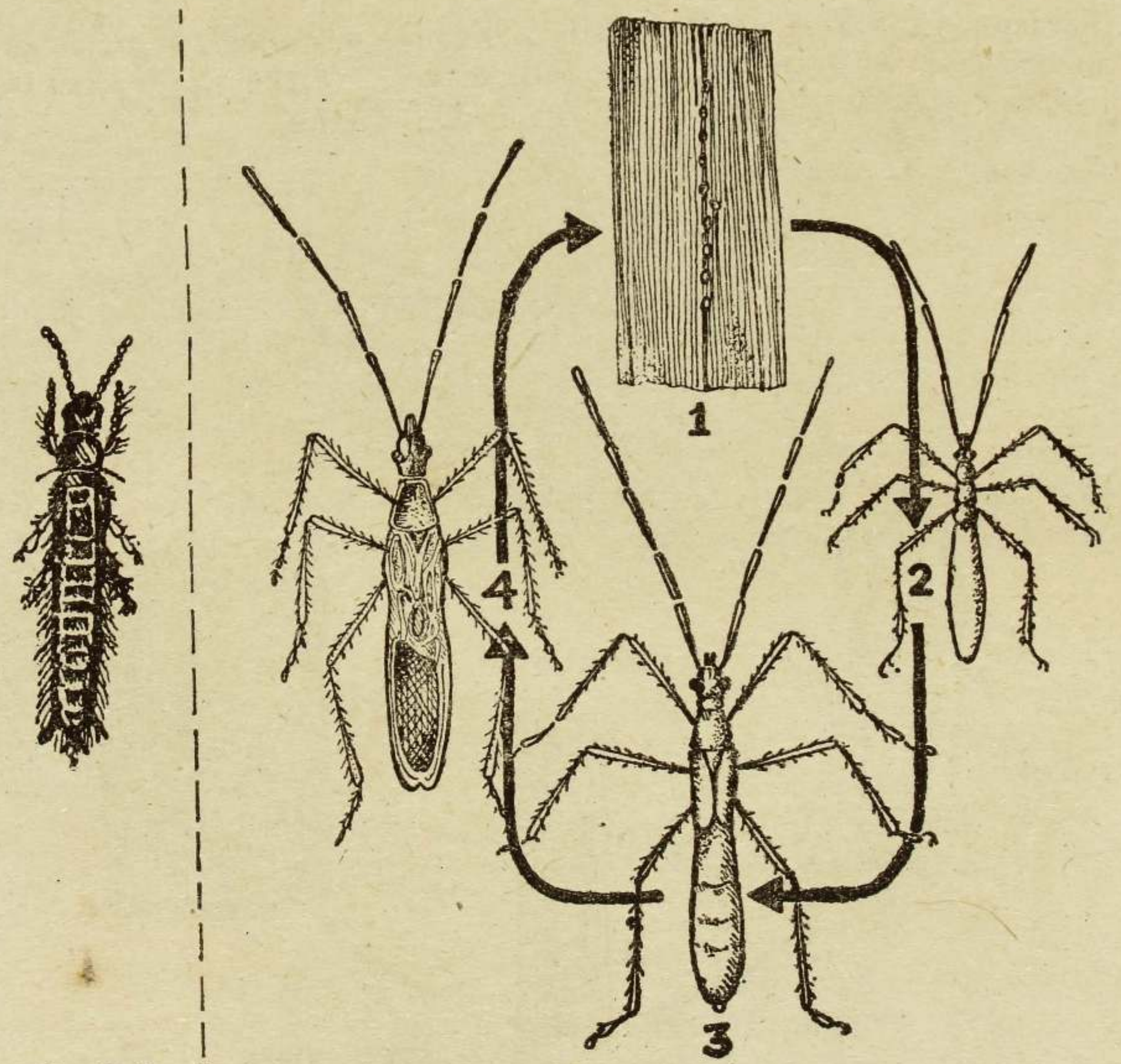


Fig. 2·5

Right: *Paddy bug showing life cycle. 1. Eggs 2, 3. Nymphal stages 4. Adult bug. (Approx. twice life size)*

Left: *Thrip (greatly enlarged).*

THRIPS: (Fig. 2.5) These are minute yellow or brown insects which feed on the leaves of the young rice crop when it is 10 - 14 days old. Damaged leaves take on a yellowish red colour and tend to roll, specially in hot weather. Spray with any of the following: Dimethoate 40 EC. (Rogor L 40, Rogor 40), Fenthion 50 EC. (Baytex, Lebaycid), Quinalphos 25 EC, (Bayrusil), Carbaryl (Sevin) or Propoxur 20 EC. (Undane).

PADDY BUG (Fig. 2.5): This is a brown, elongated insect about three-quarter inch long which generally attacks the earheads when the grains are in the milky stage. Control is effected cheaply by dusting the crop with BHC. The dusting should be repeated in three days. In the alternative spray Quinalphos 25 EC. (Bayrusil) or Fenthion 50 EC. (Baytex, Lebaycid).

Other than these insect pests rats and crabs can be a nuisance. Rats nibble the basal parts of the plants at the *heen bundi* stage and feed on the developing earheads within the stems. When the earheads mature they cut down the plants with their teeth and store the earheads in their burrows. Rats concentrate their feeding first in the middle of a field and then move outwards. Their burrows will be noticed just above the water line on the bunds.

Poison-baiting is the most effective method of control. It should be started in rice fields when the plants begin to tiller. Any anticoagulant type of rodenticide like Racumin, Ratafin, Warfarin, Tomarin or Dethmor may be used. One part of such a rodenticide should be mixed with 3 parts of flour to form a paste with water. Half-inch pieces of manioc are then dipped in the paste and allowed to dry in the shade. Two or three are placed in a hollow bamboo and located on the side of the bund above the water. About 15 such bamboos carrying poisoned bait will be required per acre of crop. The poisoned bait should be replaced every 3 - 4 days or earlier if necessary. To accustom the rats to this bait, prebaiting with manioc slices dipped in a floury paste without the poison should be done for about a week.

Crabs can be a problem up to about the tillering stage. They nibble the plants at the base and cause partial or complete severance. Since the crabs live in little burrows in the bunds down near the water level, action must be taken to plaster all the bunds at preparatory tillage. And if burrows are subsequently opened up by the crabs, squirt in an insecticidal solution of Bassa, Bayrusil, Baytex, Lebaycid or Basudin.

DISEASES: Diseases are not as serious as pests. Those commonly affecting the leaves causing spots and streaks to appear are blast, brown-spot and narrow leaf-spot. All the Bg varieties of rice, however, and even H4 and 62-355 are bred for blast-resistance so that the blast disease is no longer a problem. The other two diseases rarely develop into problematic proportions.

Of the stem diseases viz., stem rot, foot-rot and sheath-blight, the last named is the most serious, specially in the hot, wet low-country. The characteristic symptom is the greyish black discolouration ot the leaf sheath at the base of the stem. Spraying with 'tuzet' is an effective control measure. Also it is necessary to avoid dense planting and the excessive use of nitrogenous fertilizers in areas where this disease is prevalent.

Among the other diseases Bacterial-Leaf-Blight has gained some importance in recent times. The first symptoms are the appearance of yellow streaks parallel to the veins at the top of the leaves. Eventually, these coalesce and the entire leaf blades turn brown or dirty grey, giving the plants a withered look. Since chemical control measures are very expensive and not always guaranteed to give the necessary control action, be careful to avoid flooded areas and the excessive use of nitrogenous fertilizers. Flooding and too much nitrogen predispose the crop to this disease.

CROP BUDGET: The following budget may be used as a guide for the cultivation of a 4 months improved variety like Bg 90-2 under irrigation and using all the recommended inputs in one acre of land:

Inputs		**Cost** (Rupees)
Seed (2 bushels)		90
Tractor (Dry Ploughing)		140
Fertilizers (50% Subsidy)		220
Weedicides		150
Insecticides		200
Tractor (Threshing)		100
Labour (@ Rs. 7/50)		450
Total cost of Production	Rs.	1,350
Total output of 80 bushels of paddy @ Rs. 40/-	Rs.	3,200
Profit	Rs.	1,850

Maize *Zea mays*

At present maize is cultivated mainly in the dry zone during the *maha* season (October - January). Yields are very low because the varieties used for cultivation are degenerate strains and the level of management is poor. In a programme of maize improvement therefore the first thing to consider would be improved varieties.

IMPROVED VARIETIES: Thai Composite, Cupuerico × Flint Compuesto and T48 are recommended because they are yellow-seeded varieties (unlike the mixed *chena* types) which command a better price in the market. These varieties can produce high yields of 25 - 30 cwt of seed per acre if they are correctly and adequately "fertilized".

FERTILIZERS: Fertilizer application is related to the growth of the crop. Most maize varieties take 110 days to mature. The first 55 days are devoted mainly to vegetative growth and the balance 55 days to the reproductive phase *viz.* flowering, pollination, grain setting, tillering and maturing. The tassel or male flower, which is found at the top of the plant opens out in about 50 days. The silks or stigmata of the female flowers, which are found in the developing ear on the stem of the plant, are fully developed and ready to be pollinated when the plant is 55-60 days old.

It has been found that although nitrogen and phosphorus are absorbed by the maize crop through its life period, the phosphorus is more important for root development while nitrogen is absorbed rapidly during the second or reproductive growth phase. Potassium is absorbed largely during the early vegetative phase. Based on these findings the logical fertilizer practice would be to put the phosphorus and potassium fertilizers in the ground just before or at planting, with perhaps a little nitrogen fertilizer to facilitate rapid growth, followed by the major application of the nitrogen fertilizer later in the life of the crop close to the reproductive phase.

Translated into practical terms this means the application of 50kg (1 cwt) concentrated superphosphate, 25 kg ($\frac{1}{2}$ cwt) muriate of potash and 18kg (40 lb) urea per acre soon after ploughing when the land is being harrowed. This is the basal mixture followed by a top-dressing of 56 kg ($1\frac{1}{8}$ cwt) urea per acre about 40 days after planting. The fertilizer is spread 4 - 6 inches away from the base of the plants and the plants are promptly earthed-up.

OTHER CULTURAL DETAILS: The seed rate per acre is 15 lb. Seeds are dibbled $2\frac{1}{2}$ ft between rows and 10 inches apart in the row, placing 2 - 3 seeds at each point and thinning out a fortnight later to one plant—the most vigorous at each point.

If a chemical weedicide is used, Simazine is recommended. It should be sprayed on the ground soon after planting and before the seeds germinate. It must be sprayed on moist soil soon after a shower of rain for best results. Simazine checks weed growth for 3 - 4 weeks. In the alternative see that the crop is weeded manually or by tractor 2 - 3 weeks after planting and again 4 - 5 weeks before the top-dressing of nitrogenous fertilizer.

Stem borers can be a problem, but they can be kept under control if action is taken as soon as the first signs of damage are noticed *i.e.* when the new leaves unfold and show translucent streaks or small holes where the pests have chewed the leaves. If spraying is done at this stage the pest can be prevented from boring into the stalks and causing severe crop damage. Any one of these insecticides will be effective: Azodrin 60% EC., Bayrusil 25% EC. or Thiodan 35% EC.

Harvesting is done by snapping the cobs from the stalks. These are dried in the sun for a few days before being husked and shelled. If maize is to be stored it is best left unshelled. Unshelled cobs that are reserved for planting should be dusted with 4% Malathion or 10% BHC dust to guard against weevil attack.

Sorghum *Andopogon sorghum*

Sorghum I.S. 2941 is a dwarf, yellow-grained variety that has the remarkable ability to produce several ratoon crops without any loss in yield.

Ratooning, or the practice of cutting the stalks down to the ground after harvest and allowing a new crop to develop on the existing root system is a decided advantage because it involves the least expenditure of capital, there being considerable saving in establishment time, land preparation and planting costs.

It must be noted, however, that ratoon crops can only be taken in areas where the rainfall is well distributed over the whole year, as in the wet zone and certain parts of the Intermediate zone, or where irrigation is assured all the year round.

In the dry zone under purely rain-fed conditions no ratoon crops can be taken. Only one crop is possible, the planting being done in the first week of November after the first heavy *maha* rains are over.

A single crop of sorghum may also be taken in the *yala* season in the dry zone in paddy fields that are allowed to lie fallow for lack of irrigation water. If the planting is done with the light rains falling in March/April, there should be enough water in the tanks to carry out subsequent light irrigations at 10 - 14 day intervals.

DISINFECT THE SEED: Since 'smut' is a seed-borne disease it is essential that the seed be disinfected before planting with an organo-mercurial seed dressing like Ceresan. Two ounces of the dust will be required per bushel of seed (60 lb) or one ounce of the liquid dissolved in one gallon of water for same quantity of seed. 12 lb of seed is enough to plant an acre.

PREPARE A GOOD SEED BED: Plough the field once and harrow several times to discourage weed growth which can otherwise be very competitive in the early life of the crop.

Early weeding is necessary to give the crop a good start. This can be done manually, or mechanically using a hand tractor. The first weeding is done at 15 days followed by another at 30 days after planting.

In the wet zone, regular rains sometimes interfere with mechanical and manual weeding, thus giving the weeds the opportunity to get the upper hand. In such places it is best to use a pre-emergent weedicide such as Ramrod which is available both in the water wettable and granular forms. Applying the granules is more convenient because it does not need a sprayer. Granules, however, are more expensive. This weedicide should be applied immediately after planting when the soil is wet. Applied when the soil is wet it should give effective weed control for a period of three weeks.

PLANT CLOSE: 20 inches between rows and 4 inches in the row is a good spacing for ratoon crops. A wider spacing viz. 2 ft between rows and 6 inches in the row, may be used for single crops in the dry zone. Seeds are dibbled and later thinned out to stand 4 - 6 inches in the row.

APPLY FERTILIZERS: The recommendation is the same as for maize, except that the nitrogenous top-dressing is given a little earlier viz. 30 days after planting instead of 40 days. Ratoon crops must be given the same fertilizer applications as the original plant crop.

CONTROL PESTS: Stem borers can be a nuisance as in maize. The same control measures may be used. But birds, especially parrots, can be a very big problem in the dry zone. They eat the seed and cause seed shatter. Bird scarers must therefore be employed from the time the grains in the earheads are in the milky stage of development up to harvest — a period of one month.

HARVESTING: Do not wait for the plants to die down. Unlike in maize the stalks stay green. Harvest the earheads separately and then cut the stalks down to about one-inch above ground level. The new stalks of the ratoon crop will develop from the stubble. The first crop takes 100 days and subsequent ratoons 85 days. Average yields of 2500 - 3000 lb of seed per acre may be taken from each crop.

SEED STORAGE: Since weevils are a big problem, seed for consumption purposes should be marketed as soon as possible. Line up a forage merchant or livestock owner if you cannot use the grain yourself.

Seed stored for planting purposes should be dried thoroughly (moisture content of not more than 14%) to prevent deterioration through rotting. As weevils are always a nuisance the seeds should be sprinkled with an insecticidal dust like 4% Malathion or 10% BHC.

SORGHUM AS LIVESTOCK FEED: Grain sorghum has a feeding value similar to maize. Livestock do well on the grain, but it must be cracked or ground before it is fed.

A recent Texas study has shown that ground *moist* grain sorghum is more efficient than dry grain as a feed. Cattle feeders in the U.S. are now reconstituting the dry grain (adding water to bring the moisture content up to 25% or higher before feeding). This improves the digestibility by nearly 30%.

The mature stalks when fed to cattle at harvest time make an excellent fodder. There is no danger of HCN poisoning since the HCN content of I.S. 2941, unlike certain African sorghums, is at all stages within the safe limit.

The stalks also make excellent high energy silage.

SORGHUM AS HUMAN FOOD: While there are slight differences in the nutrient values of sorghum and other cereals, they are not large enough to make any significant difference in the food value of diets based on sorghum as the chief source of carbohydrate. In fact, the Flour Milling Corporation (Sri Lanka) means to incorporate sorghum flour with imported wheat flour up to 10 percent. For this purpose it requires 10,000 tons of flour annually. The Authorities are consequently planning to have 30,000 acres under sorghum for this purpose during the next three years (1977-1980).

Grain	Mois-ture	Pro-tein	Carbo-hydrate	Other Extracts	Fibre	Mine-ral	Calories per 100 mg.
Country Rice	13.24	7.44	77.28	0.73	0.33	0.98	345.5
Kurakkan	12.36	7.61	74.76	1.25	1.57	2.35	341.6
Maize	12.81	7.20	73.76	3.99	1.20	1.04	359.8
Sorghum	9.38	7.57	74.93	3.92	1.31	2.89	365.2

(*Source:* Department of Agriculture)

CROP BUDGET: The following crop budget may be used as guide for a rainfed crop in one acre. The profit from the first crop (plant crop) could apply either to the dry zone (*maha*) or the wet zone. The profit from the following two ratoon crops applies only to the wet zone and intermediate zone:

Inputs	**Cost** Rs.
Seed	30.00
Fertilizers (50% Subsidy)	200.00
Insecticide	30.00
Labour @ Rs. 7.50 (man), Rs. 6.00 (woman) and 4.50 (boy).	
Planting (6 women)	36.00
Weeding twice (15 women)	90.00
Syraying & applying fertilizers (3 men)	22.50
Bird Scaring (30 boys)	135.00
Harvesting (6 women)	36.00
Cleaning, drying & bagging (6 women)	36.00
Tractor Ploughing & Harrowing	180.00
Tractor Threshing	100.00
Miscellaneous	104.50
Total cost of Production	1,000.00

Income

$1\frac{1}{4}$ tons of seed @ Rs. 1,500.00	1,875.00
Profit from first crop	875.00

First Ratoon

Total cost of production is the same above less the cost of seed, tractor ploughing, but plus an extra weeding (15 women) soon after harvest	844.00

Income

I ton of seed @ Rs. 1,500.00	1,500.00
Profit from 1st ratoon	656.00

Second Ratoon

Total cost of production	844.00
Income from I ton of seed @ Rs. 1,500.00	1,500.00
Profit from 2nd ratoon	656.00
Total Profit from three crops in one year	2,187.00

Kurakkan *Eleusine coracana*

Apart from maize and sorghum the millets are of some importance. Kurakkan is the most widely cultivated of these. It requires 20 - 35 inches of rain and is grown primarily in the *chenas* in the dry zone during the *maha* season and or steep slopes in the mid-country. In the Jaffna Peninsula it is sometimes grown in paddy fields under irrigation.

VARIETIES: Local varieties tiller profusely and lodge badly leading to considerable loss of seed. Maturity is also uneven because earheads develop from each tiller and even from the nodes. The age of these varieties is usually 4 months.

SOWING: In *chenas* and on hillsides the seed is broadcast. About 6-8 lb of seed are required per acre because of a high proportion of immature seed. 4-6 lb should suffice if the seed is dibbled in rows 6 inches apart. If cultivated in paddy fields 2 lb is broadcast in 1000 sq. ft. of nursery. This area will produce enough seedlings to transplant one acre. Seedlings are transplanted like rice at 3 - 4 weeks, 3 - 4 inches apart with 2 - 3 plants.

Although the field is kept moist, no irrigation is done for the first fortnight. After that water is let in every 4 days.

FERTILIZER: A top-dressing of nittogenous fertilizer is sometimes applied e.g., 12.5 kg of urea per acre, 14 days after sowing or transplanting. This is given to accelerate growth which is slow in the early stages. Since initial growth is poor care must also be taken to weed the crop thoroughly at this stage.

DISEASE: In very wet weather "Brown-Spot" (*Helminthosporium nodulatum*) can be a problem. This disease causes rusty spots to appear on the leaves and blotches on the nodes, leaf sheaths and spikelets. Grain development is adversely affected and consequently poor yields result. Since the disease can be carried from season to season via the infected seed, seed disinfection should be carried out soon after harvest and prior to resowing by dusting with an organomercurial seed dressing like Ceresan.

HARVESTING: Two harvests have to be taken at 10 day intervals because of uneven maturity. Grain is threshed in a mortar as and when required and milled in a kurakkan hand mill. The out-turn is about 95 percent.

Under *chena* conditions you can get about 450 kg (1,000 lb) of seed per acre—that is about 16 bushels. Higher yields are obtained in paddy fields under irrigation. The storage quality of kurakkan is good. Damage from insect pests is not as severe as in sorghum or maize.

Meneri *Panicum miliaceum*

Meneri was once the traditional crop of the *chenas* in the *yala* season. The two-month variety which is locally known as *ma-meneri, kansa meneri* or Indian Millet must not be confused with the small-seeded *heen-meneri* of 3½ months duration. *Ma-meneri* is distinguished by its large oval seed with longitudinal streaks.

Ma-meneri is usually broadcast in the *chenas* with the rains that fall in March-April—about 12 lb per acre are required for this purpose. Yields of 10 - 15 bushels are average. On regularly cultivated highland, however, row-dibbling is the rule one foot apart, the plants thinned to stand six inches in the rows. This enables the farmer to intercultivate and 'fertilize' his crop at 3 weeks. The addition of 25kg or ½ cwt of urea per acre will boost yields considerably. When the crop is row-dibbled 8 lb of seed should be adequate per acre. The bushel weight is 26kg (58 lb).

A great advantage of *meneri* is that it is almost completely immune to pest attack and diseases both in the field and storage.

All food preparations made from rice and rice flour can be made with *meneri* and *meneri* flour. Seed can be pounded both in the raw and in the par-boiled state. It should not be boiled however to the same extent as paddy since overboiling reduces the seed to a paste. In the preparation of flour the raw grain is first soaked in water for 8 hours and then pounded ; 16 measures of seed will give 9 measures of raw grain or 12 measures of flour.

Thana hal *Setaria italica*

Thana Hal or Italian Millet is a 3 - 4 months crop. It requires more water than *meneri* and is therefore cultivated in the wetter *maha* season. 7 - 10 lb of seed are required to sow one acre. If dibbled the spacing should be 12 inches between rows, the seedlings being thinned out later to stand about 2 inches apart. Average yields are 270 - 405 kg (600 - 900 lb) per acre. With a top-dressing of 25kg (½ cwt) of urea these yields can be considerably improved. *Thana hal* like *kurakkan* stores fairly well.

The three millets, *kurakkan*, *meneri* and *thana hal* are better balanced foods than rice, sorghum and maize by virtue of their higher protein, fat and mineral contents.

	Protein %	Ether Extract Fat %	Minerals %
Rice (Polished)	6.31	0.38	1.60
Rice (Country)	7.44	0.73	0.98
Maize	7.20	3.99	1.04
Sorghum	7.57	3.92	2.89
Kurakkan	7.61	1.35	2.35
Meneri	11.43	3.08	4.98
Thana Hal	11.41	4.83	3.46

(*Source:* Department of Agriculture)

YAMS

In any programme of food production yams must figure prominently because they require relatively less space than cereal crops, and yet they are capable of giving higher yields with very little attention. Researchers in the U.S.A. say that cassava can produce six times more food material than wheat in the same area.

The great diversity of local yams makes it possible to find suitable varieties for every ecological situation and also to grow them all the year round. The longest aged variety is the elephant-foot-yam which takes 12 months to mature. This is followed by the dioscorea yams which take 9 months, taros which take 6 - 9 months, manioc and *innala* (6 months), and the tannias and sweet potatoes of 2½ - 4 months duration.

Manioc or Cassava *Manihot utilissima*

FOOD VALUE: The food value of manioc is undisputed. It is a wholesome food containing an abundance of carbohydrate and enough calcium, thiamine, riboflavia, niacin and vitamin C for the daily requirements of an active adult male in the tropics. It is deficient in protein however and this has to be supplemented from other sources.

The most outstanding character of manioc from an economic standpoint is its capacity for producing large amounts of food per acre at a low cost. 150 tons of this root crop is equivalent to 175 million calories which is sufficient to meet the entire food energy requirements of 175 adult males living in the tropics, on the basis of a per capita requirement of 2,500 calories a day.

The tuber possesses a high total of digestive nutrients, which makes it extremely suitable as an animal feed too. In fact, several countries are using manioc in the livestock feed industry today. Tubers can be fed as a succulent in the form of fresh roots, or as meal made either from cooked roots or flour.

The leaves and the tops too can be used for feeding livestock. Although the tubers are deficient in protein, fresh manioc leaves contain 20 - 22% protein and also vitamins A and C. The prussic acid content in the leaves can be brought down to a safe level either by boiling or by drying them in the shade. In fact, manioc leaves form a popular vegetable in Africa and other countries where the high protein value of the leaf is made to compensate for the low protein value of the tuber. For this reason manioc is known in Africa as the "all sufficient food", because as the Africans say: "We get bread from the tubers and meat from the leaves".

Flour preparation from manioc is easy and economical, because the tubers can be easily dried in the sun and stored over long periods. This is how it is done: Fresh raw tubers are washed, the outer skin and inner rind are removed with a knife and the peeled tubers then cut into slices called chips. The chips are dried in the sun quickly to avoid fungal growth which introduces undesirable flavours. Dried chips when ground produce an attractive white flour which has a pleasant taste and flavour. But as manioc flour is deficient in protein it must be fortified with soyabean flour or groundnut flour which is rich in protein. In India, for instance, commercial preparations are fortified in this manner. Tapioca Macaroni containing 60% manioc flour, 25% wheat flour and 15% groundnut flour; Mysore flour containing 75% manioc flour and 25% groundnut flour; and Nutro flour containing 75% atta flour, 17% manioc flour and 18% groundnut flour.

OTHER ADVANTAGES: From the agricultural point of view too manioc has several advantages. It grows well, for instance, in diverse soils and climates and can produce economic yields even in depleted soils which are considered unsuitable for other crops. The ability of the manioc plant to extract nutrients from the deeper strata not usually accessible to most other food crops is due to its penetrative root system which can go down as far as 40 inches. Manioc is also free from serious pests and diseases which take a heavy toll of other food crops.

Another advantage of manioc is that it is not season-bound, hence the planting and harvesting can be adjusted to suit the farmer's time schedule. The usual time to uproot manioc for consumption is at 5 - 6 months, but the tubers can be kept safely in the soil without too much deterioration in tuber quality until they are 9 - 12 months old. This wide flexibility in planting and harvesting should enable farmers to utilize their spare time, after attending to the main crop, thereby avoiding the necessity to have a large labour force during peak planting and harvesting times.

Finally the cost of production is comparatively low as it is easily propagated and requires less labour than the cereal crops. It is estimated that only 30 man-days are required to produce one ton of manioc in contrast to 153 man-days for an equivalent quantity of rice and 73 man-days for maize and sorghum. Under favourable climatic conditions and with the application of fertilizers manioc can produce 10 tons of tubers per acre.

HIGHLIGHTS OF CULTIVATION: Manioc can be grown over a wide range of rainfall from 20 - 100 inches per annum—the optimum rainfall being 40 - 60 inches. It is most susceptible to water deficiency in the first month. This is also the time during which growth is at its slowest so be careful to water the crop and to give it a fertilizer boost during this period viz., 50kg (1 cwt) urea at about 60 days. Light sandy soils will also benefit from an application of muriate of potash at 25kg (½ cwt) per acre.

Since manioc is a very exhaustive crop continued cropping in the same piece of land must be accompanied by the following basal dressing of fertilizers in addition to the top-dressings indicated above — 50kg urea plus 50kg of concentrated superphosphate and 50kg of muriate of potash.

Crops should be earthed-up when they are about 3 feet high, after which no further intercultivation or weeding should be necessary. To make maximum use of the land up to this time you should grow short-aged crops in between the widely spaced rows of manioc. Manioc is usually planted 3 ft apart.

Manioc is propagated by cuttings 8 to 9 inches long. One cutting is planted at each point in little pits made by a single stroke of the mammoty. The cutting is planted slantwise with the buds facing upwards. About half the cutting should be exposed above ground. The Department of Agriculture selections MU 10 and MU 71 are recommended for planting. They may be lifted at 5 - 6 months but the highest yields are obtained at 8 - 9 months.

COOKING MANIOC THE SAFE WAY: Manioc is a potentially poisonous yam unless it is handled and cooked properly. It is potentially poisonous because it contain a cyanogenetic glucoside which has hydrocyanic acid or prussic acid in the bound form. Manioc also contains a certain enzyme, which if it is allowed to come in contact with the cyanogenetic glucoside immediately releases the poisonous prussic acid.

The enzyme is usually activated when manioc tubers are damaged or allowed to go stale after harvest. So the first precaution is to select only undamaged tubers which are fresh and not more than three days old. If the tubers are damaged or stale the inner flesh will show a discolouration or purplish-blue streaks extending from the outer skin to the middle. Such tubers are unfit for human consumption.

The undamaged fresh tubers should be peeled of their outer skin (which contains a high proportion of cyanogenetic glucoside) before they are cut into pieces and boiled in plenty of water.

Boiling must be done for about one hour in an open pan. An open pan is essential to ensure that the prussic acid is allowed to escape as a volatile gas in the process of cooking. The remaining water must also be thrown away.

If you take these precautions you will not expose yourself to poisoning by manioc.

Sweet Potato *Ipomea batatas*

VARIETIES: The Department of Agriculture has tested a number of varieties from abroad viz. Julian, Jewel, FA 17, B5 etc. but although these varieties have been found to give high yields under regular manuring and a high standard of management, their yields under poor conditions of soil, climate and management are seen to fall off drastically. These varieties are also of the baking type rather than the sweet boiling type which is popular with the local palate. In the circumstances, it would be best to confine choice of variety to local types. There are several village varieties which are capable of giving high yields. Pick those that are either yellow or pink-fleshed as they are most nutritious.

The "Wariyapola Sweet Potato" — a local selection which is available from the Department of Agriculture—has an yield potential of 8 - 10 tons per acre. The tubers may be lifted at 2½ months or left in the soil for 4 months without getting too fibrous. The only real hazard in keeping this variety in the soil for a long period is the root-eating weevil. This pest can riddle the tubers. As a precautionary measure therefore, "dust" the soil around the plants at one month of age when the tubers begin to form. Use an insecticide like Aldrin 2 - 2½% dust at 30 lb per acre. It may be necessary to give a second dusting, but remember not to apply the dust within one month of lifting the yams. In the alternative apply Birlane at 8 lb per acre when the tubers begin to form one month after planting. Spread the insecticide in 6 - 8 inch wide strips along the rows near the base of the vines.

CLIMATE & SOILS: Sweet potato is a fairly drought resistant crop, but the yields are reduced considerably if a water shortage occurs 50 - 60 days after planting when the yams are developing. The "Wariyapola Sweet Potato" does not require more than 15 inches of rain during the growing period.

As far as possible select open-textured light soils for planting, since sweet potato does not thrive in heavy clayey soils which prevent tuberization and also lead to the formation of deformed and split tubers.

PLANTING MATERIAL: Apical cuttings are the most vigorous. They are also the safest in that they are usually free of the eggs of the root-eating weevil. Cuttings should be 9 - 18 inches long containing seven or more nodes. Planted at a spacing of 18 - 24 inches in the row, between 22,000 and 39,000 cuttings are required to plant one acre. The wider spacing should be used in wet areas.

To ensure good germination and uniform crop stand, the cuttings should be bundled in moist-gunny sacks and stored in the shade for 2 days prior to planting them out on the third day. Keep sprinkling the sacks with water from time to time. This gives the cuttings a chance to develop incipient roots so that when they are finally planted out they establish themselves much quicker and with less casualties than if they were planted straight away after being taken from the vines.

In dry areas planting is done on the flat. In wet areas ridges are preferable. Cuttings are planted to a depth of 2 - 3 inches either on top of the ridges or on either side of them.

Rejuvenation of cuttings is essential to maintain high yields. If cuttings from the same crop are taken over and over again without any selection yields can deteriorate rapidly after the 4th or 5th season. After three seasons therefore, select plants that give 3 - 4 large smooth tubers. Bed these tubers side by side in a well manured nursery and take your cuttings for the 4th season of planting from this source. About 35 sq. metres of bedding area will provide enough slips to plant one hectare (2½ acres).

FERTILIZERS: As in manioc the quickest way to boost yields is to apply fertilizers. In heavy soils apply a mixture of 25kg urea, 50 kg concentrated superphosphate and 50 kg muriate of potash per acre a few days after planting so as not to damage the emerging roots. This may be followed by a top-dressing of 25kg of urea 4-6 weeks later. In light soils the basal mixture contains 50kg urea, 50kg concentrated superphosphate and 50kg muriate of potash. There is no top-dressing.

Large - leaved Yams

"Large-leaved yams" is an umbrella term that is used to describe two distinct types of yams with several different varieties within each type. The two types are the Tannias and the Taros.

TANNIA. *Xanthasoma sagittifolium*: This type is the taller of the two. It has large arrow shaped leaves with prominent marginal veins and pointed tips. Tannias are long-aged varieties which prefer well-drained highland conditions. The typical example is *kiri-ala*. This is usually grown in coconut estates. It is lifted in 8 - 9 months. The yams are carrot shaped.

TARO. *Colocasia antiquorum*: These types are short with heart-shaped leaves. There are no prominent marginal veins. The life span is usually 3 - 4 months. Typical examples are *gahala* (4 months) and *thummas-ala* (3 months). They have barrel-shaped corms. In contrast to the tannias, the taros are adapted to a moist environment. You find them growing in *owita* lands and near water courses.

CULTIVATION: The method of cultivation in both types is the same. In the case of the long-aged tannias (e.g. *kiri-ala*) where the yams are big, small pieces are used for planting. A large yam is cut into two or three pieces, each having two or three buds. As a safeguard against rotting the cut ends are smeared with kitchen ash before planting, or dipped in a solution of copper fungicide. One to two tons of planting material are required to plant one acre at a spacing of 3ft by 3ft.

In the case of the short-aged varieties e.g. *gahala* and *thummas-ala*, small whole yams are planted 3ft by 2ft apart in high rainfall areas with heavy cloud or 2ft by 2ft in drier regions.

Crowns are also used for planting both the tannias and the taros. A crown is the top-portion of a yam with a portion of the leaf-stalk attached.

Except for an occasional weeding and earthing-up the plants require very little attention. They are ready for lifting when the leaves turn yellow. The output is 5 - 8 tons per acre in the case of the longer-aged tannias and 3 - 5 tons for the taros; 3 - 5 lb of yams per plant are average yields for the 3 - 4 months varieties. Double this quantity can be expected from the 6 - 8 months types. If stored under dry and well ventilated conditions the corms can be kept from 3 - 6 months.

Climbing Yams *Dioscorea sp.*

Dioscorea yams are the most nutritious, but they are not favoured for large-scale cultivation because of their long age (9 months) and climbing habit, which means that they have to be staked. The stakes are 10 - 12 feet high.

These yams require a rainfall of 40 - 60 inches evenly distributed over 6 - 7 months. Less than 40 inches is limiting.

You require about 1,250 lb of setts or cut tubers to plant one acre at a spacing of 2 ft apart. The tubers which are usually lifted in December-January cannot be planted till March - April because they have a period of dormancy. To break this dormancy the setts may be planted close in a sand nursery i.e. in shallow trenches covered with sand. Small uncut yams, weighing 10 - 12 oz each are best. They give higher yields than cut portions. If cut portions are used they should contain a dormant bud or two each and weigh about the same. The cut portions are smeared with kitchen ash or dipped in a copper fungicidal solution to prevent rotting. When setts have sprouted in their sand trenches they are removed and placed in manured holes to a depth of 6 inches. Well rotted cattle dung is the favoured manure.

Dioscorea yams may be cultivated as a monoculture, or as a catch crop in new cleanings of rubber and coconut or in between rows of young rubber and coconut.

Yams may be lifted in 8 - 9 months when the vines begin to wither and the leaves develop brown spots. The King Yam may be harvested earlier in 6 months, even before the yams are fully mature. Up to 50 lb can be taken from large-tubered varieties. 5 - 15 lb is the average yield. The yams can be stored safely up to 3 months if undamaged and properly cleaned. They should be kept in a cool dry place in the house over a layer of dry sand. The King Yam stores best: it may be kept up to 6 months.

KING YAM *Raja-Ala* (Fig: 2.6): Medium-sized, regular yam, purple-fleshed, stores well, soft and mealy when boiled.

JAFFNA PURPLE (Fig: 2.6): Larger than the King Yam but irregular in shape, soft and mealy when boiled.

MAURITIUS RED (Fig: 2.6): Medium-sized yam, red-fleshed, somewhat hard when cooked.

Rakthavalli & *Lenadandilla*: These cannot be recommended as they do not store well and become slimy on boiling.

Kiri-Kondol (Fig: 2.6): Longish yam, white flesh, stores well, soft, starchy and tasty when cooked.

MAURITIUS WHITE: Medium size, white flesh but somewhat hard on boiling.

Ulaki-Vali: Less tasty than *Kirikondol* but stores well.

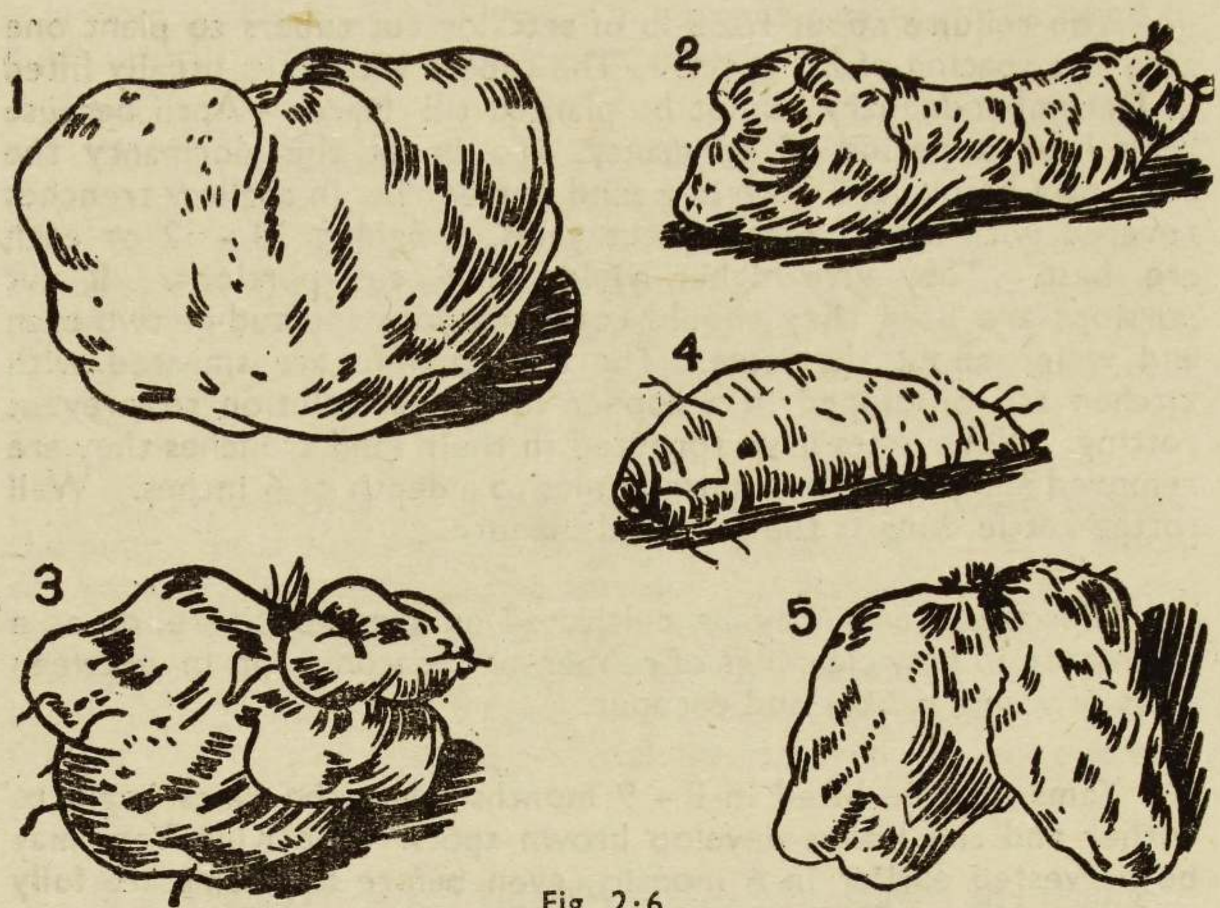


Fig. 2·6

POPULAR TYPES OF DIOSCOREA YAMS

1. King Yam, 2. Kiri Kondol, 3. Jaffna Purple
4. Kukul Ala, 5. Mauritius

Kombuvalli & *Ini-ala*: Cannot be recommended. Former does not store well. Latter is of poor eating quality.

Kukul-ala (Fig: 2.6): Yams about the size of large potatoes, borne in clusters of 2, 3, and 4. About 3 - 4 lb per plant. Good eating.

Angili-ala: Single fairly large yam with finger-like projections. Good eating.

Hiritala: Longish, thin, white and flattened yam. Five to six such yams to each vine.

Udala: Single fairly large yam. Good eating.

Innala *Lectranthus tuberosus*

VARIETIES: There are two varieties viz., the small-tubered kind known as the "*Sinhala Innala*" and "*Rata Innala*" which has larger yams.

PROPAGATION: *Innala* is propagated from cuttings. Plump yams taken from the previous season's harvest are grown in a nursery at a spacing of 6 inches apart.

The nursery is prepared with well-rotted cattle manure and thrown into beds about 3 feet wide. Since *Innala* is generally grown only in the *yala* season the nursery must be planted in March / April to allow for adequate growth to take place so that cuttings can be taken and planted with the rains in June and July.

Quick, vigorous growth can be induced by manuring with a dilute solution of cattle urine 3 weeks and 6 weeks after planting in the nursery (50 : 50 urine and water). Use only diluted cattle urine as undiluted cattle urine or a strong solution will scorch or even kill the leaves and young stems.

PLANTING: Innala is planted on rigdes as it does not tolerate poor drainage. Prior to making the ridges the soil should be well mixed with well rotted cattle manure. Ridges, 18-24 inches wide at the base and 12-18 inches at the top, are spaced 3 ft apart.

There are various methods of planting, which are traditional to different localities, but the most common is to take 6 inch long cuttings and plant them in 2 or 3 rows, nine inches apart on the ridges. Cuttings are planted about 3 inches deep, the leaves being stripped except for about 3 or 4 at the end. Keep the land free of weeds.

HARVESTING: Six months from planting out in the field the crop should be ready for lifting. As the yams are formed in the surface layers of the soil, harvesting can be done easily with the aid of a handfork. Four to five tons of yams can be lifted from one acre of land.

Comparative Nutrient Values

Yam	*Protein* %	*Carbo-hydrate* %	*Minerals* %	*Cal. Value per* 100g.
Dioscorea	1.7	25.4	0.9	108.9
Manioc	0.8	29.6	0.4	127.0
Sweet Potato	1.4	15.9	1.2	72.5
Kiri-ala	2.0	26.6	1.2	112.0
Innala	1.3	1.7	0.9	—

(*Source :* Department of Agriculture)

Elephant - Foot Yam *Amorphophallus campanulatus*

The edible yam or corm is a modification of the underground stem. Its depressed globose form, which often has a diameter of 12 inches and weighs 15lb under good cultural conditions, resembles the foot of an elephant. Fresh corms are acrid because of the presence of calcium oxolate crystals. They must, therefore, be boiled or baked thoroughly before eating. Nutrient value is as follows: Water 74.9 - 78.7%; protein 1.2 - 5.1%; fat 0.4 - 2.1% and carbohydrates 18.1 - 18.4%. It is also well supplied with minerals and vitamins A and B_1.

This yam does not favour warm humid conditions. Dry conditions are best for corm development. This is why the cultivation of elephant-foot yam is confined to the Northern Province.

Propagation is from small pieces of yam containing a dormant bud or two. The dormancy period is 2 - 3 months. Planting distance: 4 ft apart. Harvesting can be done at the end of one year.

Edible Canna *Canna Edulis*

Also known as the Purple Arrowroot or *Buth-sarana* this plant has purplish stems and canna-like leaves. The yams are also purple surrounded by a lot of fibrous roots. It is cultivated in home gardens below 1,500 ft in the Kandy and Kegalla Districts.

Propagation is from fully formed tubers bearing 1-2 healthy undamaged buds. Dipping in a 10% solution of Copper Sulphate or a copper fungicidal solution prior to planting is advisable to prevent rotting. The spacing is 3ft apart. One ton of tubers is required to plant one acre.

There is a difference of opinion as to the ideal harvesting time. Maturity it is said is indicated by a triangular slit in the outer scale leaf of the underground stem (rhizome) assuming a purple colour. Anyway it is common practice to lift the yams in 6 - 8 months. The stalks are cut and the clumps of tubers allowed to dry. They are then scraped free of soil and stored for several weeks in a dry cool place.

The nutritive value of *buth-sarana* is as follows: 72.6% water, 24.3% carbohydrates, 1% protein, 0.1% fat, 0.6% fibre and 1.4% ash.

Jerusalem Artichoke *Helianthus tuberosus*

This plant, about 3ft in height, produces a number of small knobby tubers 4-8 inches long and 1-3 inches in diameter. These tubers are cooked and eaten as a vegetable similar to potatoes. They are also used in soups and stews.

Jerusalem Artichoke grows best at elevations between 1,000 and 2,500 feet, where the temperature is 65 - 80° F and the rainfall is 50 inches, evenly distributed throughout the growing period.

Propagation is by 2 oz bits with 2 or 3 eye-buds. Spacing is 3 ft by 2 ft. The crop is earthed up at one month like the potato. About 250 - 300 lb of setts are required to plant one acre.

Harvesting can commence at 3 months and continue thereafter. Since the artichoke has very poor storage qualities once it is lifted it is best left in the ground and harvested when required only. Its "field-storage" quality like manioc is very good. 5 - 10 tons of tubers can be taken from an acre.

Note: POTATO. *Solanum tuberosum:* This crop may also be included for convenience in this section since like the other yams it is mainly a starch product, but because in this country it is cultivated as a vegetable rather than a substitute for rice it is included in the section under "Vegetables".

PULSES

Cultivating Rice and Pulses as Complementary Crops

In an integrated food and nutrition production strategy there is an urgent need for the cultivation of rice and pulses as complementary rather than competing crops. The pulses occupy the unique position of providing the required protein of the average diet in this country, in the absence or poor availability of the more expensive animal protein foods such as meat, fish, eggs and milk.

Protein is a complex of twenty or more compounds called amino acids — at least ten of which are essential to human metabolism. Only animal protein contains all the essential amino acids, so that if the major source of protein is going to be pulses, then it is essential that any deficiencies must be counterbalanced with amino acids from other sources of food, specially rice which is our staple diet.

Fortunately, the rice protein supplements the pulses. Rice is generally short in lysine, but the pulses are rich in this amino acid.

Pulses in turn are deficient in methionine, but this amino acid is found in moderate quantities in rice. As such the two foods taken together eliminate these deficiencies.

The first essential in a food and nutrition strategy programme therefore should be to intensify the production of rice and pulses with a view to overcoming the present protein-calorie imbalance, which is a feature of the local diet. Agricultural policy however up to very recent times has concentrated on increasing the output of rice while neglecting the pulses. The average yield of pulses on a national basis, therefore, as compared to rice has remained low.

Perhaps the main reason for this neglect could be attributed to the import of cheap pulses. Our farmers naturally found it more profitable to cultivate rice. But with recent government policy which has totally banned the import of green gram, black gram, cowpeas and groundnuts, and steadily reduced the import quotas of other pulses like lentils and pigeon peas, the farmer has been given the necessary incentive to produce pulses on a profitable basis.

The first consideration in any pulse development programme is the use of improved varieties which have been bred for a higher harvest index in a shorter space of time. Such varieties are now available from the Department of Agriculture. Two of them in particular viz., MI 35 cowpea which is a popular substitute for the imported lentil Masoor Dhal, and MI 4 green gram, may be harvested in 60 - 75 days and yet their yields are superior to the indigenous varieties.

The benefit of the high genetic potential of these improved varieties however cannot be fully realised unless the farmer is prepared to give them a higher standard of management than he has been accustomed to in the past, specially in the matter of fertilizer application. The fact that pulses have been grown in marginal land does not necessarily mean that these crops are unresponsive to fertilizers. On the contrary, the improved varieties show a very significant response to fertilizers specially in soils of poor fertility where a starter dose of at least ½ - I cwt of concentrated superphosphate and ½ cwt of urea per acre is essential.

A word of advice however about later top-dressings of urea. Unlike most crops pulses do not require much nitrogenous fertilizer; in fact, too much urea or ammonium sulphate is detrimental in that it prevents rhizobia formation and this in turn results in poor growth. Phosphate, however, is very essential to promote rhizobia development.

With the availability now of improved pulses which are fertilizer-responsive the time has come for these crops to be included in intensive cropping patterns in rotation with rice. The short-duration varieties in particular may be cultivated successfully in rice fields as relay crops at the tail end of a crop of rice, or as sandwich crops in between two major crops of rice. The very small water requirements of these varieties makes this a feasible proposition.

In fact, this characteristic of low water requirement should be further exploited by using these pulses to replace rice in fields which are unable to cultivate this crop because of a shortage of water. For instance, in the dry zone there are several thousands of acres of rice fields which are allowed to lie fallow during the *yala* season for this reason—there are about 200,000 acres in the Anuradhapura and Kurunegala Districts alone. This is a disproportionately large extent of wasted land which could be considerably reduced by switching to pulse production.

Crop diversification of this nature is very essential if we are to make the maximum use of our limited land resources and make the best use of expensive fertilizers. The pulses derive the cumulative benefit of the phosphorus and the potassium fertilizers given to the previous rice crop. Being leguminous crops they also manufacture a certain amount of nitrogen for themselves with the assistance of nitrogen-fixing bacteria (rhizobia) which are found in the root nodules. Any excess nitrogen is available to the following paddy crop when the stubble is ploughed in at the end of the season. There are other fringe benefits too: the rice crop benefits from the intensive weeding that is given the pulses, in the sense that there are less weeds to bother the rice crop than if the fields had otherwise been left fallow.

A word of warning though about irrigation. The rice farmer who takes to cultivating pulses in his fields is prone by force of habit to flood the fields. The water is let in and allowed to stand for long periods. Now, while this is alright for rice it is detrimental to pulse production. Pulses either receive a set-back in growth or, in the case of MI 35 cowpea, they run to leaf at the expense of pod production when they are given too much water. The ideal pattern of irrigation therefore would be several light irrigations rather than flooding — perhaps four of five at the most, every 10 days or so, and just enough to wet the soil to a depth of four inches.

The rice farmer who takes to pulse production is also liable to be caught napping in the matter of weeding. Accustomed as he is to weed control by flooding he tends to forget that when several light irrigations are given instead, weeds spring up faster than usual. These weeds must be eliminated, particularly during the first month if a successful harvest of pulses is to be expected.

In the wet zone too the greater part of the highland, which is presently left uncultivated or only haphazardly cultivated, could be harnessed for pulse production. In fact, pulses could profitably replace some of the coarser cereals like maize and sorghum, whose increased production it has been difficult to sustain in the face of fluctuating market prices and the cheap-import of wheat flour.

All in all then a significant increase in pulse production could be achieved with profitable returns to the farmer if the new varieties offered by the Department of Agriculture are henceforth included in diverse cropping patterns so that they complement rather than compete with the production of rice.

Green Gram, Black Gram and Cowpea

Phaseolus aureus, Phaseolus mungo and Vigna catiang

RECOMMENDED VARIETIES :

Crop	*Age (months)*	*Seed Rate (per acre)*	*Spacing (2 seeds per point)*
Green Gram:			
MI-1	3	20 lb	12″×6″
MI-4	2½	20 lb	12″×6″
Black Gram:			
MI-1	3	20 lb	12″×6″
Type 9	2½	20 lb	12″×6″
Cowpeas:			
Bombay	3	20 lb	18″×6″
Arlington	3	20 lb	18″×6″
MI-35	2½	25 lb	12″×6″

Age of crop is influenced by soil moisture and fertilizer content. Too much rain, over irrigation and excessive fertilizers will delay maturity. On the other hand, too little rain, under-irrigation and inadequate fertilizers will hasten maturity.

TIME OF PLANTING: (*a*) In the dry zone under rainfed conditions plant 3-months varieties in early November and 2½-months varieties in late November in the *maha* season.

In the *yala* season plant only the 2½ months varieties in late March to April.

(*b*) In the dry zone under irrigation planting may be done at any time making allowance for the ripening period to coincide with dry conditions.

(*c*) In the wet zone avoid heavy rainfall areas and plant so that ripening takes place in the dry period. Best times to plant are November and July.

Note: Under irrigated conditions, the land after ploughing and harrowing will have to be thrown into ridges and furrows. Seed is planted on the ridges (which are 4-6 inches high) and the water is let into the furrows. During the first two weeks after planting water is let in every 4 days, and thereafter at 10 days intervals until two weeks before harvest.

Ridges could also be used to advantage in very wet areas to avoid waterlogging.

BASAL FERTILIZER DRESSING:

50 kg / 1 cwt conc. superphosphate
25 kg / ½ cwt muriate of potash
25 kg / ½ cwt ammonium sulphate OR
12½ kg / ¼ cwt urea

The above mixture is applied just prior to planting.

PRE-EMERGENT APPLICATION OF WEEDICIDES:

Two-three days after planting and before the seeds sprout above the ground, spray one of the following weedicides:

(i) Lasso—5 pints in 40 gallons water per acre

OR (ii) Ramrod 65%—4½ lb in 40 gallons water per acre

Note: Cowpeas are sensitive to the above weedicides. Hence Linuron 50% may be used instead.

AGROMYZA FLY CONTROL: Since the Agromyza fly can cause damage to the plants when they are in the two-three leaf stage, a preventive spraying at this time may be advantageous. Use Monocrotophos 60% i.e. Azodrin 60.

TOP-DRESSING WITH NITROGENOUS FERTILIZER: About 45 days after planting give the crop a booster dose of 12.5 kg ($\frac{1}{4}$ cwt) urea per acre if it looks yellow and exhibits other signs of poor growth. Spread the fertilizer between the rows and earth-up. Or in the case of ridges, spread the fertilizer on the side of the ridges and use soil from the furrows to earth-up.

CONTROL LEAF-EATING CATERPILLARS: If leaf-eating caterpillars become a problem, spray with Monocrotophos (Azodrin 60%):

HARVEST

Crop	*Irrigated*	*Rainfed*
Green Gram	1,200 lb	500 lb
Black Gram	1,400 lb	600 lb
MI 35 Cowpea	1,000 lb	400 lb
Other Cowpeas	1,500 lb	700 lb

Cowpea and black gram may be harvested in one picking. Green gram, however, requires three or more picks bacause the pods shatter.

CROP BUDGET: The following crop budget for one acre of green gram may be used as guide for the cultivation of other pulses too:

Inputs	Rs. Cts.
Seed (20 lb @ Rs. 5/-)	100.00
Ploughing, harrowing and ridging by tractor	240.00
Fertilizers (50% subsidy)	150.00
Insecticides	60.00
Weedicide	180.00
Labour (@ Rs. 7/50)	
Land Preparation	15.00
Planting	60.00
Spraying, fertilizer application, additional hand-weeding & earthing-up	75.00
Harvesting & Processing	120.00
Total Cost of Production	1,000.00

Income:

800 lb of seed (under irrigation) @ Rs. 3/- per lb	2,400.00
Profit:	1,400.00
500 lb of seed (under rainfed conditions) @ Rs. 3/- per lb	1,500.00
Profit:	500.00

Soya Bean *Glycine soja*

This is a relatively new crop which was introduced because of its very high protein content—40 percent in contrast to 20 - 25% in the pulses. Because of its very high protein content, soya bean has a very high nitrogen requirement. This is cheaply supplied by treating the seed with a bacterial seed inoculant prior to planting. Once the bacteria are established in the roots of the plant they begin to take up nitrogen from the free air and convert it into forms that are readily assimilable by the crop.

TIME OF PLANTING: In the *maha* season planting in *chenas* or on regularly cropped highland is done in October - November after the first heavy rains are over.

In the *yala* season, soya beans may be planted on the highland under irrigation. A total of 10 irrigations will be required at 3 - 4 day intervals up to one month and at 8 - 10 days thereafter up to two weeks before harvest.

Planting may also be done in paddy fields that do not have enough water to support a rice crop, but sufficient water to take 4 or 5 light irrigations at 10 day intervals for soya bean.

RECOMMENDED VARIETIES :

Davis	—	90 days, large, cream seed
Bossier	—	90 days, medium, cream seed
Hardie	—	90 days, small, cream seed
Improved Pelican	—	90 days, large, cream seed
SJ 2	—	90 days, small, cream seed
P B I	—	80 days, very small, cream seed

60 lb of seed are required to plant one acre at a spacing of 18″ between rows, the seeds being dibbled to stand 2 - 3 inches in the rows. The land should be ploughed, harrowed and thrown into slightly raised ridges. The tops of the ridges should be 18 inches apart. The seeds are dibbled on the tops of the ridges.

SEED INOCULATION: The seed inoculant e.g. Nitragin 'S', is a powder. This powder (for the correct quantity to apply see manufacturer's instructions) is sprinkled over the seed after the seed has been moistened, and the seed mixed thoroughly till the powder adheres to the seed coat.

In the alternative mix the powder in water to form a slurry and then pour the slurry on to the seed, mixing thoroughly till all the seeds are coated.

Allow the seeds to dry in the shade for 15 - 20 minutes before planting. Be sure to plant in moist soil (and not dry soil) so that the bacterial culture is immediately activated.

FERTILIZER APPLICATION: If soyabean is planted in *chenas* after a chilli crop which has been given a complete fertilizer mixture, or if it is planted in paddy fields after the previous rice crop has been completely 'fertilized', then no further fertilizer applications are necessary.

On the other hand, if soyabean is planted in regularly cropped highland, or in old *chenas*, or paddy fields that have not been previously manured (with fertilizers), then a basal dressing is essential viz., 50 kg (1 cwt) conc. superphosphate and 25 kg ($\frac{1}{2}$ cwt) muriate of potash per acre.

WEED CONTROL: Use chemical weedicides as recommended for weed control in green gram, black gram and cowpeas, or manually weed the crop twice — 3 weeks and 6 weeks after planting.

PEST CONTROL: Agromyza flies and leaf-eating caterpillars may be controlled as recommended for green gram.

YIELDS: Yields will depend on soil fertility and availability of water. 1,000 lb is the average yield per acre. With assured irrigation and good management this yield may be doubled.

NOTE 1: Soyabean seed has a low viability — up to 3 months in storage. To ensure maximum germination use seed that is not more than 3 months old after harvest.

NOTE 2: The hare can be a nuisance, eating young plants up to four weeks old. In small plots control is effected by enclosing the plots with cadjan fences. This is not economical in large plantations, but then in large plantations the damage is negligible, being confined to the periphery cf the crop.

NOTE 3: If the seed is not inoculated prior to planting the following top-dressings of urea must be applied and lightly worked into the soil:

25 kg 3 weeks after planting,
25 kg 6 weeks after planting,
50 kg when 50 percent of the crop is in flower.

Groundnut* *Arachis hypogea*

TIME OF PLANTING: This crop is planted in late September before the October rains for the *maha* season, or March/April for the *yala* season under irrigation. The frequency of irrigation is once in 4 days during the first three weeks and 10 - 12 days thereafter. Irrigation must cease when the crop is 90 days old to permit the pods to mature and dry.

RECOMMENDED VARIETIES: The varieties given below are erect-growing bushy types which take 110 days to mature: Red Spanish, Uganda Erect, A20, A92, MI-1 and SAA6. The highest yielders are MI-1 and SAA6. MI-1 has a big seed and SAA6 contains three seeds per pod instead of two.

ENSURE GOOD GERMINATION: To ensure good germination plant shelled seed 2 - 3 days after shelling and not later. Otherwise, viability deteriorates quickly till one week after shelling the germination percentage is not more than 50 percent.

If you are unable to shell the pods quickly, plant them unshelled, but to overcome delayed germination and uneven germination see that they are soaked overnight in water and dried in the shade for 1 - 2 hours before planting.

You will require 120 - 130 lb of unshelled pods or 80 - 90 lb of shelled seed to plant one acre. The better practice, however, is to plant shelled seed because this way you are able to select only the plump, well-filled seed for sowing and you are able to disinfect the seed to guard against fungus diseases causing seed rot and collar rot.

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* Groundnut is normally classified as an oil crop, but as it is not used for this purpose in this country it is included under pulses where the seeds are edible.

Only plump seeds should be selected for planting because the poorly-filled kernels rarely germinate and even if they do the plants are not vigorous and quickly succumb to drought.

Fungus diseases which become active both before and after the emergence of the plants can cause seedling mortality up to 40 percent. It is advisable, therefore, to disinfect the seed with an organo-mercurial seed dressing like Ceresan or a fungicidal solution like Perenox or Captan, prior to planting.

PLANT ON RIDGES: Once the land has been ploughed, harrowed and 'fertilized' with 50 kg (1 cwt) concentrated superphosphate, 25 kg (½ cwt) muriate of potash and 12.5 kg (¼ cwt) urea per acre, it is thrown into ridges 6-9 inches high and 2ft apart from top of ridge to top of ridge. Seed is dibbled 4 inches apart on top of the ridges, placing one seed at each point.

WEEDING, TOP-DRESSING & EARTHING-UP: If you intend using a weedicide it should be sprayed immediately after planting. In the alternative the crop is manually weeded 3 weeks after planting, and then top dressed with 12.5 kg (¼ cwt) urea. The fertilizer is applied on the sides of the ridges and covered with soil scraped from the furrows.

These operations must not be delayed beyond three weeks, because in the fourth week the crop begins to flower — the flowers are borne on long stalks or gynophores which push themselves into the soil to form the underground pods. Since, the gynophores are delicate and easily damaged all cultural operations must be completed by the end of the third week.

PEST & DISEASE CONTROL: Groundnut is relatively free of pests and diseases. The cercospera fungus often causes brown spots to appear on the leaves, but unless these spots enlarge so as to kill the leaves no action need be taken. If on account of the fungus, however, the foliage begins to die then use a copper fungicide to spray the crop. If leaf-eating caterpillars become troublesome spray with Sevin, Tamaron or Monitor according to manufacturer's instructions.

HARVESTING: In 110 days when the crop is mature whole plants are pulled out and the pods separated and dried. Under rainfed conditions average yields range from 1,000 - 1,500 lb of seed per acre. Higher yields up to 2,500 lb may be obtained with controlled irrigation.

STORAGE: Be sure that groundnut is stored under the correct moisture conditions to avoid the problem of aflatoxin. If the seed is not dried sufficiently before storage *aspergillus flavus* a common fungus or mould develops rapidly. This fungus invades the kernels and causes toxic compounds to develop. These toxins have been given the umbrella term "aflatoxin".

The presence of aflatoxin in groundnut has been known to cause the death of several kinds of livestock. And although there is no evidence as yet to prove that man has suffered ill-effects from aflatoxin poisoning, it has been suggested that aflatoxin could be implicated in the development of primary liver carcinoma.

The moisture content of groundnut soon after harvest varies from 9 - 16%. The critical level is 9% and unless the moisture in the kernels is dried out to less than 9% *soon after harvest* aflatoxin can be formed. Subsequent storage conditions too should be such that the moisture level is kept continuously below 9%. If it should go up aflatoxin will develop and no amount of subsequent drying will get rid of it.

Quick-drying and dry storage conditions are therefore absolutely essential to ensure an aflatoxin - free product, which will be acceptable in all markets, but especially international markets since tests have been developed for detecting the presence of aflatoxin and the quantitative assessment of toxic material. Potential exporters of groundnut therefore must pay particular attention to the quick drying and storage of their harvested product. Otherwise all the good work done in producing a bumper crop would be brought to nought.

PART III

VEGETABLES

Potato — Cabbage — Lettuce — Leek — Peas—Beans — Brinjal, Capcicum and Tomato — *Bandakka* — Gourds, Cucumber and Pumpkin — Local Leaf Vegetables — Ash Plantain — Jak — Breadfruit.

VEGETABLES

The old-time separation of vegetables into two distinct classes viz., up-country vegetables and low-country vegetables no longer holds good because, except for leeks which are grown only in the Nuwara Eliya region, all the other vegetables may be cultivated successfully today in the low and mid-country, so long as there is water for this purpose.

Yet, despite this universality there is some degree of regional specialization. In the wet up-country for instance, i.e. the Nuwara Eliya District, farmers concentrate on the cultivation of potato, cabbage, beet, carrot, leek, radish and also grow smaller areas of cauliflower, lettuce, peas and bell-peppers.

On the other hand, in the low-country farmers specialize in the cultivation of brinjal, bandakka (okra), cowpeas, gourds, tomatoes, knol khol, capsicums or curry chillies and the local leafy vegetables, although there is some cultivation of potato, cabbage, beet, radish and carrot too in irrigated areas like the Jaffna Peninsula.

In the Badulla District, however, which is the dry up-country in the rain shadow of the S. W. Monsoon, farmers combine the cultivation of up-country and low-country vegetables. Beans are their speciality, but they also grow potato, capsicum chillies, tomatoes and brinjals.

Potato *Solanum tuberosum*

Ever since the government ban on the import of consumption potatoes there has been a remarkable outburst of local production which is limited only by the scarcity of seed potato. Today there are 8,000 acres of which 3,000 are in the Nuwara Eliya District, 3,000 in the Badulla District and 2,000 in the Jaffna District. The techniques of cultivation are the same in all three areas except for variations in the time of planting and in the fertilizer mixture.

VARIETIES: The Department of Agriculture issues several tested varieties, some of which are imported and others that are raised on government farms. Some of the older varieties which are still popular are Ginike and Arka. Arka, in particular, is very resistant to the 'late blight' disease. Ginike has an excellent quality. But it is very likely that these varieties will soon be replaced by Desiree, Baraka, Fanal, Mirka, Nordstern and Cardinal. Desiree is excellent for making "chips" since it gives a light yellow, uniformly coloured "chip" of good texture. Baraka, Fanal and Cardinal are good cooking varieties with a floury texture.

SUITABLE PLANTING TIMES: Although the Nuwara Eliya District is suitable for potato cultivation throughout the year, the following points should be noted: (i) avoid planting from December to January in frost-affected areas, and (ii) from June-July in wind-affected areas. The best time for planting is February- March. All planting is done on highland.

In the Udukinda and Badulla District potatoes are planted in paddy fields during the *yala* season i.e., from May to July, and on the highland between November and January during the *maha* season.

In the Jaffna District only one season of potato cultivation is taken, because this is the only time soil temperatures are low enough to permit tuber formation. The best time to plant is between mid-November and the end of December.

LAND PREPARATION AND MANURING: In very acid soils in the Nuwara Eliya and Badulla Districts it is advisable to add 15 cwt of dolomitic limestone per acre every 3 years. This is not necessary in the Jaffna Peninsula where the soil is not acidic in reaction. All soils however will benefit from a seasonal application of about 5 tons of cattle manure per acre. The land is ploughed and harrowed in the usual way and thrown into ridges about 6 inches high and 1½ feet apart. Fertilizers are added to the intervening furrows just prior to planting. Here are the per acre recommendations for the three different regions:

NUWARA ELIYA DISTRICT

BLACK SOILS:

75kg (1½ cwt) Urea

250 kg (5 cwt) Conc. Superphosphate

50 kg (1 cwt) Muriate of potash

JUNGLE SOILS:

100 kg (2 cwt) Urea
300 kg (6 cwt) Conc. Superphosphate
50 kg (1 cwt) Muriate of potash

UDUKINDA AND BADULLA DISTRICT

PADDY FIELDS:

75 kg ($1\frac{1}{2}$ cwt) Urea
225 kg ($4\frac{1}{2}$ cwt) Conc. Superphosphate
50 kg (1 cwt) Muriate of potash

PATANAS:

112.5 kg ($2\frac{1}{4}$ cwt) Urea
300 kg (6 cwt) Conc. Superphosphate
50 kg (1 cwt) Muriate of potash

JAFFNA DISTRICT AND DRY ZONE

JAFFNA:

62.5 kg ($1\frac{1}{4}$ cwt) Urea
100 kg (2 cwt) Conc. Superphosphate
125 kg ($2\frac{1}{2}$ cwt) Muriate of potash

DRY ZONE:

100 kg (2 cwt) Urea
200 kg (4 cwt) Conc. Superphosphate
50 kg (1 cwt) Muriate of potash

After sprinkling the fertilizers in the furrows, they are mixed with soil thoroughly. Now place the potatoes in the furrows 10 - 12 inches apart and cover them with about 3 inches of soil. About 18 cwt of seed potato are required to plant an acre.

Potatoes must be sprouted prior to planting. Each whole potato should have about 4 thick sprouts. Whole potatoes or cut-pieces may be planted, but to prevent the cut pieces from rotting in the soil, they should be first dipped in a fungicidal solution (e.g. Antracol, Daconil, Lonacal M, Dithane M 35, Dithane M 22, Magna

Curit or Manzanate) prepared at the rate of 1 oz in 3 gl. water and allowed to form a callus before planting. Cut-pieces should not be less than 1½ oz in weight.

AFTER CARE: When the potato plants are 3 - 4 inches, weed the crop and earth up the plants, taking the soil from the ridges and filling up the furrows. Repeat this process two weeks later. By now the original ridges should be furrows and the original furrows should be ridges.

In dry periods irrigation is necessary. Water is let in to about half the depth of the furrows so as to permit aeration at the top of the ridges where the tubers are developing. Do not splash water from the furrows on to the crop as this will encourage 'late-blight' infection.

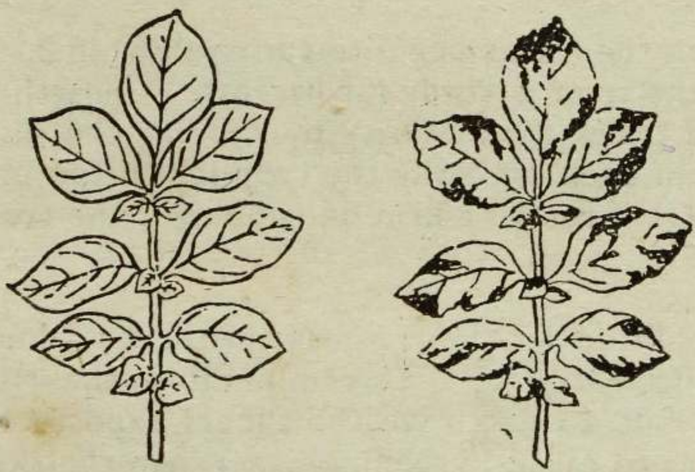
Pests, and specially diseases, are a serious problem. Constant vigilance and timely action are therefore necessary to control them. 'Late-blight' is the most serious disease. (Fig: 3.1) Brown to black patches form on the leaves, enlarging rapidly to give a blighted appearance. Infected tubers develop purplish-brown discolourations on the skin followed by a dry rot. Give the crop a preventive spraying 4 weeks after planting, and in cloudy weather follow this up with further sprayings at 10 day intervals. Antracol, Dithane M45, Manzate B, Daconil, Dithane 32, Lonacol M and Magna Curit are effective pesticides. Follow manufacturer's instructions.

"BACTERIAL WILT": Although not as serious as "late-blight", this disease is beginning to assume problematic proportions in certain areas (e.g. Nuwara Eliya) when land congestion has compelled farmers to grow the potato crop over and over again in the same piece of land without rotating it with other crops. Consequently, the bacteria (for which no effective control measure has as yet been found) build up and spread in the soil causing more and more casualties every season.

The reason why farmers continue potato cultivation on the same land without a break is undoubtedly the profitability of this crop. A recent survey (1975) carried out by the Agricultural Economics Division of the Department of Agriculture showed that potato cultivated in the Nuwara Eliya District earned a profit of Rs. 76/- per field day in comparison to Rs. 29/- in cabbage, Rs. 24/- in beet, Rs. 17/- in radish, Rs. 13/- in carrot and Rs. 12/- in leek.

But this practice cannot be condoled. If the "bacterial-wilt" disease is to be kept under control in the interest of maintaining the profitability of potato, then strict rotation must be enforced. This means that neither potato nor specifically related crops like brinjal, chilli, and tobacco should be grown in the same piece of land for two years or four seasons. In the "resting" period other crops like beans, peas, lettuce, leeks, carrots and beets may be grown since the bacteria have no affinity for them and as such will not multiply themselves. Incidentally, any diseased plants that are noticed in a crop should be promptly uprooted and buried or burnt. Symptoms of disease are drooping leaves and wilted plants. If the stem is cut a white exudate may be noticed.

VIRUS DISEASES: The most common is the 'leaf-roll' disease, (Fig. 3.2) which causes the leaves to roll upwards and inwards. "Leaf-mosaic" virus causes the leaves to take on a yellow mottled appearance. The plants also become stunted and distorted. As there is no chemical control measure for these virus diseases, be sure to spot the diseased plants and destroy them in time.



Healthy potato leaf *Potato leaf affected by "late blight"*

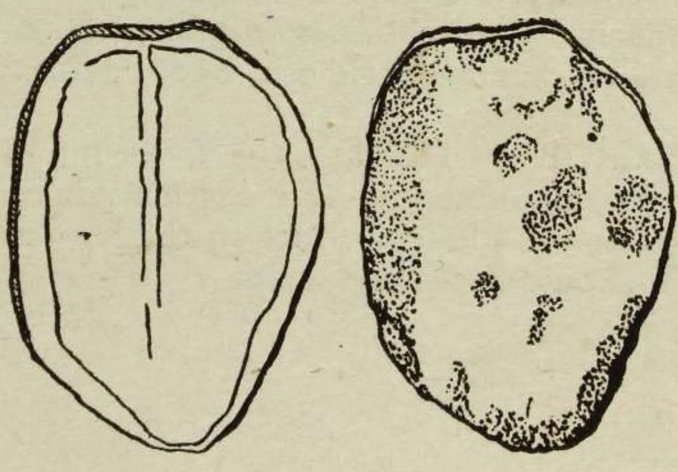


Fig. 3.1

Cross-Section of healthy potato tuber *Cross-Section of tuber affected by "late blight"*

CUT-WORMS are a menace in the young days of the crop. They live in the soil and come out to feed on the stems and leaves, often 'cutting' the young plants at the base. Protective spraying 4 weeks after planting or even earlier is the only solution. The spray solution should be directed to the soil surface between the plants. Use Methamidiphos (Tamaron or Monitor) in accordance with the manufacturer's instructions.

Fig. 3·2

Potato leaf showing symptoms of leaf-roll

TUBER MOTHS are also a nuisance. Their larvae eat the leaves and riddle the tubers in the field. They also damage tubers kept in storage for the next season's planting. Use Carbaryl 85% S. P. (Sevin) for field use at fortnightly intervals if necessary and 4% Malathion dust (2 - 3 lb per 100 lb of tubers) in the store.

HARVESTING: When the leaves begin to turn yellow in 3 - 4 months, it is a sign that the crop is ready for harvest. Unearth a few tubers at random and check for maturity by rubbing the skin with the thumb. If the skin peels off easily the crop is still too immature. Only when the skin remains firm on rubbing is the crop ready for harvest.

After the tubers are lifted let them remain in the field long enough to permit superficial drying. This minimises the risk of "rotting" in storage. But do not leave the tubers exposed to the sunlight for too long as to cause "greening". When the skin takes on a green colour the potato becomes unpalatable. In the field too be sure to have the potatoes covered at all times with soil and not exposed to sunlight to prevent "greening". If storing is necessary it should be done in a well ventilated room. When properly stored potatoes will keep up to 3 months without sprouting. The average yield is 5 - 6 tons per acre.

CROP BUDGET: The following crop budget taken from a survey conducted by the Agricultural Economic Division of the Department of Agriculture in the Nuwara Eliya District in August, 1976 should serve as a guide.

Inputs	*Rate*	*Cost*		*Cost as Percentage of Total*
1. Seed Potato				
Planting Material	18.1 cwt @ 246.40	4,459.84		
Transport		80.00		
Labour	6.5 Units @ 7.50	48.75		
Other expenses		8.74	4,597.33	46.02
2. Land Preparation				
Labour	44.13 Units @ 7.50	330.98		
Other expenses		32.51	363.49	3.04
3. Preparation of Ridges & Furrows				
Labour	14.26 Units @ 7.50	106.95		
Other expenses		17.74	124.69	1.25
4. Planting				
Labour	12.02 Units @ 7.50	90.13		
Other expenses		12.63	102.78	1.03
5. Earthing Up & Weeding				
Labour	36.81 Units @ 7.50	376.08		
Other expenses		15.71	291.79	2.92
6. Control of Pests & Diseases				
Labour	25.37 Units @ 7.50	190.28		
Insecticides	70 oz @ 3.28	229.60		
Fungicides	22 lb @ 22.00	484.00		
Other expenses		24.26	928.14	9.29

7. Application of Chemical Fertilizer				
Labour	33.98 Units @ 7.50	254.85		
Fertilizer	16 cwt @ 43.30	692.80		
Transport		80.00		
Other expenses		19.40	1,047.05	10.48
8. Application of Organic Manure				
Labour	16.08 Units @ 7.50	120.60		
Manure	6 Lorry loads @ 250/-	1,500.00		
Other expenses		9.70	1,630.30	16.32
9. Harvesting				
Labour	22.34 Units @ 7.50	167.55		
Other expenses		15.10	182.65	1.83
10. Grading				
Labour	9.80 Units @ 7.50	73.50		
Other expenses		15.10	88.60	0.89
11. Marketing				
Labour	13.56 Units @ 7.50	101.70		
Other expenses		18.18	120.88	1.21
12. Watching (Guarding the crop)				
Labour	68.31 Units @ 7.50	512.33	512.33	5.13
	Total cost	Rs.	9.990.03	

INCOME :

AVERAGE YIELD :	106 CWT PER ACRE
AVERAGE SELLING PRICE :	Rs. 140 PER CWT
AVERAGE INCOME PER ACRE :	Rs. 14,840
AVERAGE PROFIT PER ACRE :	Rs. 4,850.

Cabbage *Brassica oleracea*

Cabbage was once thought to be a purely up-country vegetable. Only in the cool climate of the hills was it expected to develop a "head", while running to leaf in other parts of the country experiencing hotter climates. But thanks to the progressive advance of science this myth has been exploded, and today we have farmers cultivating cabbage successfully from Kankesanthurai to Hambantota, irrespective of the climate, so long as there is adequate water.

VARIETIES: This revolutionary change was brought about with the introduction of the Japanese Hybria Cabbage. Particularly the KY Cabbage. This 3 months variety is extremely tolerant of high temperatures and has been grown successfully even in the dry zone. The other hybrids are AS and NS Cabbage (4 - 4½ months) and SD Cabbage (5 months). But these three varieties unlike KY are recommended exclusively for the up-country. Along with KY they give heads ranging from 4 - 8 lb, and a marketable crop of about 150 - 160 cwt per acre. These hybrids are now being challenged by four new hybrids viz., Hercules (4 months), Big Cropper (3½ months), Leo 80 (3½ months) and Atlas (3½ months).

There are two other varieties that merit consideration — at least from the home-gardener's point of view since they give smaller heads and cost much less to purchase as seed. One of these is an introduction called Takai Special (3 - 3½ months), which is recommended for the up-country above 3,000 ft. The other variety is *Lankagova*: it also takes 3 - 3½ months but the heads are small (about 1 lb each). This variety must be cultivated below 3,000 ft since at the higher altitudes it flowers and produces seed instead of producing heads.

NURSERY: No matter what the variety, the cultivation procedure is the same. Seeds are first planted in a nursery, so that the young plants which are very delicate can be better protected and hardened for the field.

A nursery area of 150 sq. ft.— that is, a bed 30 ft long by 5 ft wide, should be quite adequate to raise all the seedlings necessary to plant an acre. Six ounces of seed is the required quantity. Seed should be sown thinly in drills about 2 inches apart and covered with a half-inch layer of soil pressed down.

Frequent watering is necessary in the early stages to induce rapid germination, but once the plants appear above ground, the quantity of water should be reduced — the aim being to keep the soil moist at all times but never too wet.

Seedlings should be ready for transplanting in 4 weeks. Only vigorous plants with six leaves each should be transplanted 1½ to 2 ft apart, the closer spacing being used for short-aged varieties like KY, *Lankagova* and Takai Special.

MANURING: Partly-rotted cattle dung is the best manure for cabbage. You will need one-basket (20 lb) per 20 sq. ft. of nursery bed, and 5 - 10 tons per acre, which is the equivalent of half-basket for each planting hole.

Fertilizers are also necessary to produce high yields. The "Vegetable Fertilizer Mixture" marketed by the Sri Lanka Fertilizer Corporation is quite adequate for this purpose.

In the alternative you can prepare your own ration viz., 50 kg (1 cwt) urea, 225 kg (4½ cwt) conc. superphosphate and 50 kg (1 cwt) muriate of potash per acre as a basal-dressing followed by a top-dressing of 100 kg (2 cwt) urea 4-5 weeks after transplanting.

PESTS & DISEASES: Cut worms and caterpillars can cause serious damage unless kept under control by regular spraying from the time the plants are two weeks old in the nursery to two weeks before harvesting. Methamidiphos (Tamaron, Monitor) or Quinalphos (Bayrusil) are quite effective. In the nursery the spray should be directed on the plants to control caterpillars and the soil around the plants to control cut worms. But in the field the spray is directed only on to the leaves as the cut worm is not a problem at this stage.

'Club-root' is a fungus disease. As the fungus favours very acid soils like those found in the Nuwara Eliya area, such soils should be treated with crushed dolomitic limestone, which is spread on the land (5 lb per 100 sq. ft.) at the time of preparatory tillage. This discourages the fungus, which otherwise attacks the root causing it to swell in the shape of a club. Growth is thus affected and the plant remains stunted or dies.

CRACKED HEADS: Cracked or split heads are caused as a result of unsettled moisture conditions, for instance, when a sudden drought follows a wet spell. Wherever possible, therefore, irrigate the crop or water liberally during dry periods following rain to reduce the percentage of "crackers". A typical sign of water scarcity is when the leaves become dark green and feel leathery to the touch. When there is enough water the leaves are light green in colour and brittle.

Carrot, Beet and Radish

Daucus carota, Beta vulgaris & Raphanus sativus

These crops can be cultivated separately or as a mixture in raised beds 4 - 6 inches high and 4 ft wide. These beds should be manured with well rotted cattle dung and fertilizers. If the soils are very acid dolomitic limestone (crushed) should also be added (15 cwt per acre) but at least two weeks before the application of fertilizers to prevent harmful chemical reactions.

Remember that beet and carrot do not favour freshly matured beds since the roots tend to fork and produce mis-shapen specimens. To guard against this, the soil should be well dug over and manured with well rotted cattle dung at least one month before planting.

Organic manure must be supplemented with fertilizer. The Corporation Fertilizer Mixture for root crops is popularly used. If you want to prepare your own, mix 100 kg urea (2 cwt), 250 kg conc. superphosphate (5 cwt) and 62.5 kg muriate of potash ($\frac{3}{4}$ cwt) and apply it as a basal dressing per acre between the dibbled rows of seed.

The usual practice in the up-country is to dibble alternate rows of carrot and beet root, spaced 9 - 12 inches apart with radish as a single border row around the edge of each bed. Seed is dibbled closely and later thinned out so that the seedlings are 3 - 4 inches apart for carrot and beet and 9 inches apart for radish.

Keep the soil between the rows repeatedly forked to control weeds, and apply top-dressings of a complete fertilizer mixture. If you are using your own ration apply 100 kg (2 cwt) urea and 62.5 kg ($\frac{3}{4}$ cwt) muriate of potash per arce 4 - 6 weeks after planting. Fertilizer should be spread in a band a little away from the base of the plants, lightly forked into the soil and thoroughly watered immediately after if there is no rain.

Radish, if it is the "Ball" variety, may be harvested in 45-60 days; beet may be lifted from 60 - 70 days when they are 2 - 3 inches in diameter up to 3 months when they are fully grown. Carrot takes 3 months.

VARIETIES: Nantes Half Long, Cape Market and Top Weight are popular carrot varieties. Among the beets Crimson Globe, Detroit Dark Red and Quick Globe are favourites. The Japanese Ball Radish—a large round variety—is the prime choice, although a long root called "Tropical" or *Birulu* is preferred in the Galle District.

The seed rates per acre are 6 lb for carrot and beet, 4 - 5 lb for radish. Average yields are 150 cwt per acre for beet, 130 cwt for carrot and 95 - 100 cwt. for radish.

CROP BUDGET FOR CABBAGE, CARROT, BEET, LEEK AND RADISH

Operation	Operational Costs				
	Carrot	*Beet*	*Cabbage*	*Leek*	*Radish*
1. Seed ...	227.00	205.95	129.76	128.76	108.80
2. Land Preparation ...	283.83	490.48	234.75	348.95	179.61
3. Planting ...	105.67	215.83	139.22	266.38	74.68
4. Weed Control ...	262.92	206.10	133.76	152.32	90.42
5. Fertilizers & application ...	1,948.70	2,371.58	802.50	2,386.20	343.99
6. Pesticides & Disease Control	260.67	414.98	230.16	381.32	80.64
7. Pesticides & Pest control ...	136.67	224.33	237.18	184.73	90.23
8. Harvesting ...	131.84	115.23	99.26	124.72	80.64
9. Processing & Grading ...	29.17	64.29	38.18	50.45	—
10. Transport & ... Marketing ...	6.25	—	36.50	3.02	—
TOTAL ...	3,392.72	4,303.77	2,081.37	4,085.55	1,049.15
Labour Units ...	153.5	192.3	118.7	194.3	61.4
Average Yield (Cwt)	131.13	150.97	155.39	140.05	97.27
Average Price per lb (Cts) ...	0.36	0.37	0.27	0.40	0.17
Total Income (Rs.)	5,298.12	6,253.37	4,699.35	6,276.40	1,852.60

(*Source*: Agricultural Economics Division, Department of Agriculture)

Lettuce *Letuca sativa*

Lettuce is best grown in the wet up-country. At lower elevations it tends to run to seed rapidly at the expense of leaf growth. The current favourites are Grand Rapids, Great Lakes and Mignonette. These are looseleaf types in contrast to the Cos Lettuces which have a more compact head of tender leaves resembling a longish head of cabbage.

Like, cabbage, lettuce requires 6 ounces of seed to plant an acre. It may be planted in a nursery and transplanted later to the field, but the usual practice is to seed direct on raised beds in shallow drills 8 - 12 inches apart and the seedlings thinned to the same distance apart in the rows. If transplanted the seedlings should have developed their second pair of leaves. Sowing or transplanting should be made at weekly intervals to ensure a succession of plants for the market. In the absence of rain, beds should be watered liberally to promote rapid and unchecked growth.

Both cattle manure and fertilizers are important. The same fertilizer mixture used for cabbage may be applied here; lettuce will be ready for lifting in 3 - 4 weeks. You can get 2,000 lb of leaf per acre.

Leek *Allium Porrum*

Leek is the staple vegetable of the Nuwara Eliya market gardener. It is important to him because it is the *only* vegetable that can be grown all the year round in the up-country above 5,000 ft. This is because it is hardy enough to withstand the heavy rains and strong winds experienced in the area in the months of May, June and July. In fact, leeks thrive on copious quantities of water and organic matter. This is why they do so well on the black soils found in the Nuwara Eliya region.

The choice variety of market gardeners is "Large Long Summer." The seed rate is 4 lb per acre. Since it is a long-aged crop of 5 - 6 months, successional sowings are done in order to obtain a regular supply for the market. Seed is first sown in a nursery and the young seedlings are planted out in trenches when they are big enough to handle.

Trench planting is the accepted practice as it is the most convenient way to "earth-up" the stems of the plant as they elongate. This must be done to keep the stalks white and edible. If the stalks are exposed to the sun they will become green and develop a bitter taste. The average yield per acre is about 140 cwt.

Leeks may be given the same basal fertilizer mixture prescribed for cabbage and lettuce. The top-dressings, however, should be given as follows: 50 kg (1 cwt) of urea at 6 weeks after transplanting and 50 kg (1 cwt) again 3 months after transplanting.

Cauliflower *Brassica oleracea botrytis*

Cauliflower is generally cultivated between 4,000 and 6,000 ft in the up-country. The recommended variety is "Early Phenomenal." Cauliflower is also cultivated in the Jaffna Peninsula but the variety suited to the area is the "Early Patna."

Cauliflower is a delicate plant and requires extreme care and attention in the initial stages of growth. For this reason the nursery technique will be discussed in some detail.

A mixture of sandy soil and well rotted, powdered cattle manure or leaf mould is used in the nursery bed. The seed (6 oz. to the acre) is mixed with ash to ensure uniform sowing and sprinkled on the surface. It is then covered with a thin layer of soil and pressed down with a plank. The plants should be watered morning and evening.

The nursery should be covered to protect the plants. But the cover should be removed from time to time for short periods to accustom the plants to the sun. When the seedlings are 6 - 8 inches high they are transplanted in raised beds at a spacing of 1½ feet.

Cauliflower requires lime in the soil (same as cabbage), an abundance of cattle manure and a complete fertilizer mixture to maintain a steady, rapid growth and the formation of good flower heads. As an alternative to prepared mixtures on the market you could mix your own as follows: 150 kg urea, 250 kg conc. superphosphate and 50 kg muriate of potash as a basal dressing, followed by a top-dressing of 50 kg per acre 6 weeks after transplanting.

When the flower heads or curds begin to form tie the leaves over them to shut out the light. By this blanching process, white heads, as demanded by the market, are produced. If this is not done the curds will turn a sickly yellow colour, and this detracts from their market value. Good heads will form in 9 - 12 weeks. They should be cut off before they begin to spread badly or develop blemishes.

Peas *Pisum sativum*

Green peas are grown exclusively in the Nuwara Eliya area because they are a cool season crop. "Fill Basket" and "Senator" are popular varieties.* About 80 lb of seed are required to plant an acre. Seeds are dibbled in rows 18 inches apart and the seedlings thinned out to stand about 4 inches apart. Since these are climbing varieties they must be given some form of support—twigged branches are good enough. Peas should be given the same manure and fertilizer rations as beans.

Beans *Phaseolus vulgaris*

Beans offer quick returns to the producer. Bush types are ready for picking in 45 - 50 days. Pole types take 15 - 20 days longer. Popular bush types are "Top Crop", "Wade" and "Cherokee Wax." The first two are green beans (5 - 6 inches long) and the third variety is a butter bean. Among the climbing types "Kentucky Wonder" is still the favourite. It produces 7 - 8 inch long beans. There are two types, green and yellow. A more recent variety is a German introduction called *Lanka Nil*. This is a green bean.

The seed rate for bush beans is 30 - 40 lb per acre. Climbing types require double this quantity. Bush varieties are spaced 2 - $2\frac{1}{4}$ feet between rows and 4 - 6 inches within rows. Pole varieties are spaced 3 ft apart with 4 plants to each pole or other form of support. Alternatively, they may be grown in rows 3 ft apart with the plants spaced 9 inches apart in the rows and trained to grow up a trellis 6 feet high.

Bush beans are picked 3 - 4 times and pole beans 5 - 7 times. The interval between picks will vary from 5 - 10 days. Since absence of fibre is an important factor in the quality of the beans, the best time to pick them is when the pod in the thickness of a pencil, or perhaps a little thicker.

To produce high yields fertilizers are required in addition to cattle manure. You could use any of the appropriate vegetable mixtures available in the local market, or you could mix your own rations as follows: 25 kg ($\frac{1}{2}$ cwt) urea, 175 kg ($2\frac{1}{2}$ cwt) conc. superphosphate and 50 kg (1 cwt) of muriate of potash per acre. This should be applied as a basal dressing. The same mixture could also be used in the cultivation of peas.

BEAN FLY CONTROL: Bean flies are a serious pest. They are particularly active in the hot, wet, low-country and the mid-country. In the up-country the cold climate acts as a deterrent.

This is why bean cultivation is particularly recommended for the Welimada - Bandarawela area where the climate is cold enough to discourage this pest, but not cold enough to cramp the growth of the crop.

Flies lay their eggs on the leaves, and the larvae or maggots which hatch out bore into the leaf stalks causing the plants to turn yellow and die. Later on these maggots pupate at the junction of the leaf stalks with the main stem, and even at the bottom of the main stem in the case of young plants giving them an unmistakable swollen appearance.

Since flies can lay their eggs at anytime during the life of the bean crop, the secret of effective control is to start spraying when the plants are 7 - 10 days old, when they have just put out their first two real leaves. Do not mistake the cotyledons for these two leaves. Spraying will have to be continued at 14-day intervals up to the time of pod formation. Dimetheoate 40% E. C. (Rogor 40) is an effective insecticide.

Cowpea *Vigna sinensis*

In the low-country where the bean fly is active it is more advantageous to cultivate vegetable cowpeas which are resistant to bean-fly attack. These cowpeas are just as nourishing. In fact they contain more protein than beans, although their fat and mineral content is a little lower.

Among the climbing types the two most popular are the Department of Agriculture selections, namely *Hawari-me* and *Polon-me*. Both these varieties crop freely and choice is merely a matter of personal preference as to whether you fancy a short fleshy cowpea like *Polon-me* or the long thin pods of *Hawari-me*. Since these varieties are climbers they must be provided with some form of support e.g. twigged branches 4 - 5 ft high. The plants are spaced 3 ft apart in the rows and 1 foot apart in the row. Plant two seeds at each point. The seed rate is 20 lb per acre. Cropping commences in two months and will continue for a period of six weeks. Yields are in the region of 2,500 lb per acre. Bean yields are higher, between 3,000 and 4,000 lb to the acre. The same fertilizers recommended for beans may be used here.

"Bush Sitao", an introduction from the Philippines, is an excellent dwarf variety. It is a prolific cropper, starting at about 45 days and going on till it is about 75 days old. The pods are about 8 inches long, fleshy and of excellent quality.

Although this variety can be cultivated in the wet zone, it tends to run to leaf and begins to creep at the expense of pod production. It really thrives in the dry zone where it is now freely available been Padawiya in the North to Hambantota in the South. It has satisfied a long felt need for a tasty and inexpensive protein vegetable in the dry zone. The seed rate is about 20 lb per acre at a spacing of 18 inches by 6 inches, with two plants at each point.

Brinjal (*Solanum melongena*)
Capsicum (*Capsicum grossum*)
Tomato (*Lycopersicuum esculentum*)

Since these three vegetables belong to the same family their method of cultivation is very similar. For instance, they are first sown in a nursery and then transplanted to the field. Four - six ounces of seed are required to plant an acre.

NURSERY: About 50 sq. ft. of nursery is required to sow one ounce of seed. A raised bed 12 ft long by 4 ft wide should be ample. As a precaution against "damping-off" disease caused by certain fungi in the soil, the bed should be sterilized prior to planting by burning trash on the surface. Well rotted cattle manure is then added, preferably in the powdered form and the soil is made up to a fine tilth.

Seeds are sown on the surface in rows 3 - 4 inches apart and covered with a thin layer of fine soil. The nursery should be shaded till the seedlings appear above ground. Then the shade is removed and the soil is kept moist by light watering twice a day, morning and evening.

When the plants are about 2 weeks old, thin them out so that the remaining seedlings have more room to develop as sturdy vigorous plants. Transplanting may be done when the plants are 4-5 weeks old. The usual practice is to 'top' them by breaking off the terminal end a few inches. Topped plants however, do not give higher yields than untopped plants as some people believe. But they do develop a better framework that prevents them from growing into thin and spindly specimens that tend to topple over later.

If well-rotted cattle manure is available a double-handful to each planting hole at the time of transplanting is desirable. Seedlings are transplanted at the following spacing: 3 ft × 3 ft for brinjal, 2 ft × 2 ft for capsicum and 2 ft × 1 ft for tomato. Two seedlings are placed at each point. Transplanted seedlings should be shaded for a few days till well established.

FERTILIZERS: In addition to cattle manure fertilizer is necessary. You could either use the prepared mixtures on the market according to manufacturer's instructions, or prepare your own as follows: 150 kg (3 cwt) urea, 250 kg (5 cwt) conc. superphosphate and 50 kg (1 cwt) muriate of potash. Apply 5 cwt of this mixture per acre to all three vegetables as a basal dressing prior to planting, and follow up with two top-dressings one month and two months after planting, giving the crop 50 kg (1 cwt) per acre at each application in the case of brinjal and capsicum. For tomato just give 50 kg (1 cwt) of urea 6 weeks after transplanting.

TRAINING: In the case of brinjal and capsicum chilli you allow the plants to grow naturally. With tomato, however, it may be necessary to prune and train the plants to grow on stakes. The common - or - garden *goraka thakkali* and the "Wilt-resistant Tomato" may be allowed to grow naturally like brinjal or capsicum. But if you are cultivating the introduced varieties e.g. Marglobe, Eilon and Roma, then it is necessary to prune, stake and train them to get high yields.

The plants as they grow should be allowed to develop only one or two stems. Any branches that subsequently develop in the axils of the leaves should be pinched out. The stems should be tied lightly to upright stakes 4 - 5 ft high. Fruits are usually borne in clusters. About five clusters will be formed on each plant.

HARVESTING: Picking can commence 2½ - 3 months after transplanting and may be continued for 2 - 3 months. In the case of brinjal however, you can extend the life period to 12 months by pruning back the branches and remanuring at the end of the first season. Pruning and remanuring should be done when the plants are 6 months old. This practice, however, is not recommended for commercial production. It is all right in home gardens.

DISEASES: In addition to the similarity in the method of cultivation there is also some similarity in the diseases that plague these varieties. The "bacterial-wilt" disease, for instance, is common to brinjal, tomato and capsicum. It is recognised by the sudden wilting of the leaves, as though the water-supply to the plant has been suddenly cut off. The leaves remain drooping and do not recover, so that ultimately the plant dies.

This disease shows up only sporadically in the brinjal and chilli crop where only a few plants may be affected. But it is very serious with the introduced varieties of tomato viz., Marglobe, Roma and Eilon, which can succumb *en masse*. This is why it is specially recommended that these varieties should be grown only in the cool, dry up-country, where the climate discourages the growth of the bacteria. In wet areas, the alternative is to cultivate the "Wilt-resistant Tomato." This variety is a prolific bearer. Fruits are smaller than those of the introduced salad varieties but they are just as good in quality.

Since there is no chemical control measure for this disease, be careful to inspect your crop regularly and destroy diseased plants as and when they appear.

Apart from "bacterial-wilt" which is common to all three varieties, there are two other diseases that warrant discussion. One is "anthracnose" of capsicum. It is caused by a fungus which first discolours and then rots the fruit in patches. But it can be brought under control by spraying with a copper fungicide. Avoid spraying during rainy spells because the fungicide is then washed off without forming a protective layer on the fruits.

The other disease is " blossom - end - rot " of tomato. In this disease partly mature fruits tend to rot on the plants, the rotting taking place at the bottom end which is farthest away from the stalk. Small watery patches appear and coalesce till the flesh shrinks and almost half the fruit is destroyed.

This disease is peculiar in that it is not caused by either fungus or bacterium. On the contrary it is a physiological disease caused by the interrupted supply of water to the plant: When water is scarce at the time of fruiting the plant withdraws moisture from the end of the fruit thereby causing this disorder. The answer to the problem is to maintain a constant supply of water to the crop, particularly at the time of fruiting.

PESTS: Capsicum and tomato are fortunately free of serious pests. Brinjal, however, is troubled by caterpillars which eat the leaves and bore into the pods. These insects however, can be controlled by spraying any of the following insecticides: Methamidiphos (Tamaron, Monitor), Mathomyl (Lanate), Fenthion (Lebaycid), Fenitrothion (Sumithion), Carbophenothion (Trithion 2E), Fenthoate (Cidial, Elsan, Papthion). Spraying may have to be repeated at fortnightly intervals if the infestation is heavy.

VARIETIES & YIELD: There are some local selections of brinjal: Jaffna Long, Department of Agriculture Purple and the *Lena-Hiri*. These are preferred to any others. In tomato, the introduced varieties Marglobe, Eilon and Roma are recommended for the dry up-country and the low-country dry zone under irrigation.

The "Wilt-Resistant Tomato" is recommended for the wet low and mid-country. As far as capsicum chilli is concerned the introduced Hungarian Yellow Wax is head and shoulders above all other varieties.

On a conservative estimate the yields should be 150 cwt per acre for brinjal and 50 cwt for capsicum and tomato.

Bandakka (Okra) *Hibiscus esculentus*

Local varieties of this vegetable succumb easily to virus disease which causes all the leaves to take on a yellow mosaic pattern. Consequently, the vigour of the plant is affected and yields are poor. Be sure therefore to cultivate only virus-resistant strains. Three such strains are available from the Department of Agriculture, namely MI-5, MI-7 and *Bandakka* VT. The letters MI denote the research station at Maha-Illuppallama where MI-5 and MI-7 were bred, and VT stands for "virus-tolerant." MI-5 and MI-7 start flowering in 1½ - 2 months; VT is an earlier cropper. Since the pods grow remarkably fast, several picks can be taken at very close intervals.

PLANTING & AFTER-CARE: *Bandakka* seeds are large enough to be planted direct in manured holes in the field—the holes being made, like for brinjal, capsicum and tomato seedlings, with a single stroke of the mammoty. Add half a basket of well-rotted cattle manure and some fertilizer. 3 - 4 lb of seed are required to plant one acre.

After two weeks thin the seedlings out to two per hole. Intercultivate frequently to keep the weeds in check and water liberally during dry periods. Look out for catepillars that bore into the pods and keep them under control in the same way prescribed for brinjal borers.

In addition to at least 2 - 3 tons of cattle manure per acre, fertilizer too should be used. You could use the appropriate Corporation Mixture or mix your own as follows: 150 kg (3 cwt) urea, 250 kg (5 cwt) conc. superphosphate, and 50 kg (1 cwt) muriate of potash. Use 5 cwt of this mixture per acre as a basal dressing and top-dress one month later at 50 kg per acre. The average per acre yield is 6,000 lb.

Gourds

Snakegourd *Trichosanthes anguina*, Luffa (*Luffa acutangula*), and Bittergourd *Mormordica Charantia*) are three popular gourds, although they are of very little value nutritionally. Since these gourds are exhaustive feeders, satisfactory crops can only be obtained if the creepers are supplied with liberal quantities of organic manure in the form of 5 tons of cattle manure per acre and supplemented with fertilizers. If you desire to use your own ration, mix 150 kg (3 cwt) urea, 250 kg (5 cwt) conc. superphosphate and 50 kg (1 cwt) of muriate of potash. Apply 250 kg of this as a basal dressing just before or after planting and top-dress with 50 kg of the mixture one month later and again with 50 kg two months after planting.

Planting holes are spaced 4 ft apart as four seeds are sown at each point, and the seedlings later thinned to two per hole. Seed rate for snakegourd and bittergourd is 5 lb per acre and 3 lb for luffa. Plants should be trained to grow on some form of support—a pandal about 7ft high for snakegourd, or a trellis 4 - 5ft high in the case of bittergourd and luffa. Picking can commence in 2½ - 3 months and will continue for 1½ - 2 months. In the case of long snakegourd little stones should be strung to the end of the developing gourds to help them grow straight down instead of curling. Yields are 10,000 - 15,000 lb per acre.

PEST CONTROL: Aulacophora beetles, with orange to orange-red bodies spotted with black, are a serious pests of gourds. They destroy the young leaves by feeding on them. Prompt action should therefore be taken to keep them in check by spraying with any one of these insecticides: Fenitrothion (Sumithion), Metamidiphos (Tamaron, Monitor), Mathomyl (Lannate), Fenthion (Lebaycid), Phenthoate (Cidial, Elsan, Papthion) or Carbophenothion (Trithion 2E). It is not enough to spray the leaves only since the beetles drop off on to the ground underneath and continue their life cycle there. More effective control is obtained if both the leaves and the soil underneath the creepers are sprayed with the insecticide.

The gourd fly is another serious pest, particularly with snakegourd. Flies lay their eggs in the developing fruits, and the maggots that hatch out inside feed on the tender flesh causing it to rot in patches. The full-grown maggots emerge from the fruits and fall on the gourd where they pupate and give rise to a second generation of flies. As the season continues therefore, there is an appreciable build-up of these pests, and unless farmers are prepared to take early precautions to arrest their multiplication a large number of fruits can be destroyed later in the season.

The only sure way to control this pest is to spray the crop as soon as the young fruits start forming, or even earlier in the flowering stage, and to continue this spraying at fortnightly intervals up to two weeks before picking. A mixture of Malathion and molasses has been recommended, but in view of the difficulty to obtain both these products, Dimethoate 40% E.C. (Rogor 40) is suggested as an alternative insecticide. This insecticide does not kill the fly, but at least it destroys the maggots.

Cucumber *Cucumis sativus*

Two pounds of seed are required to plant an acre. Four seeds are planted in each hole and only the two most vigorous seedlings allowed to remain after two weeks. Manuring and fertilizer application are as for gourds.

Plants are allowed to creep along the ground. They start cropping in two months. Beware fruit fly and take steps to control this pest as suggested under "gourds". A marketable crop of 10,000 - 15,000 lb may be expected per acre.

Note : A coarser variety known as kekiri (*cucumis pubescens*) is widely grown. It is used as a cooked vegetable and not as a salad.

Yellow Pumpkin *Cucurbita maxima*

This cucurbit is essentially a *chena* crop of the dry zone. 1 - 1½ lb of seed are required to plant one acre, and the planting holes are spaced 6 ft apart. Two to three seeds are planted in each hole but only one vigorous seedling is allowed to remain. The vines creep along the ground. They bear separate male and female flowers on the same vine. Successful cropping therefore depends on natural pollination by insects or artificial pollination by hand. A good supply of water is also necessary to produce large fruits. Harvesting may be done in 4 months. Pumpkins can be stored for long periods so long as they are kept in a dry airy room.

ASH PUMPKIN (*Benuncasa cerifera*) or "Alu Puhul" is not cultivated on a large scale like the yellow pumpkin. Single vines in home-gardens are more the rule. Ash pumpkin is usually used for making sweets.

Knol Khol *Brassica caulorapa*

Knol-Khol or Khol-rabi is cultivated for its globular stem. It thrives in the mid and low-country wet zone. The popular variety is Early White Vienna. You require 8 oz of seed to plant an acre. Seedlings are first raised in a nursery and transplanted in 3 weeks when they are 2 - 3 inches high. Planting is done at a spacing of 15" × 6" and the beds provided with shade till the seedlings are well established.

Fertilizers should be applied as in the case of beet root, carrot or radish, and as the stems begin to thicken the soil around the plants is loosened with a pointed stick or hand-fork, but on no account should the stem be earthed up.

The swollen stems may be lifted according to demand any time between the third and fourth month after nursery sowing. The ideal time however, is when the stem is about the size of a small orange. About 6,000 lb can be taken from an acre.

Leafy Vegetables

Every home-gardener should attempt to grow some leafy vegetables in the form of *Kathurumurunga*, *murunga*, spinnach, *thampala*, *gotukola*, *mukunuwenna* or *kankun*, because these vegetables are rich in mineral salts and vitamins, particularly iron, carotene and vitamins A and C. Nutritionists recommended that an adult should have at least 4 oz of leafy vegetables a day.

KATHURUMURUNGA (*Sesbania grandiflora*) is a small tree which flourishes in the low-country. Both the leaves and flowers are used, although the flowers are not as nutritious.

Seeds should be planted in well-manured holes spaced 8 - 10 ft apart. About 2 lb of seed are required to plant an acre. In large scale planting it is more advisable to raise the plants in a nursery and to transplant when they are 1 - 1½ months old. The first pick may be taken in 6 - 8 months. Leaf-eating caterpillars if they become a problem should be controlled by spraying with Lannate, Azodrin, Tamaron, Monitor etc.

MURUNGA (*Moringa pterygosperma*) is also a small tree that is adapted to the low-country. It is propagated by planting 4 - 5ft long cuttings about 1½ inches thick. Same spacing as for *kathurumurunga*. Although the tree is grown mainly for its tender pods, the leaves too are nutritious. Picking can commence in one year. Leaf-eating caterpillars to be treated as above.

SPINACH (*Spinacia oleracea*) thrives under shade and responds markedly to applications of fresh cattle manure and urine. It is best propagated from seed since cuttings give rise to plants that bloom and set seed prematurely. Seed rate is 4 - 5 lb per acre or ¼ oz per 1,000 sq. ft. Planting distance is usually 1½ ft apart—3 seeds are planted at each point and later thinned down to two plants. Stems commence climbing in 2 months: at this stage they should be trained to grow over a low trellis about 2 ft high.

Leaves should be picked from the base upwards, always leaving a few leaves on each plant for quick regeneration. Picking can commence 3 months after planting and could be continued for another 4 months. Leaf-eating caterpillars to be controlled as above. The Katugastota Giant Spinach variety, with leaves 6 - 9 inches long, can give 15 - 20,000 lb of leaf per acre under intensive cultivation.

THAMPALA (*Ameranthus*). There are many varieties. The tall green spineless variety marketed by the Department of Agriculture is perhaps the best. Although *thampala* can be propagated from cuttings, seeds are preferred because they give rise to more vigorous plants. Two pounds of seed are required to plant one acre in rows spaced one foot apart with seedlings 6 inches apart in the rows.

Seedlings can be lifted wholesale when they are a little over-one foot in height, or the plants may be allowed to grow uninterrupted and the leaves picked as and when required. Usually the first pick is taken in 1½ months, and pickings are continued for a period of 2 months. Leaf-eating caterpillars are sometimes a problem.

GOTUKOLA. (*Centella Asiatica*). There are two varieties viz., the small-leaved creeping type and the erect-growing large-leaved type. The large-leaved type is usually cultivated in beds and pots. A shady moist location is essential to induce profuse leaf growth. Divisions of the plant are spaced 6 inches apart. Picking can commence in 3 months and continue for a year.

MUKUNUWENNA (*Alteranthera triandera*) is propagated by planting six-inch long stem cuttings at a spacing of one foot apart. About 45,000 cuttings are required per acre. The crop quickly forms a thick cover. Picking can commence in two months and continue for over a year.

KANKUN (*Ipomea aquatica*) grows best in moist, water-logged situations, or sunken beds that can be flooded. Propagation is by 8 - 9 inch long cuttings planted horizontally one foot apart. Plants produce trailing stems which can be cut back in 3 months. Picking can continue for over a year.

KOHILA (*Lasia spinosa*) is propagated by six-inch long cuttings planted vertically in low-lying land with adequate water. The planting distance is 3 ft by 3 ft. Tender leaves are picked when the plants are about 9 months old. The duration of the crop is many years.

Ash Plantain *Musa sapientum*

Ash plantain is a popular vegetable. There are two varieties: the indigenous *alu-kehel* and the Indian introduction Mondhan. The method of cultivation is the same as for banana. This variety however, is highly susceptible to 'anthracnose', a fungus disease which causes blemishses and rots to appear on the developing fruit. Control is effected by spraying a copper-containing furngicide on the fruit at the beginning of the wet season and two or three times after up to maturity

Jak *Artocarpus integrifolia*

As a source of food the jak is recognised throughout the Island. It can take the place of rice. A single fruit is equivalent to one measure of rice and is adequate for a family of three of four persons as a single meal. What is more, it can be cooked at all stages. When tender it is chopped and used as *mellun* or cooked into a *polos* curry. The mature but not ripe fruit is curried or simply boiled and eaten. The ripe fruit is relished as a dessert. Even the seeds could be roasted and eaten.

There are several types of jak viz., *kuru kos*, *del kos*, *waraka* and *vela*, and the introduced Johore Jak which bears in 3 years. Two *waraka* selections made by the Department of Agriculture must be mentioned, namely "Father Long" Jak and *Rosa kos*. "Father Long" is an early type which comes into bearing in 3 - 4 years and continues to do so heavily for 15 - 20 years. Fruits are of medium size—15 to 20 lb each, with firm yellow pulp: they are borne throughout the year. *Rosa kos* has similar characteristics except that its flesh takes on a light pink tinge when cooked.

These varieties may be propagated by seed or grafts. Seedlings are planted 25 ft apart, grafts 18 ft, in small manured holes 1½ feet square and 1½ ft deep. Be sure to select a well-drained spot for planting since jak cannot tolerate waterlogging. Poor drainage causes the leaves to turn yellow and fall off in large numbers. This is followed by the blackening and decay of the fruits.

Breadfruit *Artocarpus altilis*

Breadfruit like jak requires a warm humid climate with a well distributed rainfall of 80 - 100 inches per year. It is propagated by planting root suckers. These suckers are produced by deliberately injurying the surface roots. The sprouted roots are separated from the mother plant and planted during the rainy season. Breadfruit can also be successfully propagated by budding on wild jak stocks.

Planting distance is 35 ft. A little 10% commercial BHC dust may be incorporated with the soil to protect the young sprouts from grubs. Young plants grow best under shade which may be removed as the plants grow and spread their branches. Cattle manure and wood ash in the holes is alright for a start, but once the tree starts bearing you should add 4 lb of conc. superphosphate annually to each tree to enhance the size and quality of the fruits. Trees come into bearing after 5 years.

Soft rot is a common fungal disease which results in fruit drop at all stages of development. This can be controlled by spraying with a copper fungicide or Bordeaux Mixture twice after fruit set at an interval of one month.

PART IV

FRUITS

Vegetative Propagation — Banana — Passion Fruit — Pineapple — Mango — Papaw — Cashew — Grapes — Oranges — Lime — Strawberry — Apple — Peach — Pear — Guava — Avocado — Sapodilla — Anonas — Pomegranate — Rambutan — Mangosteen — Durian.

FRUITS

There are two main reasons why fruits are valuable in a well-balanced diet. In the first instance, they contain the important vitamins A and C. Secondly, they contain citric acid and other fruit acids, which — though it may appear paradoxical — can correct acidity within the body: this is because in the body they are converted into alkaline carbonates.

Sri Lanka is fortunate in that it has a wide variety of fruits. But very few of them are systematically cultivated. Only pineapple, passion fruit, bananas and grapes to a small extent are cultivated on a commercial scale; other varieties are treated as home-garden crops or allowed to grow wild. Before we discuss the cultivation details of these crops individually let us examine the methods of propagation that are peculiar to them.

VEGETATIVE PROPAGATION: Most plants are propagated from seed, but owing to the cross-pollination that can take place during the life of the crop seedlings cannot be expected to reproduce the same characters as their parents. This is why vegetative propagation is resorted to in fruit production. The vegetatively-propagated plants breed true to type and maintain the desirable qualities of their parents, specially in regard to fruit quality which is most important in fruit production.

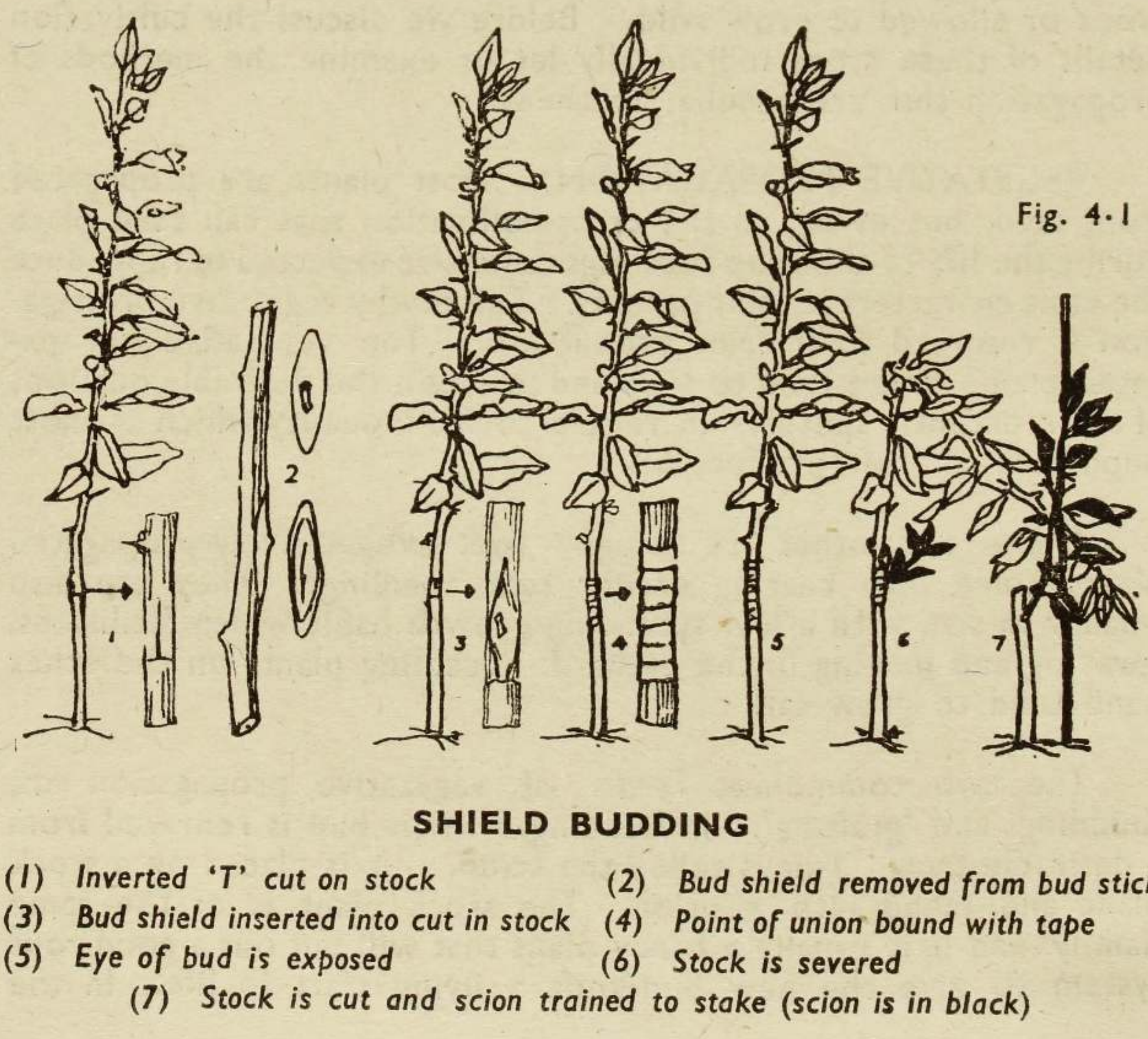
There are other advantages too. Vegetatively-propagated plants come into bearing earlier than seedlings. They are also smaller in size with a low spreading growth habit which facilitates, spraying and picking in the orchard. Seedling plants on the other hand tend to grow tall.

The two commonest forms of vegetative propagation are 'budding' and 'grafting'. In budding, a single bud is removed from a desirable tree. This is called the scion. It is placed on a stock plant and taped into position. The stock plant is of the same 'family' and it is usually a hardy plant that will put out a good root system to give the new bud-graft a flying start in life. In the grafting method a piece of stem, root or leaf — usually a stem — is taken as scion material from a desirable plant and taped into position on a hardy stock plant as before.

SHIELD BUDDING: This form of budding, also called "Inverted T" budding is used almost exclusively for citrus. As inverted 'T' cut is made in the stock, the vertical cut being 1 - 1½ inches and the horizontal cut ½ - ¾ inch. This incision is made at a height of 8 - 10 inches from the ground when the stock is of pencil thickness. Stock plants have to be raised separately in a nursery from seed. In the case of citrus the stock plant is sour orange or rough lemon.

The bud, or scion, with some bark and a thin layer of wood underneath is sliced from a twig of the previous season's growth and inserted into the junction of the vertical and horizontal incisions on the stock. To facilitate the entry of the scion bud the horizontal incision is widened by lifting the two vertical flaps with the spatula of the budding knife. The bud is pushed firmly into the vertical slit and tied with waxed tape which should cover all cut surfaces.

About two weeks later the bud should be examined by removing the tape. If it is alive the tape is re-tied leaving the eye of the bud



SHIELD BUDDING

(1) Inverted 'T' cut on stock *(2) Bud shield removed from bud stick*
(3) Bud shield inserted into cut in stock *(4) Point of union bound with tape*
(5) Eye of bud is exposed *(6) Stock is severed*
(7) Stock is cut and scion trained to stake (scion is in black)

exposed. A week later the top of the stock plant is either severed or bent over at a point six inches above the bud union. The scion bud is allowed to produce only a single shoot. This is trained to grow erect by tieing it, first to the stub above the bud union and later to a stake in the ground. The stub is cut back to the bud union when the scion is well established, and all other growth from the stock is suppressed.

'H' BUDDING: The 'H' method is used in most other fruit trees like avocado, cacao and rambutan. The stock is of the same kind as the scion. Two vertical cuts and a horizontal cut are made on the stock in the form of a letter 'H' 8 inches from ground level. The upper flap is peeled slightly upwards and the lower flap slightly downwards. The bud with wood attached is cut from the present season's growth and is held firmly in position on the panel made on the stock by replacing the peeled flaps of bark over it. The lower flap is trimmed back to expose the 'eye' or bud of the scion. The scion bud and the exposed tissues are bound tightly with budding tape. Three weeks later the tape is unwrapped, and if the bud is green it is tied back leaving the 'eye' exposed. The stock is then cut back about 2 inches above the bud patch. This forces the bud to sprout.

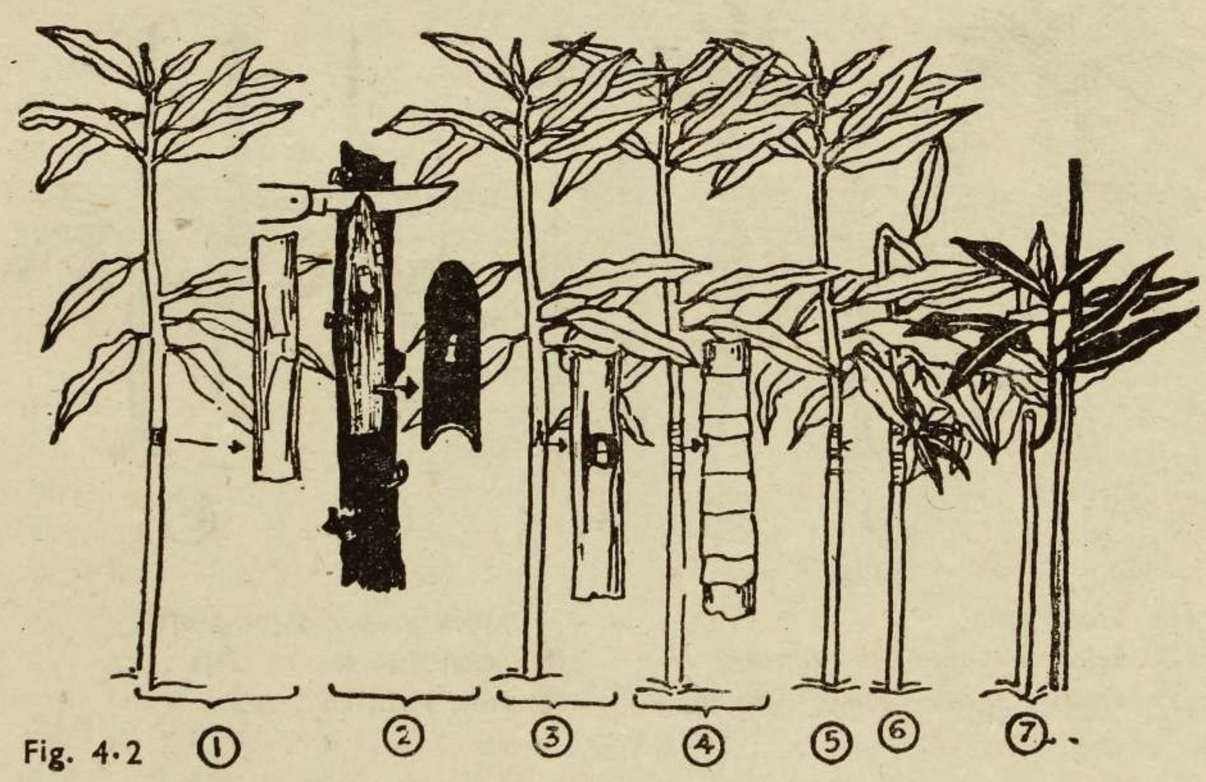


Fig. 4·2

H BUDDING

(1) Preparation of stock *(2) Scion bud shield is cut from bud stick*
(3) Bud is grafted *(4) Point of union is taped*
(5) Bud eve is exposed *(6) Stock is cut*
(7) Scion is trained to stake (scion is in black)

CHIP BUDDING: This method is used almost exclusively for the grape vine, in which the bark does not peel readily from the wood. The scion bud is taken with a chip of wood and inserted in a notch made on the stock.

CLEFT GRAFTING: This is a popular method of propagating the mango. The stock is topped at a height of 8 - 9 inches and split vertically from the top to a depth of about one inch. The scion — in this case a piece of stem carrying dorment buds, which is taken from the previous season's growth — is then shaped into a wedge at the base, and inserted into the cleft cut in the stock. If the stock and scion are of different sizes the scion piece is pushed to the side rather than placed in the middle. The scion is held firmly in place by waxed tape, which is bound tightly so as to cover the cut surface. The stock is *wal amba.*

An oil paper or polythene bag is placed over the union to exclude rain water and prevent it from desiccation. After a few weeks if the union has taken place the scion will produce a new flush of growth. When the scion is well established the wax tape is removed. This method makes it possible to produce a mango graft within a year.

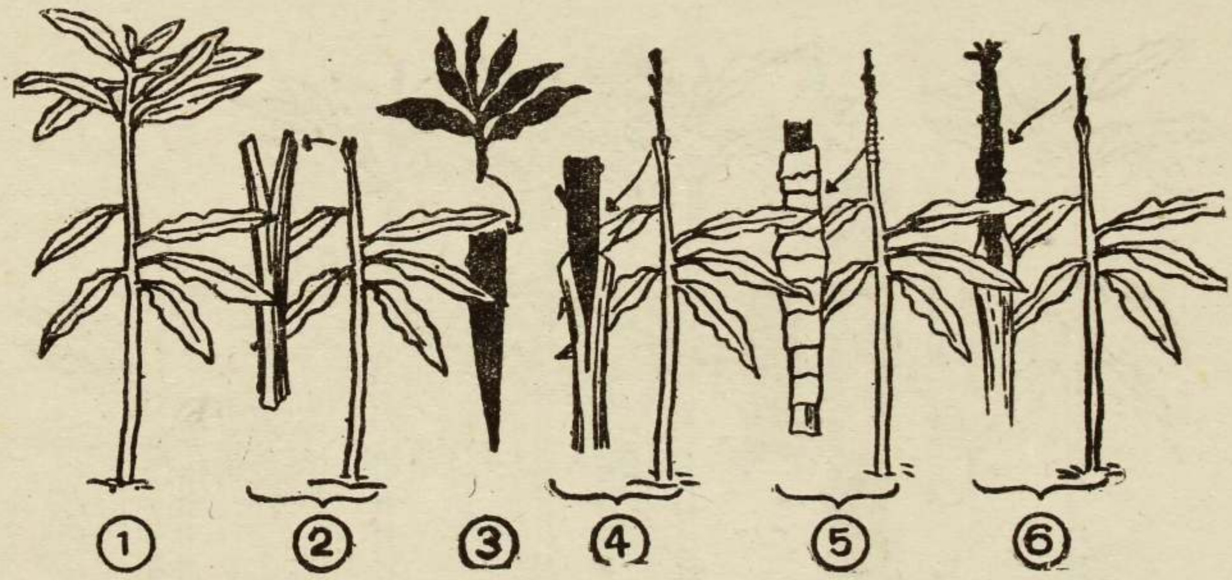


Fig. 4·3

(1) Stock plant
(2) Stock prepared for grafting
(3) Scion prepared for grafting
(4) Scion inserted in cleft stock
(5) Graft is firmly bound with tape
(6) New flush on scion

LAYERING: In this method which is quite often employed with lime, sapodilla and passion fruit, an under-hanging branch close to the ground is partially cut to expose the cambium, and a little moist soil in polythene is placed around it. The polythene should be tied at the two ends to prevent rainwater getting in, or the moisture in the soil escaping.

When roots develop at the cut and are seen through the polythene covering, the 'layer' or terminal portion of the branch is severed and potted as an individual plant.

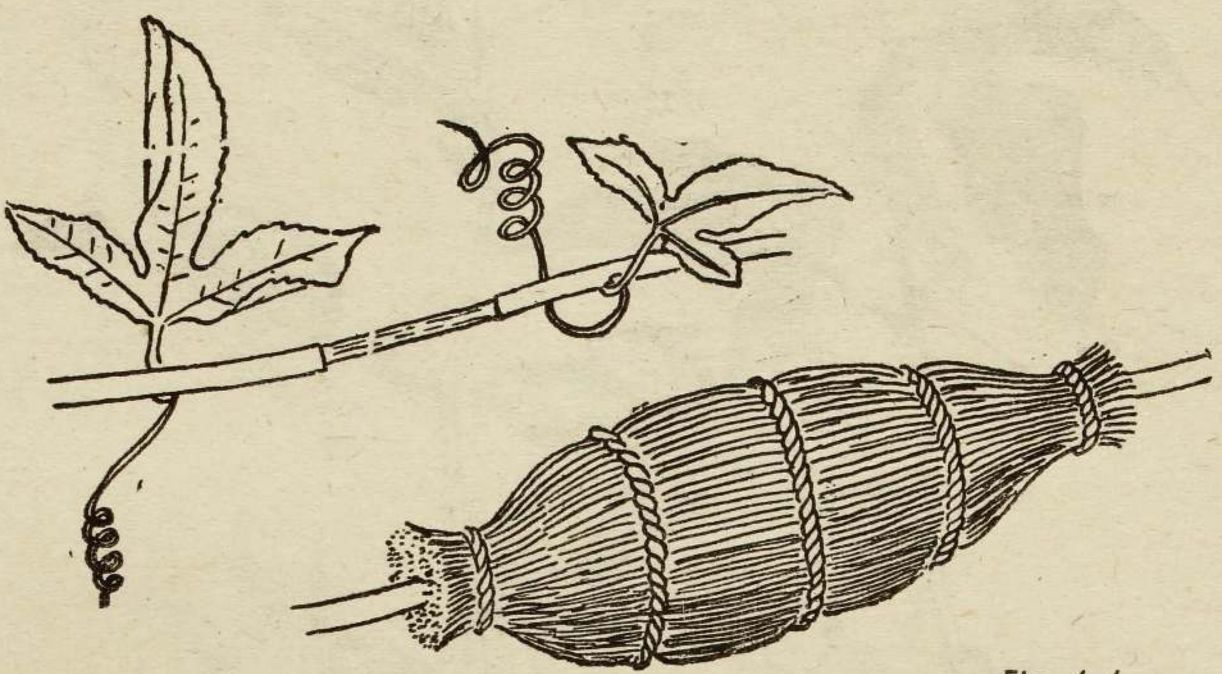


Fig. 4·4

ROOTED STEM CUTTINGS: This is the most convenient method of vegetative propagation. It may be used successfully with passion fruit. Cuttings are taken from fully grown segments of the vine, when the vine is in a state of active growth. Immature and senile material should not be used for propagation. Cuttings should be made as follows: a cut through a node or near a node at the bottom and a cut at the middle of the internode at the top.

These cuttings should be treated with a root-promoting hormone like Seradix and planted so that one-third of the cutting is buried in a rooting medium of clay, sand and compost. If a little vermiculate and sphagnum moss are added a higher percentage of rooting will be obtained. Cuttings develop roots in about one month. After this they are planted out in polythene bags filled with manured soil. (Fig. 4.5)

TRANSPLANTING GRAFTED PLANTS: Grafts should be well established before they are transplanted into their permanent sites. If the plants are in a nursery bed, then about 3 - 4 weeks before transplanting the tap roots must be severed *in situ*, at a depth of 9 inches. This is best done on a rainy day by scooping out the soil from the side. When the tap root is exposed it is cut with a pair of secateurs at the required depth, leaving an adequate number of lateral roots to nourish the plant. The soil is then put back with some leaf mould to stimulate the growth of fibrous

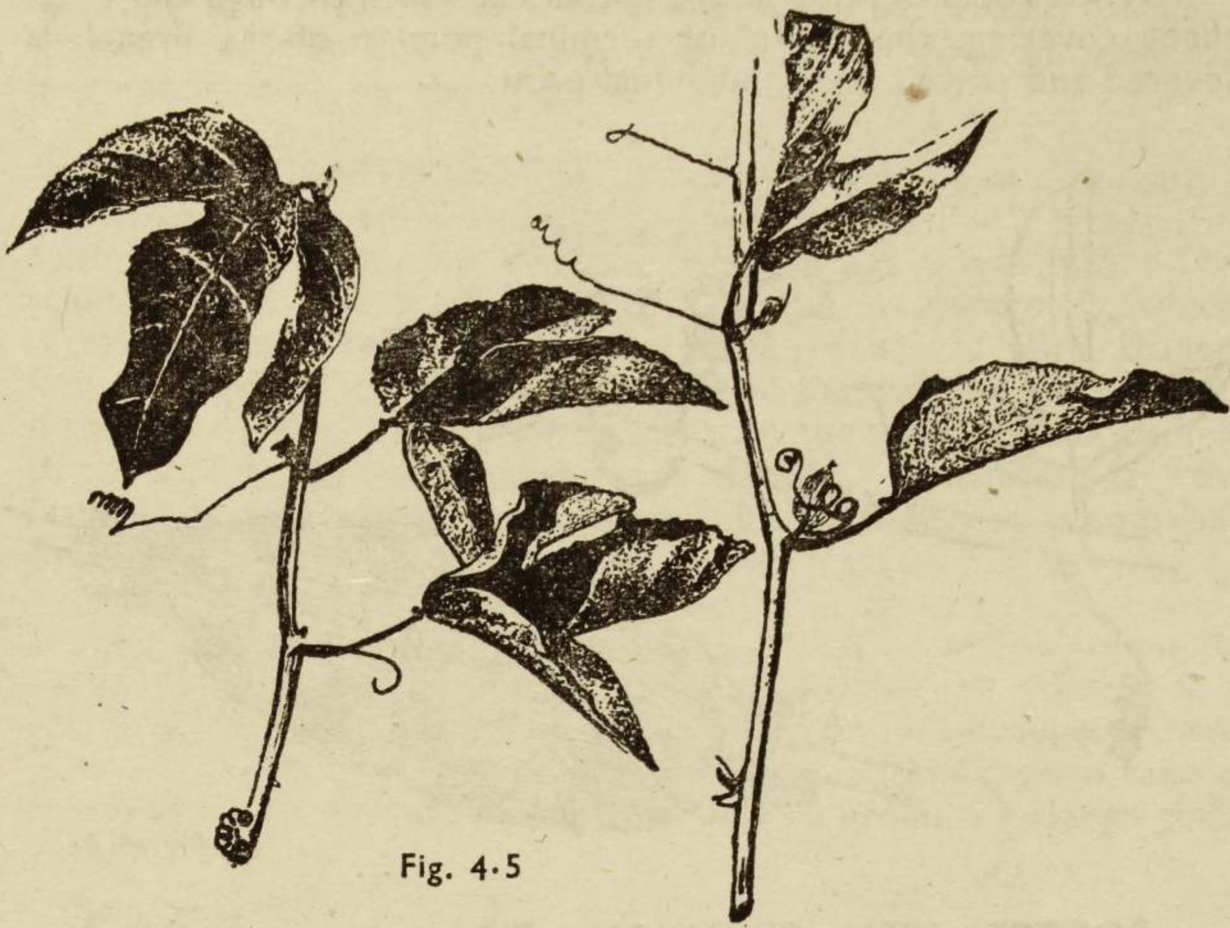


Fig. 4·5

roots from the cut end. The plants are also provided with partial overhead shade and hand-watered till they recover from the shock. Plants thus treated can be transplanted in 3 - 4 weeks during showery weather.

If the plants are in bamboo pots, the bamboo must be removed prior to transplanting. This is done without disturbing the soil as shown in the following diagram.

On the other hand, if the grafts are in polythene bags, then there is no need to remove the polythene. If the bag is slit down the two sides to permit the roots to emerge this is enough.

Planting holes should be prepared well in advance of actual planting. Holes 2′×2′×2′ should be dug at the selected sites and refilled with soil and manure to form a mound. The mound is allowed to settle down (3 weeks). This will ensure that the plants do not sink below the level at which they are planted.

The level of planting is important. The bud-union or point of grafting should not be covered with soil as this might lead to rotting. Grafted plants must therefore be planted at the same level they were in the nursery beds. Or in other words the bud or graft-union should be at least 6 inches above the soil.

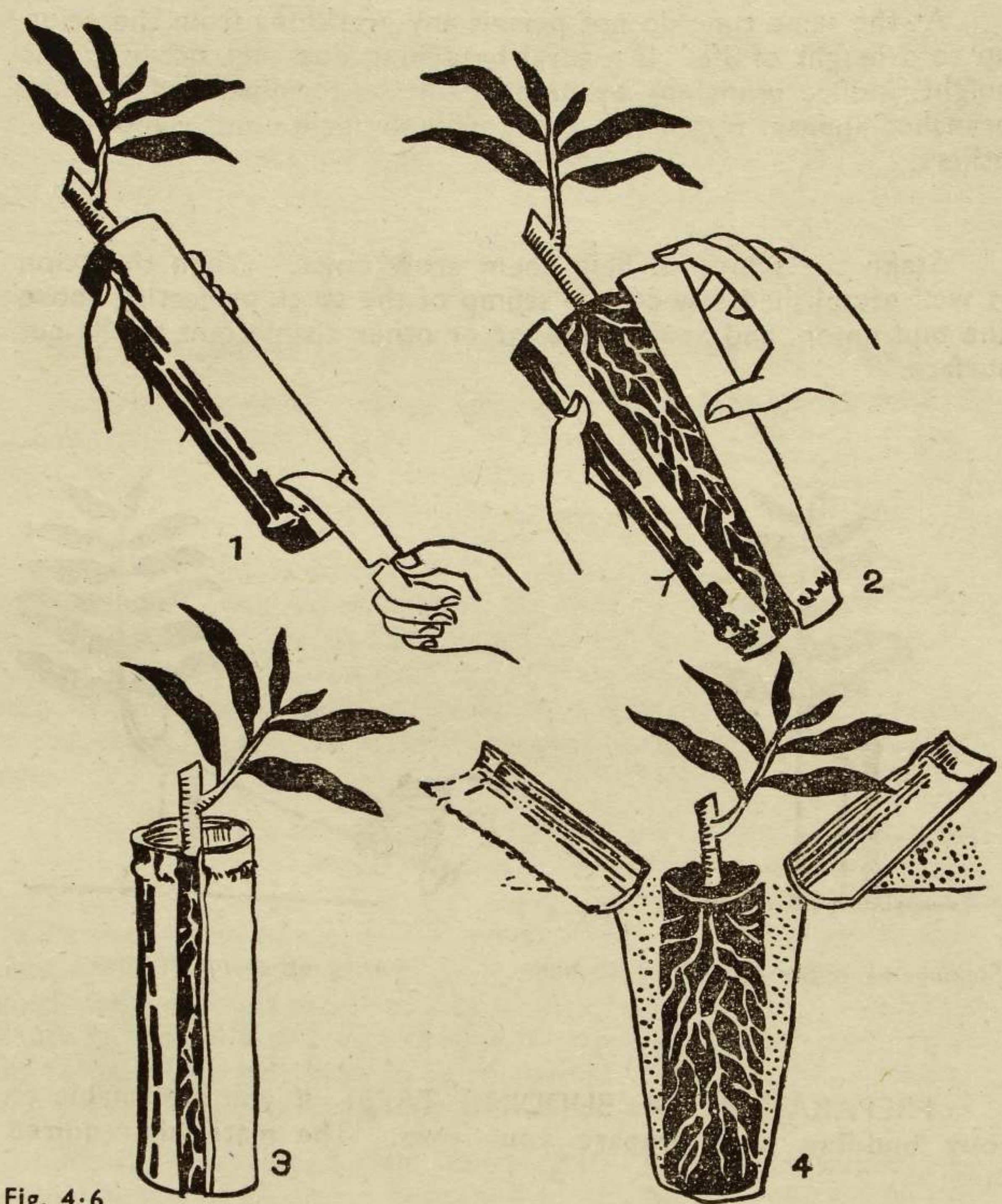


Fig. 4·6

PLANTING A BUDDED PLANT

(1) *Splitting bamboo pot*
(2) *Separating the two halves of the bamboo pot*
(3) *Replacing the two halves of bamboo pot with mouth down*
(4) *Planting and removing the bamboo pot*

AFTERCARE OF TRANSPLANTED GRAFTS: Once planted see that the stock does not put out any shoots. Only the scion should be allowed to grow. Very often stock plants are inferior to the scions, hence branches originating from them must be expected to yield inferior fruit. For this reason these branches must be cut off, or pinched off as soon as they make their appearance.

At the same time do not permit any branching from the scion up to a height of 3ft. If natural branching does not occur at this height, induce branching by nipping off the terminal bud. Once branches appear, retain 3 - 4 vigorous branches and remove the others.

Stake the scions to help them grow erect. When the scion is well established saw off the stump of the stock projecting above the bud union, and apply some tar or other disinfectant to the cut surface.

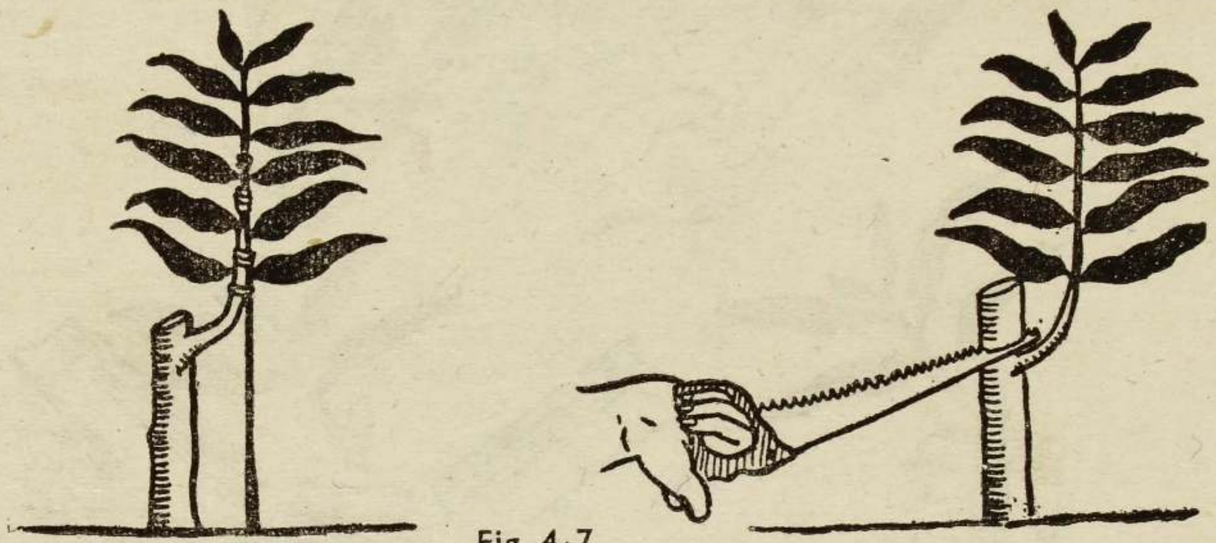


Fig. 4·7

Staking the scion shoot after planting *Sawing off stump of stock*

PREPARATION OF BUDDING TAPE: If you are unable to buy budding tape prepare your own. The materials required are:

3 parts resin

2 parts bees' wax

1 part tallow

Ordinary long cloth.

Melt the bees' wax and tallow in a metal container and bring the mixture to the boil. Add resin and stir till it is completely melted. Tear the long cloth into convenient lengths and immerse in the boiling mixture till it is well saturated. Remove the cloth and draw it through two pieces of bamboo held close together, to remove excess of wax. Spread the wax cloth on a line to dry and then fold it for use later.

RECOMMENDED FRUIT PLANTS FOR DIFFERENT CLIMATIC REGIONS: For the low-country wet zone: mango, lemonime, lime, guava, rambutan, soursop, custard apple, bullock's heart, sapodilla, mangosteen, pineapple, banana, passion fruit, and durian.

For the mid-country wet zone: avocado, mango, guava, durian, lemonime, sapodilla, banana and passion fruit.

For the up-country: pear, cherimoyer, apple and lemon.

For the dry zone: mango, grapes, orange, lime, pomegranate, cashew and banana.

Banana *Musa sapientum*

Of all our fruits banana is the most popular because it is the least expensive and is available all the year round. As such there is a ready market and a steady demand for this fruit at all times. And this is why it is such an attractive crop from the producer's point of view, not to mention the fact that it is relatively inexpensive to cultivate compared to other fruit crops like pineapple and passion fruit.

Under favourable conditions the banana grows with almost surprising rapidity. Planted in moist fertile soil it will grow into adult size and "shoot" a bunch after six months. It will then yield a marketable bunch about 3 months later. During that time the plant would have formed one or more well grown daughter plants which will maintain the sequence of bunch production. Daughter plants in turn will give rise to several more grand-daughter plants and so on, which may have to be removed in the interests of regulating growth and producing bunches of commercial value.

The fully developed stem, carrying 10-12 functional leaves may reach a height of 20 feet or more and carry a bunch weighing 60 - 80 lb in the space of 9-12 months. This fact is evidence of the truly remarkable growth capacity of banana cultivated under favourable conditions. Where the environment is less favourable however, every part of the plant may show some retardation of growth with consequent ill effects on production. In the circumstances, it will be advantageous to examine the factors that add up to favourable environment. This will give us a yardstick by which to measure our efforts at production.

ADEQUATE WATER: Because of its large leaves, and succulent pseudo-stem, which is really a concentric cylinder of overlapping leaf bases, banana requires more moisture throughout the year than any other fruit crop. A well distributed rainfall of 80 - 100 inches per annum is essential to ensure high yields.

Anything less than this will have to be supplemented by irrigation; otherwise growth and productivity will be adversely affected. First the leaves will show signs of desiccation and become yellow and wilted. And as the dry season advances, the plants will gradually stop growing and come to a complete standstill. Any bunches that may be produced will be small and will take an usually long time to ripen.

In the absence of irrigation, the existing water in the soil must be retained for as long as possible—evaporation must be prevented by mulching the surface with organic material such as cut grass, straw, dead leaves or even the harvested pseudo-stems once they are cut down and torn into strips, provided of course that they are not diseased or pest-infested.

Mulching with these materials serves not only to reduce the loss of soil moisture, but also smothers weeds and improves the texture and nutritional value of the superficial soil layer in which many of the banana roots feed. As more and more organic matter is added the soil will take on a spongy texture which helps it retain moisture over long periods.

GOOD DRAINAGE: Another favourable factor for high production is good drainage. It is true that banana wants a lot of water, but this water must not be allowed to accumulate at the root. Bananas growing in badly drained or water-logged soils, specially heavy clays, show characteristic external symptoms. For one thing the plants are subnormal in height for their age—they may indeed be even quite stunted. Leaves take on a pale-green colour fading to yellow, sometimes with streaks along the veins. Where a plantation dips from a well-drained hillside to a waterlogged hollow, the gradation from tall healthy plants to dwarfed, discoloured, 'water-soaked' plants presents a conspicuous spectacle.

Remedial measures include the installation of suitable drainage as a first step. This involves the construction of drains and ditches to bring the water surface down to at least 3 feet below the surface. Frequent cultivation and heavy application of dolomitic limestone and the incorporation of cover crops or other mulching material to improve soil structure are also measures that are likely to be helpful. But unfortunately, these measures are not always feasible, and they are also expensive. Which means that we must be very careful about siting our plantations correctly in the first instance. It is very necessary that we select only well-drained areas, because once banana is planted in ill-drained clays or other waterlogged areas, there is very little that can be done to remedy the situation without a great deal of expense.

PLANTING MATERIAL: There are three types of planting material *viz.* suckers, butts and bits. Suckers of course are the usual type. They come in two forms. There are the water suckers which have broad leaves and the sword suckers which have narrow pointed leaves. Use only the sword suckers for planting because the water suckers usually turn out to be weak growers and late bearers. And do not wait till the suckers are too big before you cut them free from the parent plant. The longer you wait the greater the shock to the parent. The best time to sever the sucker would be when it is about 2 ft tall and not older than 3 months.

A point to observe when planting these sword suckers is to see that the cut sides all face in one direction along the row. The new suckers will then develop from the buds on the uncut sides and give the plantation some form of uniformity.

On the home-garden scale suckers may be readily available. But on the plantation scale you can never get enough of them. This means turning to the other two sources — butts and bits. Butt is the term given to the underground corm. After a bunch is harvested and the pseudo-stem is cut down, the underground portion or butt can be used for propagation—it can be used whole or cut into two portions which are called bits. What you will use will depend on the fertility of the soil. In fertile soils you can plant bits, in poor soils butts. Butts contain a greater reserve of food.

The bits are prepared for planting as follows: You trim the underground portion (corm) of all roots and then cut away the pseudo-stem about 4 inches above. You will notice that there are two buds near the upper surface on opposite sides. You should split the butt longitudinally, so that two 'bits' are produced, each 'bit' carrying one of these buds. If there are any other buds you should remove them.

It is the usual practice to dig planting holes 18 inches square and about 15 inches deep. The butts or bits should be so placed in the hole that the top is about six inches below the surface after soil is filled in and tamped down. Spacing between holes is 8 to 10 ft — the wider spacing is for fertile soils.

REGULAR MANURING: Rapid growth depends on whether the top 8 - 10 inches of soil is fertile. Any manure, if it is used therefore, must be applied to this area so that the roots will develop and proliferate.

Banana, specially the *Embul Hondarawalu*, is known to get on quite well on cattle manure alone, if 3 - 4 baskets are applied to each planting hole and the dose repeated every 3 - 4 months. Other varieties, however, like *Kolikuttu*, *Suwandel*, *Anamalu* and *Embon* benefit from a supplementary dressing of fertilizer.

The experimental evidence to date emphasizes the importance of nitrogen in the nutrition of banana–it is the first mineral nutrient to which banana responds, even when it is relatively more abundant in the soil than either phosphorus or potassium. The need for potassium too has been observed in soils that have been cultivated for a long period of time. But in the case of phosphorus the response has not been so clear. Anyway, since it is known that phosphate generally improves production in the presence of nitrogen and potassium, a certain amount is included in the fertilizer mixture. The mixture is prepared as follows: 2 parts urea, 3 parts muriate of potash and 1 part conc. superphosphate. You use one pound of this mixture for every banana clump every 3 - 4 months.

Nitrogen deficiency is one of the chief causes of poor productivity in this country. Stunted yellowing plants are an indication of nitrogen deficiency, but they must not be confused with similar symptoms that are associated with poor drainage. The difference is that in nitrogen-deficient plants the leaf petiole will show a deep reddish tinge which is absent in 'water-soaked' plants.

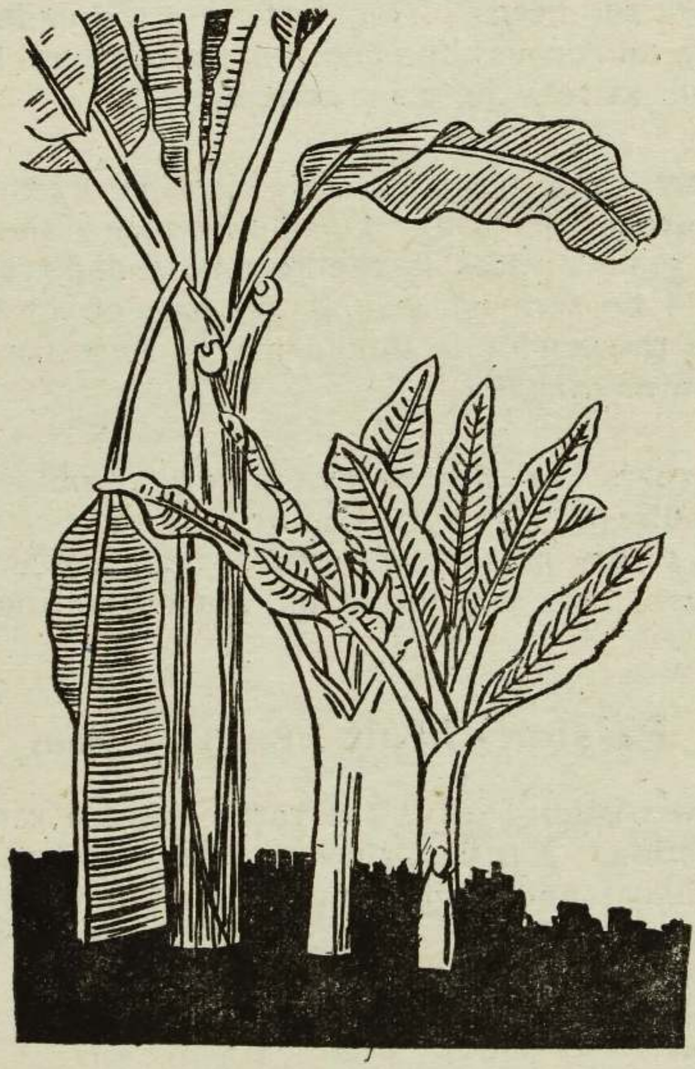
PRUNING: During its lifetime a banana plant throws up several off-shoots or suckers. If all these are allowed to grow the mother plant will be so crowded as to develop weakly and produce poor bunches of fruit. It is necessary therefore, to regulate the growth of these suckers. No suckers should be allowed to develop at all until the parent plant begins to flower. If they do appear they must be cut off cleanly without damaging the undergound corm. But after the plant flowers a first sucker may be allowed to develop. This is called the one-bunch-one-sucker system. A second sucker may be allowed to develop when the bunch on the mother plant has begun to mature. This is called the one - bunch - two sucker system of pruning. The one-bunch-two-sucker system is recommended for fertile soils and the one - bunch - one - sucker system for poor soils.

DISEASE CONTROL: All varieties of banana are subject to a serious disease called "bunchy-top", and since there is no pesticide that is effective against it, the alternative is to keep it in check by early recognition and prompt destruction of the affected plants.

Fortunately, the symptoms of "bunchy-top" are distinctive and not likely to be confused with any other disease. In a badly affected plant the leaves are typically bunched together at the apex forming a congested rosette. The plants may also be noticeably stunted.

But recognition is not always so clear cut. In some affected plants normal growth may continue until the last leaf that precedes the shooting of the bunch. The only sure way of identifying the disease therefore is to closely examine the leaves. If when the leaf is held up to the light and examined from the underside, a dot-dash pattern of dark green streaks is noticed along the mid-rib and veins in contrast to the full green colour of a normal leaf, you can presume 'bunchy-top' and go ahead and promptly destroy the diseased plants. To be perfectly sure destroy all the plants in a clump even if only a single diseased plant is discovered.

Fig. 4·8



"Bunchy-Top" of Banana. The two stunted plants in the foreground show typical symptoms.

Be sure not to use planting material from diseased clumps. If you have no disease-free clumps in the garden you may have to get your planting material from an outside source. This may be inconvenient but it is a necessary precaution that must be taken. The diseased material should be uprooted, cut-up into pieces and buried so that the infestation cannot be spread by flies and other flying insects.

Note: A fungus disease called "Panama" Disease is also prevalent in the Southern Province and in the Kegalle, Kandy and Matale Districts. Typical symptoms are yellowing leaves which collapse at the base and remain hanging downward along the pseudo-stem. The fungus lives in the soil but the use of any form of soil disinfectant is uneconomical. The disease is thus kept under control by promptly removing and burning all diseased material.

PEST CONTROL: Just as "bunchy-top" is the common banana disease so the corm-borer is the common pest. It is a black weevil, but you will rarely see it as it operates only at night. The weevil lays its eggs in the soft portion of the underground stem just below ground level, but it is the larvae that hatch out which are the real culprits. They are slug-like in appearance with whitish bodies and dark red heads. They bore into the underground stem riddling it with numerous holes and tunnels. Growth is immediately arrested and ultimately the plant collapses.

Fortunately, these pests can be controlled by the use of Heptachlor or Chlordane (Intox 8). One fluid ounce of these insecticides mixed with 2 gallons water is the recommended treatment. The solution should be sprayed around the base of the banana plants. If this is done thoroughly it should not be necessary to treat the soil again for 6 months.

In areas where the corm weevil is very troublesome, Carbonfuran 3% granules may be sprinkled around the plants at planting. But as this is a very poisonous pesticide care should be taken to see that it is used only at planting and not during the later growth of the crop.

Passion - Fruit *Passiflora edulis*

The yellow passion-fruit is the recommended variety for commercial production. It is best grown in the wet zone where a well distributed rainfall and high atmospheric humidity favour the growth of the vines. Open locations which favour maximum exposure to the sun but which are protected from strong winds should be selected.

TRELLISES: Passion vines are trained to grow on trellises. Aspect does not seriously affect the direction of trellising in this country where the sun is more or less overhead throughout the day. Yet siting the trellises in an east-west direction does help to reduce the shade cast during the early and late hours of the day.

The construction of trellises is the most expensive item in passion-fruit culture. Wooden posts which are used as supports should be of strong durable wood and resistant to termite attack, or they should be treated to ward off such attacks. These posts are planted in rows 6 - 8 ft apart. The posts when firmly fixed should be 6 - 6½ feet high above the ground to facilitate picking. Single strands of steel wire (10-12 gauge) or barbed wire are drawn across the top. To prevent the wire sagging it should be drawn tautly round each post and stapled and the end posts well trussed.

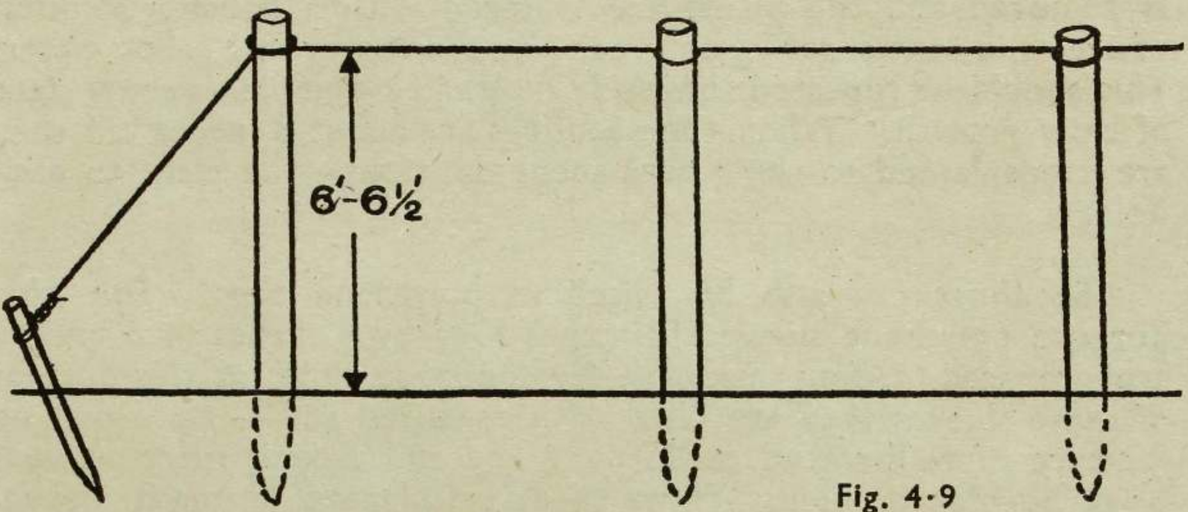


Fig. 4·9

If the trellises are 6 ft apart, planting holes should be prepared 15 ft apart along each trellis. If the trellises are 8 ft apart the holes should be spaced at 12 ft along the trellises. Holes are 2 ft by 2 ft by 18 inches deep. At these planting distances about 450 vines can be taken to the acre.

PLANTING MATERIAL: Passion-fruit may be propagated by cuttings, layers or seeds. But since there is hardly any difference in the age at first fruiting between vegetatively propagated plants and seedlings and since vegetative propagation is the more expensive of the two methods, the general practice is to raise seedlings. About 175 fruits of medium size are required to obtain one pound of dried seed. One pound contains 8,000 - 10,000 seeds. Fruits with a diameter of 2-2½ inches are taken as medium sized.

For seed extraction only fully ripe fruit should be used. They are picked off the vines and left for one week before extraction. The seeds are then scooped out and spread on a piece of jutehessian or on a gunny bag. They are rubbed till the juice sacs or pellicles burst and washed in several changes of water to remove the juice and the juice sacs. They are left for a further 3 - 4 days to ferment, then washed again and dried in the shade. After this they must be sown immediately, unless they are stored in air-tight containers in which case they can be kept for 3 months without any serious loss of viability.

Seeds are preferably soaked overnight in water and planted in cross-rows 4 inches apart in cowdung-manured nursery beds. Seeds in the row are dibbled one-inch apart and covered with a thin layer of soil. Nursery beds should be protected from sun and heavy rain by erecting a low cover of thatch over them.

Germination takes place in 14 - 28 days. When the young seedlings begin to produce their first leaves, the protective cover is removed and the plants are watered with a booster solution of urea and cane-sugar - ½ oz urea, ½ oz cane-sugar in 1 gallon water. This should be repeated at weekly intervals if the plants show signs of slow growth. When the seedlings are about 8 inches tall they are transplanted to their permanent positions—one plant to each hole.

Seedlings can also be raised in polythene bags. For this purpose polythene sleeves 12 inches long by 6 inches in diameter are prepared. After making a few drainage holes at the bottom of these sleeves they are filled with manured soil — *i.e.* a potting mixture of well-rotted cattle dung and soil mixed with crushed brick powder or sand. Three seeds are planted in each sleeve. Seedlings in polythene bags require the same treatment and care as seedlings raised in nursery beds.

FERTILIZERS: The following mixture is recommended per acre of commercial plantation: 50 kg (1 cwt) urea, 50 kg (1 cwt) conc. superphosphate 50 kg (1 cwt) muriate of potash. A basal application of 8 oz is added to each planting hole at the time of planting along with 2 oz of kieserite or magnesium sulphate. This is followed by a first top-dressing of another 8 oz. per plant 2 months later and a second top-dressing of the same quantity 6 months after planting.

Subsequently each vine should be given the following top-dressings:

1 lb at one year
1 lb at 1½ years
1½ lb at 2 years
1½ lb at 2½ years
2 lb at 3 years
2 lb at 3½ years
2½ lb at 4 years and thereafter every 6 months.

Top-dressings should be made around the base of each plant and lightly worked into the soil with a pointed stick.

TRAINING: Young plants are trained to grow along a support to the wire on the trellis. All lateral branches arising from the main stem are nipped off up to wire level. The growing plant is then bent around the top wire and allowed to grow along it. Lateral branches are now allowed to develop, but to prevent them curving back on each other and forming a tangled mass of foliage which suppresses fruit production, the tendrils are all nipped off. For the weight of the foliage and the flowers and fruits that will develop later the lateral branches (minus tendrils) will hang down freely. The growing tip of the main stem along the top wire is broken off when it reaches the other vine in the row.

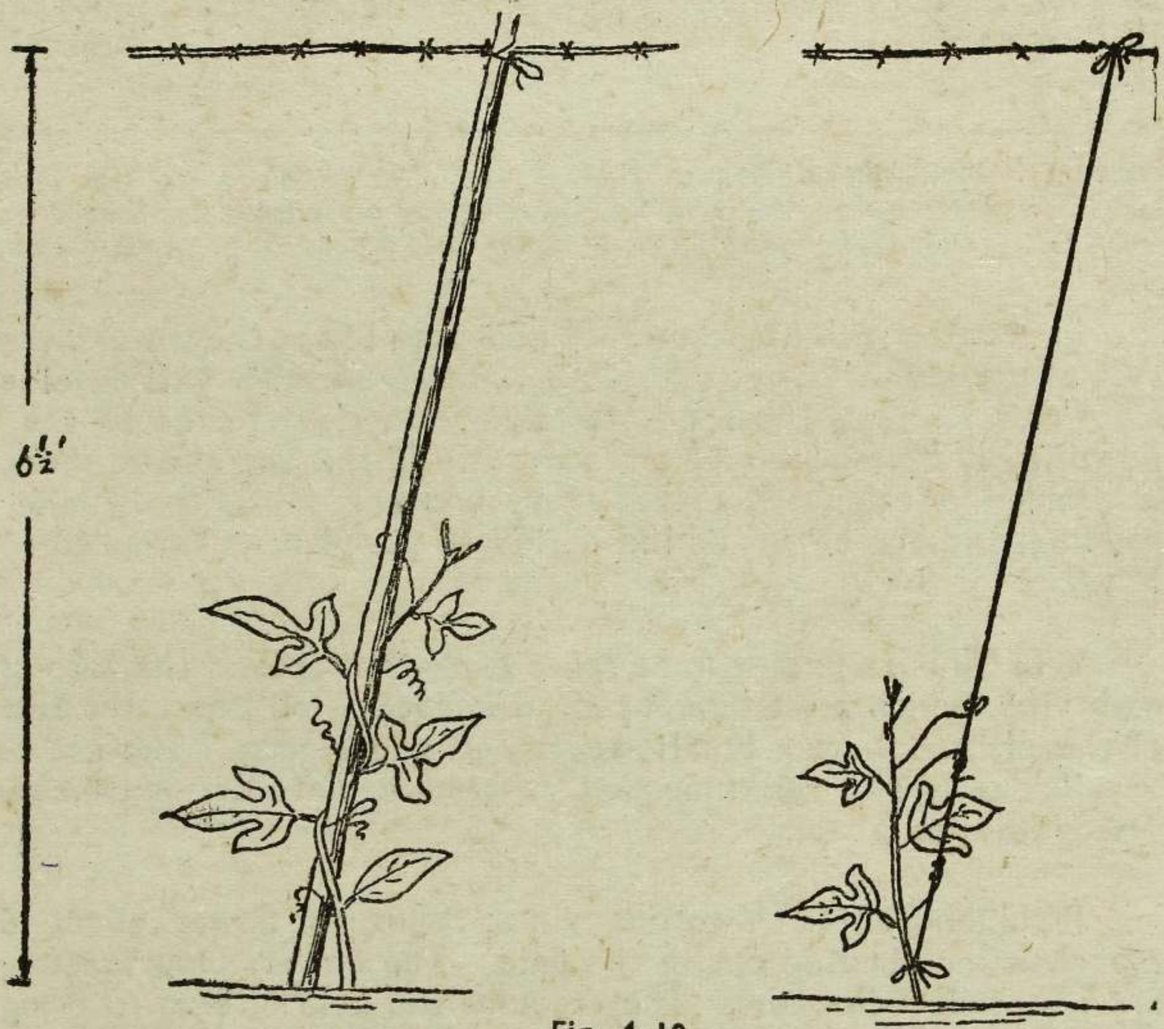


Fig. 4·10

Young plants trained to climb stake or string to top-wire on trellis.

PRUNING: Flowers and fruits are usually produced on new growth. It is necessary therefore, to regularly prune the old branches that have already borne fruit. But since passion fruit vines do not store large reserves of food like the grape vine, they cannot stand drastic pruning soon after each harvest. Only one or two of the older branches need be pruned at any one time — these branches are recognised by the fact that they trail on the ground and do not produce fruit.

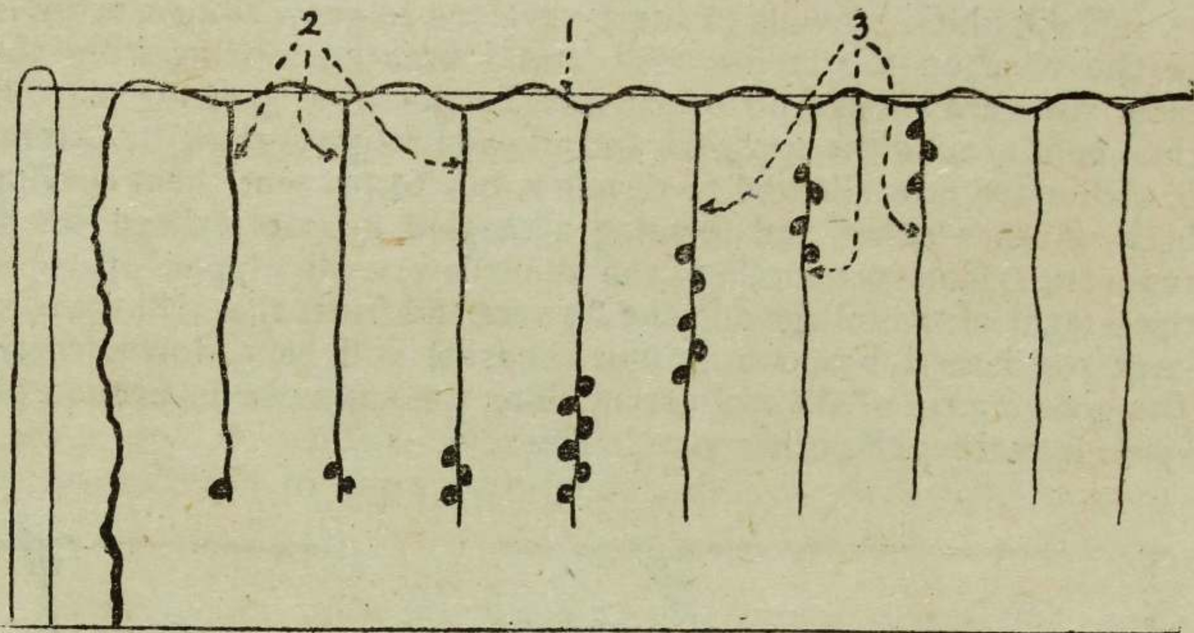


Fig. 4·11 *Adult vine trained to grow in one direction along the top wire. Lateral branches (with tendrils removed) are allowed to hang down freely. 1. Lateral Stem, 2. Branches to be pruned, 3. Bearing branches.*

In pruning such branches 3 - 5 nodes are left at the top and the rest of the branch is cut off. One or more branches will develop from this stump. These new branches are also trained to hang down freely by pinching off the tendrils. In this way severe shock is avoided, specially, if there is dry weather immediately after pruning, and the economic life period of the plant is extended to 5 years.

WEEDING: Except for a space of 2 - 3 ft around the base of each vine, which must be kept clean-weeded at all times, the rest of the plantation may be allowed to go under grass. The use of weedicides is not recommended as passion vines are extremely susceptible to them.

POLLINATION: Vigorous vines begin to flower about 6 months after planting out in the field. The flowers unfortunately are poor self-pollinators. They require the help of bees to bring about cross-pollination and fruit set. But since the flowers open only at mid-day when honey bees—the usual pollinating insects—are not active, natural fruit set is very poor. Carpenter bees and the bumble bee, certainly visit the flowers at all times of the day, but as these insects are not abundant or present all over the country, it is necessary in commercial production to resort to hand pollination.

In this method you can use a small paint brush to transfer the pollen from one flower to another. Or, in the alternative, cross-pollination can be effected by gently touching the anthers and stigmatic surfaces, of the flowers with thumb and forefinger. A skilled operator can pollinate 2,000 - 3,000 flowers a day in this manner. Flowers remain open from about mid-day to about 3 p.m. in the low-country wet zone. Hand pollination is most effective when it is done during this time on a sunny day.

PICKING: Fruits ripen 9 - 12 weeks after pollination. They should be picked once a week—twice if necessary—before they drop off the vines. Production varies according to the age of the crop. In the first year about 4,000 lb may be expected per acre. In the next two years of peak production 12,000 lb is average. In the fourth and fifth years production falls to 10,000 and 8,000 lb respectively.

Fruits bound for the factory are packed in gunny bags. Fruits intended for sale in the fresh fruit market have to be more carefully handled: they should be packed in crates or bamboo baskets lined with packing paper. Passion fruit juice has an excellent international market. The juice extraction percentage by weight is 30-33.

PESTS & DISEASES: Passion fruit is comparatively free of insect pests. There are two serious diseases however.

WOODINESS: This is a virus disease which generally appears when the vines have just begun to bear fruit. It has the effect of stifling all growth. The terminal shoots stop growing, but the most distinctive symptom is the crinkling or distorting of the leaves, which may or may not take on a yellow mottle or mosaic pattern. Fruits are also distorted. Instead of being big and round they remain small and often take on an oval shape with shrivelled indentations. Premature fruit drop is quite common. Another abnormalty of the diseased fruit is that it develops a very hard outer covering which is difficult to cut through. It is because of this characteristic that the disease is called "Woodiness".

Since the disease is caused by a virus which is spread by minute flying insects called aphids, conventional methods like spraying or dusting are not effective. The only alternative is to ensure the use of healthy planting material in the first instance and to dispose of diseased material as soon as it is observed. Do not attempt to chop off the diseased branches and take them away for burning, because in the process there is a tendency to spread the disease. The safer alternative would be to sever the main stem near the base and allow the vine to die naturally. The virus which can only thrive on live material will also die in the process.

LEAF SPOT OR BROWN SPOT: This is a fungus disease which develops rotten patches on the leaves. When the leaves rot and fall growth is retarded and there is considerable crop loss. Wind is probably the chief means of spreading this disease: the spores are easily blown about. Systematic pruning and spraying with a copper fungicide are the solution to the problem.

CROP BUDGET: For one acre containing 450 plants, the following budget may be taken as a guide over an economic life period of 4 years:

Capital Costs	*Rs. Cts.*
Land clearing	240.00
Soil Conservation	90.00
Preparation of 450 holes	450.00
Trellises (500 stakes @ Rs. 5 /-)	2,500.00
Wire & Nails	750.00
Putting up trellises	350.00
Cost of seedlings & planting	100.00
	4,480.00

Operational Costs (First year)	*Rs. Cts.*
Weeding & slashing	120.00
Training & pruning vines	150.00
Maintenance of trellises	50.00
Fertilizer & application (@ 50% subsidy)	250.00
Filling vacancies	20.00
Hand-pollination	75.00
Harvesting, sorting & packing	100.00
	765.00

Operational Costs (2nd year)	*Rs. Cts.*
Weeding & slashing	120.00
Maintenance of trellises & training vines	140.00
Fertilizers & application	250.00
Hand-pollination	90.00
Harvesting, sorting & packing	200.00
	800.00

Operational Costs (3rd year)	*Rs. Cts.*
Weeding & slashing	120.00
Maintenance of trellises	100.00
Training & pruning vines	100.00
Hand-pollination	90.00
Fertilizers & application	450.00
Harvesting, sorting & packing	200.00
	1,060.00

Operational Costs (4th year)	*Rs. Cts.*
Weeding & slashing	120.00
Training & pruning vines	100.00
Maintenance of trellises	25.00
Fertilizers & application	500.00
Hand-pollination	90.00
Harvesting, sorting & packing	200.00
	1,035.00

Gross Returns	*Rs. Cts.*
1st year—4,000 lb @ -/40 cts.	1,600.00
2nd year—12,000 lb @ -/40 cts.	4,800.00
3rd year—12,000 lb @ -/40 cts.	4,800.00
4th year—8,000 lb @ -/40 cts.	3,200.00
	14,400.00

NOTE: Labour costs have been taken at Rs. 7/- per man and Rs. 5/- per woman per day. The selling price of -/40 cents per pound was the current rate paid by the Marketing Department at time of going to press.

Pineapple *Ananas sativus*

Climatically pineapple requires a well distributed rainfall of 80-125 inches and a temperature range between 65° and 95° F. Low night temperatures for short spells do not harm the crop. Prolonged cold spells, however, retard growth, delay maturity and increase the acidity of the fruit. Pineapple also requires well drained acid soils in the pH range of 5 - 6 for optimum cultivation.

This combination of soil and climatic conditions is found mainly in the Colombo and Kurunegala Districts and parts of the Puttalam and Badulla Districts around Hali-ela, Deegala and Hathakma. In fact, all marginal tea lands which do not have extreme cold climates may be exploited for pineapple production provided the laterite soils are improved in fertility by heavy application of organic manure and fertilizers.

VARIETIES: There are two commercial varieties. The "Mauritius" (Smooth Cayenne) is strictly a table variety. "Kew" is grown for the table and for canning. Mauritius is a long fruit which turns yellowish orange on maturity. It produces a sweet golden yellow flesh. Kew is larger, barrel shaped (the barrel shape is suitable for processing), turns greenish-yellow on maturity and produces a less sweet pale flesh.

PLANTING MATERIAL: The pineapple plant produces a number of offshoots. Those that come from below ground are called *ratoons*, those that arise from the axils of the lower leaves are called *suckers*, those that arise from the stem are called *slips* and those that arise from the top of the fruit are called *crowns*.

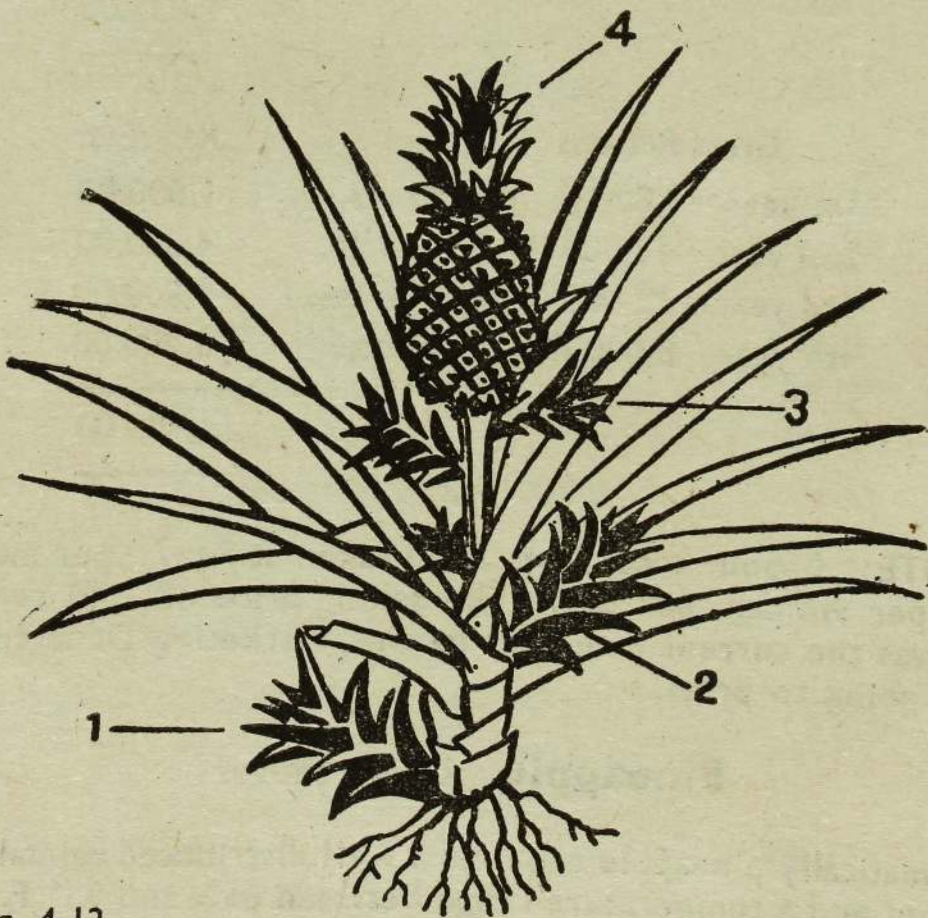


Fig. 4.12

PINEAPPLE PLANT

1. Ratoon *2. Sucker* *3. Slip* *4. Crown*

All these offgrowths may be used for propagation. Ratoons are the quickest to come into bearing taking 12 - 14 months, but they are difficult to obtain as they are usually left to continue the growth of a plantation. Only when a plantation is being uprooted are they available in fairly large numbers. Suckers are readily available and commonly used: they take 16 - 18 months to come into bearing. Slips take 18 - 20 months. They arise from the stem and must not be confused with 'collar slips' which arise from the base of the fruit itself. Collar slips are poor specimens and should *not* be used for propagation. Crowns are slow-growers taking 24 months to bear but they produce an uniform stand of plants which come into fruit at the same time.

Shortage of planting material is often a limiting factor in the expansion of this crop, which has an attractive international market. To overcome this old stems or 'butts' are used to produce 'shoots' which may be planted out. The old stumps left in the field are cut down to ground level—they are about six inches long—disinfected (see below) and planted horizontally in furrows in a specially prepared nursery. Dormant buds give rise to 3 - 6 new plants per 'butt'. These reach a height of 4 - 6 inches in 3 - 4 months when they may be planted out. They take about 18 months to come into bearing. To promote a vigorous growth of such shoots it may be necessary to spray the nursery occasionally with a dilute solution of urea and cane sugar at a concentration of 8 oz of urea and 2 oz cane sugar in a gallon of water.

DISINFECTION OF PLANTING MATERIAL: Care should be taken to see that planting material is not diseased. The only disease that one has to worry about is pineapple 'wilt' which is activated by mealy bugs, a powdery type of insect which is found in a white mass in between the leaves. A wise precaution would be to strip off the basal leaves of all offshoots used for planting and to dip the ends in an insecticidal solution prior to planting.

The same solution used for dipping the pineapple stumps prior to planting them in a nursery may be used here. It is prepared by mixing one fluid ounce of Fenitrothion 100% E.C. (Sumithion 100% E.C.) or Mathomyl (Lanate) or Methamidiphos (Tamaron, Monitor) in 3 - 4 gals of water. After dipping for a few minutes the suckers are dried in open shade and then planted.

PLANTING: Planting is done in narrow trenches. After the land has been ploughed and harrowed, trenches are dug across the contour 9 inches wide and 9 inches deep. The dug-out earth is placed on the lower side of each trench to form a small bund. Suckers, crowns or shoots are placed in these trenches 15 - 18 inches apart with the tops leaning towards the bund. A little soil is scooped from the upper side of the trench and used to cover the suckers to a depth of 3 inches. The rest of the trench is allowed to fill in naturally with soil which is usually washed in during the rains.

The distance between the trenches varies according to the pattern of cultivation that is adopted. In young coconut estates for instance (not older than 7 years) trenches are most often spaced 6 - 7 ft apart, giving a total of 3,500 - 3,750 plants per acre.

Closer spacing can be adopted but, as the hazard of the pineapple 'wilt' disease increases with a greater density of plants, such spacing should not be adopted unless the producer is prepared to adopt an intensive system of pest control as well. About 8,000 - 10,000 plants per acre may be obtained by planting two rows close together 2 ft apart and separating these double rows by a distance of 5 feet. When pineapple is planted as a pure crop (i.e. when it is not inter-cropped in young coconut or rubber) about 14,000 plants can be taken to the acre by spacing the double rows at a distance of 4 ft apart, or 17,000 plants by spacing the double rows 3 ft apart.

WEED CONTROL: Weed control is one of the most difficult and expensive operations in pineapple production because of the intermingling and 'matting' of the plants between the rows after some time. Manual weeding is the common practice in small plantations, but it has to be done frequently because of the severity of weed growth in the wet zone.

Coir-mulching has also been carried out successfully in the Colombo District. Coir dust may be had free of charge but some 60 - 75 tractor loads (150 - 200 half cart loads) have to be transported and spread over one acre of plantation—this is an expensive business.

Chemical weed control is more convenient and less expensive Diuron (Karmex) when used at 2 lb together with 2 pints of a spreader such as "surfactant" in 100 gallons of water per acre keeps the land free of weeds for about 4 months. Spraying is first done 14 - 21 days after planting and repeated at 3 monthly intervals.

FERTILIZERS: Pineapple must be heavily fertilized, starting at 2 months after planting and every 4 months thereafter. The Corporation Mixture or any other comparable mixture may be used at the rate of one ounce per plant at each application. Since there are three applications a year, this means an annual requirement of about 14 cwt per acre for 8,000 plants per acre. Fertilizer must be sprinkled under the basal leaves of the plants. On no condition should it be sprinkled on the growing tips which will die. The fertilizer mixture per acre of 8,000 plants should be comprised as follows:

225 kg	($4\frac{1}{2}$ cwt)	urea
75 kg	($1\frac{1}{2}$ cwt)	conc. superphosphate
$362\frac{1}{2}$ kg	($7\frac{1}{4}$ cwt)	muriate of potash

It is enough for three split applications applied at four-monthly intervals.

DISEASE CONTROL: Pineapple 'wilt' is thought to be caused by a virus which is activated by the feeding of the mealy bug. Mealy bugs live and feed in between the leaves specially towards the base. They are carried about in the plantation and to other plantations by ants.

It is strange though that in the up-country where pineapple has been cultivated for the past quarter century in the Hali-ela, Deegala and Hathakma areas there are no signs of pineapple 'wilt' even though mealy bugs are found to infest the plants. The possible explanation is that the virus is not found at the higher elevations.

It is called the 'wilt' disease because the leaves wither and die. Diseased leaves take on an orange-brown colouration. If the diseased plant is uprooted the roots too will be seen to be withered. Since the mealy bugs and ants are supposed to be the 'culprits' in spreading this disease — at least in the wet low-country, control action is directed against them.

Mealy bugs can be controlled by using a drenching spray of Fenitrothion (e.g. Sumithion) or Methamidiphos (Tamaron, Monitor), or Mathomyl (Lannate) or Fenthion (Lebaycid), or Phenthoate (Cidial, Elsan, Papthion) or Carbophenothion (Trithion ZE) once in 3 months. In the case of ants Aldrin or Chlordane 20% E.C. is the recommended insecticide. It is sprayed between the rows and along the periphery of the plantation.

HARVESTING & YIELDS: The time taken for the first harvest will depend on the planting material used. The yield will also vary according to the pattern of planting.

In a young coconut estate for instance, where single rows of pineapple are planted 6-7 ft apart to give an average of 4,000 plants per acre, the second year's yield will be about 3,000 fruits of approx, 6 lb each, giving a total of 18,000 lb per acre, while the third year will be about 4,000 lb of 6 lb fruits, giving a total of

24,000 lb per acre. During the fourth and fifth year the yield will remain at about 4,000 fruits per acre, but as the fruits tend to be smaller, the yield will drop to 20,000 lb and 16,000 lb respectively.

In a pure stand of pineapple, on the other hand, with a plant population of 14,000 per acre, the yield during the second year should be about 12,000 fruits of about 5 lb each, or a total of 60,000 lb per acre. In the third year about 14,000 fruits should be obtained giving a total of 70,000 lb per acre. If the plantation is maintained for a further year the yield will be reduced to about 56,000 lb to the acre. The normal life of a well managed plantation is four years.

The natural fruiting season for pineapple in the low-country wet zone is from May to July and again in November to January. Off-season production to feed the cannery all round the year has to be induced by the application of hormones, calcium carbide or alpha-naphthalene acetic acid, to the growing point in the centre or crown of the plant.

The simplest way to do this is to add a handful of calcium carbide to a vessel containing 4 gallons of water, and to apply about one-third cupful of this freshly made solution into the crown of each plant. The plants so treated come into flower in 6 - 7 weeks and the fruits mature 4 - 4½ month later, i.e. about 6 months after treatment. For best results see that only fully grown plants (with about 30 leaves) are treated in this way. If there is no rain for 48 hours after treatment success is guaranteed.

As an alternative, alpha-naphthalene acetic acid may be used in accordance with manufacturer's instructions. This hormone may be used not only to induce flowering but also to delay fruiting. In the latter instance it must be sprayed on young fruit.

CROP BUDGET: The following budget may be taken as a guide for one acre (14,000 plants) of kew pineapple grown over an economic life period of 3 years:

Capital Costs	*Rs. Cts.*
Rough Fencing	750.00
Land Preparation	250.00
Planting material @ -/25 cents (inclusive of transport)	3,500.00
Trenching & Planting	450.00
	4,950.00

Operational Costs of 3 years	Rs. Cts.
Weeding	900.00
Fertilizers—8 applications @ 10 cwt each (50% Subsidy)	4,000.00
Labour for applying fertilizer	342.00
Disease Control (Insecticides)	4,160.00
Labour for spraying	490.00
Hormone (Calcium Carbide)	315.00
Hormone application	135.00
Labour for other pest control e.g. birds, rodents etc.	300.00
Harvesting & Field Handling for 2nd & 3rd years	350.00
	10,992.00

Gross Income:	Rs. Cts.
2nd year—60,000 lb @ -/20 cents	12,000.00
3rd year—60,000 lb @ -/20 cents	12,000.00
Suckers—30,000 lb @ -/20 cents	6,000.00
	30,000.00

NOTE: Labour rates have been taken as Rs. 7/- per man and Rs. 5/- per woman per day. The selling price of -/20 cents is based on Marketing Department Cannery rates paid in the field at the time of going to press.

Mango *Mangifera indica*

Like the inevitable *thambili*, most people would like to have a mango tree or two in the garden. But what varieties do we select? That is the first question to decide, and the decision will depend on climate and in case of commercial production on the "canning" quality.

VARIETIES: So far as canning is concerned the Jaffna Mango or *Karathacolomban*, the Bombay mango or *Betti amba* and the

Willard are the most acceptable. For domestic production three more may be recommended viz., *Vellaicolomban*, *Ambalavi* and the Parrot mango or *gira amba*.

Karathacolomban and *Ambalavi* are specifically dry-zone varieties. They thrive when there is a definite dry spell to facilitate pollination, fruit set and maturity. Wet weather interferes with all these processes.

Many home-gardeners, enamoured by the reputation of *Karathacolomban* as a mango *par excellence*, have attempted to grow this variety in the wet zone with unsatisfactory results. Poor bearing, or bearing on alternate parts of the tree and in alternate years and poor quality have all resulted as a consequence of planting this variety in an unsuitable climate.

Parrot mango and *Betti amba* on the other hand are essentially wet zone varieties. *Vellaicolomban* and Willard may be grown in both zones, although they do best in the dry zone. In fact, cropping in Willard is sometimes so heavy in the dry zone, that a certain degree of fruit-thinning is desirable to produce fruits of good market value.

PLANTING MATERIAL: Grafts are preferable to seedlings because they have the double advantage of bearing true-to type and coming into production very much earlier. Grafted trees are also of a more manageable size and do not take much space in the garden. Cleft grafts at a height of 2-3 ft are common in the Jaffna and Vavuniya Districts, or bud-grafts at a lower height are the most common. There is yet another form of grafting called stone or seed grafting. This is a very rapid method of propagation—the grafts being ready for planting in 3 months. But because the plants are small and weak they require extra care and attention, and in the circumstances cannot be recommended except to professional horticulturists. The cleft-grafts and bud-grafts are the hardier and more conventional type of planting material.

PLANTING: Planting distances vary with varieties. Small varieties like the Willard and *Ambalavi* may be planted 30 - 35 ft apart. Other varieties require a wider spacing of 45 ft.

Grafts are planted in holes 2 feet square by at least 18 inches deep. In digging the holes the top 9 - 12 inches of soil are kept separate from the underlying soil. The top soil is mixed with 3 - 4 baskets of well rotted cattle manure or compost and put back into the *bottom* of the hole with the originally underlying soil on top. When the soil has settled you may plant the grafts, placing them at the same height at which they were in their bamboo or polythene containers. Then, firm the soil and follow the instruction given on training in the section on "Vegetative Propagation".

FERTILIZERS: Correct fertilizer practice is important because it ultimately regulates the capacity of the tree to bear fruit. In nine cases out of ten failure to produce fruit in mango trees that have not yet reached senility may be attributed to faulty fertilizer practice. In the circumstances, old-time recommendations to ringbark the branches and add salt to the soil are no longer valid.

What we have got to remember in respect of the fertilizer requirements of mango is that this fruit crop requires plenty of nitrogen in the early stages of growth and plenty of phosphorus and potassium in the later stages once production begins. Too much nitrogen at this stage can upset the critical carbon-nitrogen ratio in respect of fruit production.

In the early years up to bearing, therefore, urea may be applied at the rate of 1 - 7 lb per plant per year in split doses. But when bearing begins the urea is replaced by any commercially available fruit mixture containing a high proportion of phosphorus and potassium in relation to nitrogen. This mixture should be applied twice a year—at the beginning of the *maha* season and at the end of the season after the harvest has been taken—making a total of 8 - 15 lb per tree according to age.

PRUNING: There is another important practice that contributes to the continuity of high yields. This is pruning, and it is something that is neglected by most mango-growers. It is necessary to remove or cut away all the weak shoots and drooping branches in the centre of the tree following every harvest. This is necessary to provide a free circulation of air. The freer the circulation of air the greater the chances of obtaining high yields *ceteris paribus*.

PESTS & DISEASES: Pests and diseases are a bigger problem in the wet zone than in the dry zone. The most serious pest is the mango weevil. This little creature enters the fruits when they are very small. The damage it does causes the fruits to drop. Sometimes the weevil lingers on in the fruits that do not drop. And when these fruits are finally harvested they are found to be riddled in seed and flesh. There is no combative action that can be taken against these pests. Two varieties in particular are very susceptible viz., *Chembatan* and *Neelam*. Hence their exclusion from the varieties recommended earlier. Parrot mango is however somewhat resistant.

Another problem in the wet zone is tip-rotting in developing fruits. Here the damage is caused by combined insect and fungal action. Mango hoppers—these are small wedge shaped insects which attack the fruiting spurs—suck the juices from the developing fruits. A *gleosporium* fungus invades the damaged portion and subsequently causes a rot.

The obvious method of control would be to destroy the hoppers, as soon as they are observed. Their presence in large numbers is indicated by a blackening of the flowers. This blackening is caused by a fungus known as sooty mould, which lives on the sticky exudations of these insects.

These pests can be destroyed by spraying the trees during the flowering season and immediately after with a suitable insecticidal solution. Anyone of the following may be used: Fenitrothion, Folimat, Fenthion, Malathion, Dimethoate or Pirimiphosmethyl. 560 - 600 ml (20 - 30 fl. oz) of spray solution are required to spray a single tree 20 - 30 ft high with a power sprayer.

Papaw *Carica papaya*

As a health food papaw has few equals in the fruit world. It contains the vitamins A, B, C and D, and the digestive enzyme pepsin, all of which are vital to good health. When it comes into bearing in one year it bears freely and continuously for about five years. During this time you can get 30 - 40 fruits annually per plant.

This fruit crop is also easy to grow as it is not fastidious in its requirement of soil, water and climate; although there is one thing you must ensure if you want to be successful, and that is good drainage. Emphasis has to be laid on good drainage because papaw is extremely susceptible to waterlogging, which causes the stem to rot. Be sure therefore, to plant this fruit crop on high or sloping ground. Or if this is not possible, then it may be necessary to dig drains during the rainy season to carry standing water away from the plants. If you do not take this precaution the papaw plants are likely to be diseased. What happens is that a pythium fungus attacks the stem at ground level causing it to rot. When this happens the leaves take on a yellow colour, and in extreme cases there is complete defoliation. Examination of the base of the trunk should reveal rotting tissues slightly below and above ground level.

VARIETIES: Unfortunately, there are no specific varieties. Some time ago the Department of Agriculture had the Solo Hawaii and the Peterson. But today these varieties cannot be identified because they have been freely cross pollinated by other varieties. This is the trouble with papaw. It is so freely cross pollinated that no pure forms are available.

And this, of course, poses the problem of selection. Unless you have some sort of sixth sense, you will have to rely completely on your taste buds. If you happen to come across a particularly tasty fruit, then by all means keep the seeds for planting.

A word of warning though! Do not keep the seeds too long. Plant them within a week or they are liable to lose their viability. You can either plant them straightaway in their mucilaginous state, or more conveniently you could dry them in the sun first. You may plant the seeds straightaway in prepared holes in the garden, spaced 8 - 10 ft apart, or you could first plant them in a nursery and then transplant them later to the prepared holes. But if you transplant the seedlings be sure to do so before the plants become too mature. A good time to transplant would be when the seedlings are between one and two months old. At this stage they should be about one foot high. Make sure that the transplants are planted at the same level in the hole that they were in the nursery. This precaution is necessary to prevent the occurrence of collar rot.

SEX DIFFERENTIATION: But no matter what method you employ—direct seeding in the holes or transplanting seedlings—you must remember to use 3 - 4 times the number of seeds or plants that you actually require. This is necessary not only to make allowance for the rejection of weak plants at a later date, but also for the rejection of useless male and female plants.

Papaw seeds give rise to three different types of plants. One type has only male flowers; one type only female flowers; and one type has bisexual flowers, which have both the male and female parts in the same flower. It is only these bisexual plants that should be maintained because they can cross pollinate and fertilize themselves, whereas the male plants and the female plants need each other to do this. And in a small garden there is usually no room for this separation of sexes. Although in large plantations it is customary to keep sufficient male plants (one male to every 8 - 10 females) to ensure cross pollination and fruit set.

The point is that you cannot distinguish these three types till the plants come into flower and this happens only 4 - 6 months after planting. This is why you initially plant 3 - 4 times the required number of seeds or plants and begin to sort them out at flowering.

The male plants are easily recognised because they bear long hanging recemes of flowers. On the other hand, the female plants and bisexual plants bear single flowers at the junction of the leaf stalks with the main stem. To distinguish between them you have to examine the flowers. If the flowers have only prominent ovaries at the base and no stamens or anthers, then they are female. But if they have prominent ovaries and also stamens and anthers then they are bisexual. One bisexual plant should be maintained in each hole and the other plants removed.

DISEASES: In recent times a serious virus problem has cropped up, which causes the leaves to turn yellow with an unmistakable mosaic pattern. The problem can be very frustrating from the grower's point of view, because the symptoms do not usually manifest themselves until the plants are well grown and ready to bear. Then you suddenly notice that the top leaves become yellow and stunted. When growth is retarded in this way the plant does not bear fruits. Or if it does, the fruits remain immature and finally drop off.

Since the disease is caused by a virus there is really nothing you can do to control it. No economically effective control measures have yet been found. All you can do is to cut down the plants and destroy the diseased foliage. This might seem unduly drastic, but it is the only sure way to control the spread of the disease.

Of course, in the alternative, you could cut off the diseased crown and allow the stem to branch again. And once the new leaves appear you could spray them at fortnightly intervals with a suitable insecticide (Monitor, Lannate, etc.). This way you could attempt to prevent the little insects which carry the virus from settling and feeding on the leaves. But it is not a foolproof method of control. It can also be costly and cumbersome.

Diseased plants do not die easily. They remain in a state of arrested growth, and this gives the unwary gardener the hope they will come round in time. But this is wishful thinking. The trees will never recover. So the best thing you could do is to cut them down and burn or bury the diseased portions. Because as long as you allow them to remain in the garden, they will act as a reservoir of infestation. Small flies called aphids feed on the leaves and carry the virus infection to other healthy plants.

FERTILIZERS: Since papaw is a rapid grower and a prolific bearer it requires plenty of nutrients to maintain vigorous growth and fruiting. For home-gardeners specially prepared papaw fertilizer mixtures are available in 3 - 5 lb polythene packs. For large plantations however, it is always best to mix your own fertilizer ration. The following may be recommended : 1 part urea, 2 parts conc. superphosphate and 2 parts muriate of potash. Half-pound of this mixture is applied to each planting hole at the time of planting. It is followed by similar applications every three months during the economic life period of this crop.

Cashew *Annarcardium occidentale*

Cashew often occurs in wasteland in the low-country, but it is really suited to the coastland from Puttalam through Mannar to Batticaloa. The yellow latosols are ideal for this crop which is very drought resistant and can thrive in areas where the rainfall does not exceed 20 inches. There are no well defined varieties. Trees that bear medium-sized nuts with plump hard kernels and which have 50 - 60 nuts to the pound may be selected as mother trees.

PROPAGATION & PLANTING: Pick the fruits when the cashew apples turn red, orange or yellow in colour. Separate the nuts from the apples and dry them for a few days in the sun. Well dried nuts can be stored for about a year without losing their viability. The nuts can be planted directly in the field, or in a nursery first. The nursery method is recommended because nuts planted direct are often eaten by rodents, pigs and monkeys.

Plant the seed in perforated, manured polythene bags 4″ × 9″ or 6″ × 12″ in a vertical position with the stalk end up. Water them and leave under light shade to germinate. Germination takes place in 10 - 15 days. Seedlings may be planted out when they are 2 - 3 weeks old. Encourage vigorous growth by watering with an urea solution (one ounce in 3 gallons water) every 3 - 4 weeks till the seedlings are 6 - 8 months old. At this stage, if more than one seedling has been planted in each hole, discard the poorer growers and maintain only the most vigorous.

Fully developed cashew trees need a spacing of 35 ft. But if the seedlings are planted straightaway at this spacing (i.e. only 36 plants to the acre) then the early yields will be low and unprofitable. It is more advantageous, therefore, to plant at a closer spacing initially and to thin out later at 5 - 7 years to the correct spacing.

The recommended initial spacing is 22 × 22 feet (90 trees per acre). This stand is thinned by removing every alternative tree to give 45 trees per acre. This is shown diagramatically below.

O	X	O	X	O	X	O
X	O	X	O	X	O	X
O	X	O	X	O	X	O
X	O	X	O	X	O	X
O	X	O	X	O	X	O

Fig. 4·13 X = *Trees removed* O = *Remaining trees*

Intercrops are useful both as an additional source of income and to suppress weeds. But do not grow castor or Toor dhal as these harbour the same pests as cashew.

FERTILIZER APPLICATION: A little cattle manure in the planting holes is alright. But for quick growth and steady productivity fertilizers are necessary. As an alternative to a recognised ready-made cashew fertilizer mixture mix your own as follows: 2 parts urea, 1½ parts conc. superphosphate and 1 part muriate of potash. Apply as shown below:

	Oz / plant per application	*Lb / ac. per application*	*No. of applications per year*
1 st year (90 trees)	2	12	2
2nd year ,,	4	23	2
3rd year ,,	8	45	2
4th year ,,	16	90	2
5th year ,,	24	135	2
After 5 years (45 trees)	32	80	2

Spread the fertilizer in a band about half as wide as the spread of the leaf canopy starting in line with the drip edge of the canopy. and fork it lightly into the soil.

HARVESTING & PROCESSING: Trees start bearing in 3 - 4 years and reach maximum production in 9 - 10 years. The yield at this age is on the average of 2,000 lb/ac or 2,000 nuts per tree.

Once the nuts have been separated and dried, the kernels have to be extracted by roasting. Approximately 4 lb of nuts will give 1 lb of kernels, after shelling. This job is usually done by women. A woman can shell 30 -35 lb of nuts a day. The next step is peeling the skin. This is done after drying the kernels in an oven. The temperature inside the oven is maintained at about 120° F and the kernels are kept there for about 3 hours.

After peeling, the kernels are graded into whole, halves, pieces, etc. The number of whole kernels per pound is graded as follows:

Grade	*No. of kernels per lb*
W 210	200/210
W 240	220/240
W 280	260/280
W 320	300/320
W 400	350/400
W 450	400/450
W 500	450/500

W 240 and W 320 are preferred by international markets.

PEST CONTROL: This crop is remarkably free of pests and diseases, but is occasionally attacked by Helopeltis bugs, stem borers and bark borers. Helopeltis attacks the young flush. It can be controlled by dusting 10% BHC at 30 lb / ac, repeated in 10 - 14 days. The stem borer is a huge larva which bores into the trunk of the tree. It is necessary to enlarge the boring in the trunk and inject a solution of Chlordane (Intox 8) to control the pest once it has established itself. But otherwise preventive sprayings can be given on the main trunk and branches with the same insecticide. This spraying will also control the bark borer.

Grapes *Vitis vinifera*

In recent times there has been a marked interest in grape-growing. Home gardeners, in particular, are always trying their hand at growing at least one vine, just for the novelty if nothing else.

Actually, there is no difficulty in growing grapes. The vines come up fairly well anywhere in the country, so long as they have enough moisture at the root for active growth. But to achieve any sort of satisfaction it is very necessary to start right—with the right variety for the right place.

Grapes are essentially a dry zone crop. They require a low rainfall and atmospheric humidity and a long dry spell during maturity to build up the sugars in the ripening fruit. Heavy rains are unsuitable as the vines become over vigorous, often giving a poor crop. High humidity during the rainy period also makes the vine more vulnerable to 'mildew' which spoils the quality of the fruit and retards growth.

VARIETIES: Several varieties have been tested at the Maha-Illuppallama Research Station viz., Semilon, Afuz-Ali, Tita-Caprio, Kara Kaltak, Israel Blue, Royal Ascot, Anab-E-Shahi, Red Prince and Shiraz. Of these the Roumanian variety "Afuz-Ali" and the Israelean variety "Israel Blue" have shown up best. They are recommended for cultivation anywhere in the dry zone. These varieties perform best when trained to grow on an overhead bower or pandal. Yields of 110 lb per vine have been taken from seven-year old vines trained in this manner.

An even more prolific variety is Semilon, from which 125 - 130 lb of grapes have been taken from vines of the same age. But Semilon cannot be recommended as a table grape because its fruits are small and tend to be acid, specially when harvested a little too early. As a wine grape however, it is good.

Royal Ascot—both the green and purple varieties—have also given good yields at Maha-Illuppallama, producing large sweet fruits, but they are inclined to be susceptible to Powdery Mildew and Downey Mildew. Despite this disadvantage, the green variety is popular in the Mannar District.

In the Jaffna District the following varieties have been successful: Concord, Danube, Muscat and Kabul.

What about the wet zone? Actually the wet zone is not a proper place to grow grapes. Yet there are people who insist on trying their hand at its cultivation in the wet zone, mainly in home gardens. To them may be recommended Improved Isabella, a variety that is resistant to powdery mildew and is also a good cropper, even if the grapes tend to be a little sour.

PLANTING MATERIAL: Grape vines are raised from cuttings containing 3 - 4 nodes and approx 10 inches long. These cuttings are raised in polythene bags first and later transplanted in the field with the onset of the rains. It would be better however, if they are planted out during the dry weather provided of course that there is irrigation: this reduces the incidence of casualties caused by mildew.

The polythene bags must be removed completely before planting and the main shoot cut back to two buds to enable it to put out vigorous new branches. Shoots that arise from the old cutting should be removed at planting time with the aid of a sharp pruning instrument.

TRAINING SYSTEM : Grapes are trained to grow on a trellis, on an overhead bower or as a bush. The first two systems are popular in this country.

TRELLISES are spaced 12 ft apart. The vines are planted 8 feet apart along the trellises. Wooden posts are erected in between the plants and three wires are drawn tautly across these posts, the bottom wire 2 feet above ground level, the middle wire 18 inches above the bottom wire and the top wire 18 inches above the middle wire. These wires may be galvanized 14 gauge.

The rooted cuttings are allowed to grow straight up with the help of a stake. When they have grown above the top wire, they are headed back just a few inches above it and six side branches are trained to grow in opposite directions along the three wires. When these branches have grown to reach the upright posts on either side they are cut back to encourage lateral branching. Laterals are spaced 6-8 inches apart, the first lateral 10-12 inches away from the main stem.

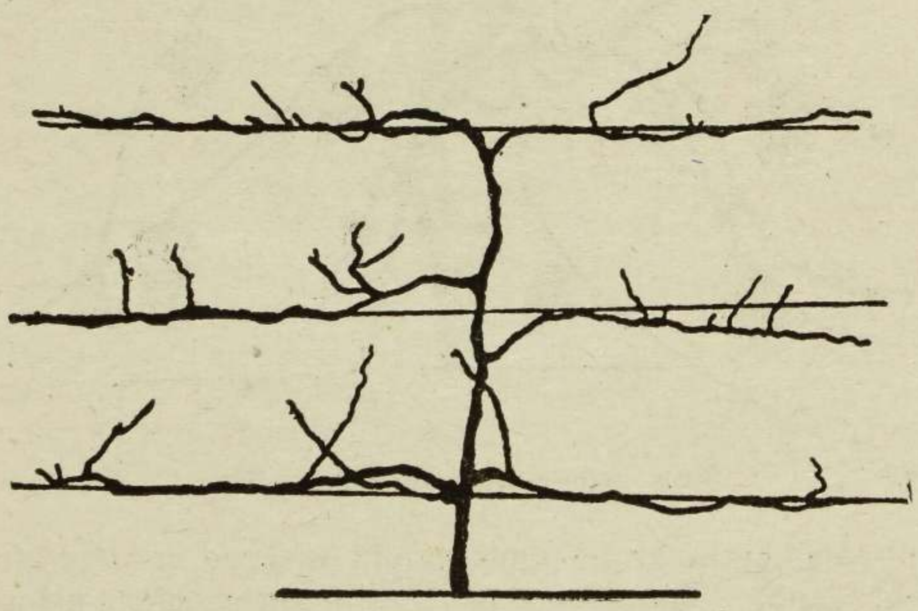


Fig. 4·14 *A diagramatic representation of the trellis method of training grape-vine.*

The *bower system* is very popular in home gardens. Here the vines are planted in rows 24 feet apart and 12 feet apart in the rows. Timber posts are erected in such a manner so that a single vine comes in the centre of four posts. The posts may be 5½ - 6 ft high with rafters fitted crosswise and sidewise to form a roof.

When the vines have grown two feet above the bower they are cut back to the top leaving three branches. All the others are removed. These three branches are trained to grow on top of the bower and after a few months the weakest is removed. From the two remaining branches laterals are now allowed to develop at two-foot intervals. These laterals are trained to grow in a herring bone pattern.

In the *bush system* no posts or wires are required. The vines are planted 5 feet square and pruned back to form bushes. As each vine (heavily staked) reaches a height of about 4 feet it is cut back leaving four secondary branches; all the other branches are removed. On these secondary branches are produced the laterals which bear the clusters of grape.

Semilon is a variety that has been successfully trained in this manner.

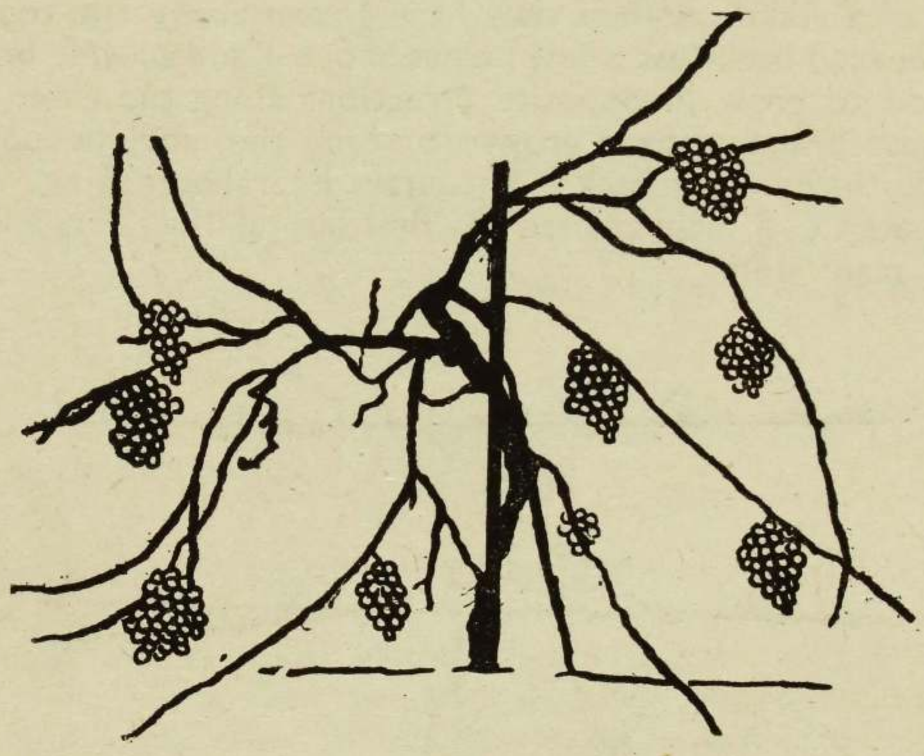


Fig. 4·15 *Bush method of training grape-wine*

The holes for the grape vines should be large, at least 3 ft square and 3 feet deep, They are dug 1 - 1½ months before planting and the soil mixed with cattle manure and fertilizer. Soil and well rotted cattle manure are mixed fifty-fifty. The fertilizer is applied at planting. (For quantity and composition of mixture see page 147).

PRUNING: Pruning is the most important operation in grape vine because it has a direct relationship with yield. In grapes, flowers are produced on the current season's growth, therefore the aim in pruning is to get enough new growth without impairing the vigour of the vine.

In the trellis system it is the lateral branches that come off the six side arms that are pruned. In the bower system it is the lateral branches that are trained into a herring bone pattern that are pruned. In the bush system the same method is employed. That is, the bunch-bearing laterals are pruned seasonally, but some attention must also be given to pruning to prevent overcrowding of the crown after the framework is formed. In the case of young vines and not so vigorous vines the laterals are cut back leaving 2 - 5 buds from which new sprouts are allowed to develop. Vigorous vines are pruned leaving 6 - 9 buds.

Usually 4 - 5 weeks after pruning the grape vine starts flowering, and from that time it takes another 9 - 10 weeks for the berries to ripen. Berries should be harvested *when fully ripened* on the vine as there is no post-harvest ripening in grapes. The maturity of the berries at the base of the bunch is a good indication of the state of ripening. When harvesting, bunches should be picked from the stalk without handling the berries. If the berries are touched the wax protection is removed and this results in lowering the keeping quality.

Grapes are pruned twice a year under our conditions. In the dry zone this is done in early December and again in late May or early June. The best crop is obtained from the second pruning because of the long dry period that follows from June to September, which is ideal for maturity and ripening. To get maximum fruit set pruning should be done when there is no rain. In the case of irrigated crops this means that irrigation must cease from at least three days before to three days after pruning. Unless this is done there can be an excessive exudation of sap from the cut portions. It is also a wise precaution to spray the vines with a fungicide immediately after pruning to prevent the entry of harmful disease-organisms at the cut ends.

FERTILIZERS: The fertilizer mixture recommended for grapes is 1 part urea, 2 parts conc. superphosphate and 3 parts muriate of potash. One pound of this mixture must be applied to each planting hole at the time of planting, followed by six-monthly top-dressings in the following quantities per vine:

1 lb six months after planting

1½ lb 1 year after planting

2 lb 1½ years after planting

2½ lb 2 years after planting

3 lb 2½ years after planting and

the same quantity thereafter every six months.

Fertilizer dressings should be timed to coincide with the pruning cycles. If cattle manure is available this too may be added at the rate of 2 - 3 baskets (50 lb) per vine every six months.

DISEASES: Downey Mildew is a serious disease during wet weather. It first appears as translucent patches on the leaf, turning to yellow and brown as the leaves die off. In the final stages of infection whitish spores may be seen on the underside of the leaves.

Since the disease can spread rapidly to other parts of the vine as well, timely control is very necessary, preferably, a preventive spraying, with the onset of wet weather. Antracol is a suitable insecticide.

Orange *Citrus sinensis*

Oranges grow best in the dry zone where low atmospheric humidity and a definite dry period aids growth and maturity of fruits. Apart from climate, soil is another important factor that must be taken into consideration when planting oranges. It has been found that soils 5 - 6 feet deep without a gravelly layer or hard pan and a water table that does not come within 3 feet of the surface are suitable. Such soils are found in the dry zone along the coastal belt stretching from Puttalam to Mannar and they constitute the potential citrus growing region in the country as soon as underground sources of water can be harnessed for irrigation.

VARIETIES: There is no great choice of varieties. At present only the "Bibile Sweet Orange" is recommended by the Department of Agriculture. And this is made available only in the seedling form because of the risk of transmitting the Tristeza virus via grafts. The Tristeza virus has been responsible for the die-back of citrus plantations all over the Island. It is so widespread that the Department of Agriculture does not advise the use of bud wood for grafting except from guaranteed disease-free mother trees. Furthermore, the use of seedlings is advocated because they are less liable to be affected by Tristeza. Research has shown that the virus causes a breakdown of the food-conducting tissues (above the bud union) only in grafts and not in seedlings.

Till such time as Tristeza-resistant stock-scion combinations are produced a greater reliance will have to be placed on the use of seedlings as propagation material. Fortunately, orange seedlings are polyembryonic, which means that they can be expected to bear true to type, even though they may take a few years longer to bear fruit than grafted plants.

PLANTING: Planting should be done in the open, away from the shade of tall trees such as jak and mango. Unless orange plants have sufficient sunlight they are liable to develop the Tristeza disease and begin to die-back in about 5 - 7 years time. Holes should be spaced 15 - 20 feet apart.

FERTILIZERS: Neglect of manuring is one of the main reasons for the poor performance of citrus in this country. When the plants are not vigorous they easily succumb to the Tristeza disease. In particular, citrus has a high nitrogen requirement and unless this is supplied production will suffer. In addition to cattle manure therefore, supplementary applications of fertilizers should also be given.

The recommended mixture for plants that are not in bearing as yet is 2 parts urea, 1 part conc. superphosphate and 1 part muriate of potash. One pound of this mixture should be applied to each hole at the time of planting. Thereafter top-dress with half-pound of the mixture every season (i.e. *maha* and *yala*) until bearing begins.

The mixture per bearing tree is 1 part urea, 1 part conc. superphosphate and 1 part muriate of potash. The quantity to be applied per bearing tree is as follows: 2 lb in the first year of bearing, 3 lb in the second year of bearing, 4 lb in the third year of bearing and 5 lb in the fourth year of bearing and thereafter. This quantity should be split into two equal doses and applied twice a year towards the end of each rainy season.

Home-gardeners having one or two plants in the garden may use the prepared fertilizer mixtures that are available in the local market.

PESTS & DISEASES: Like manuring, neglect of control of pests and disease can reduce the vigour of the crop, thus making it more susceptible to Tristeza. Strict preventive measures have therefore to be taken if a successful crop is desired. Aphids and scale insects are quite common. They usually collect on the underside of the leaves and on the young stems, and are associated with a black fungus called sooty mould. They can be controlled by spraying Fenitrothion (Sumithion), Mathomyl (Lannate), Methamidiphos (Tamaron, Monitor), etc.

Moths and flies damage the fruit. Moth damage can be distinguished by the punctures on the fruit through which the juice squirts when pressed. Fruits attacked by flies contain maggots. Control can be effected by spraying with Fenthion (Lebaycid) every two weeks from the time of fruit set.

Leaf-miners, or tiny caterpillars which tunnel into the young leaves and destroy them may be controlled by spraying with Dimethoate 40% E.C.

Pink Disease and Mildew are two common diseases. They are both active during the rainy season.

Pink disease is usually found at the forks—the characteristic symptom being a pink incrustration of the fungus on the dead bark. If the disease is well established it will be necessary to remove the dead bark and excise the diseased portion of the stem. Preventive action should be taken by spraying the trees, specially at the forks, prior to each rainy season with a 10 per cent solution of Brunolinum Plantarium.

Mildew is also caused by a fungus which is seen in powdery white patches on young leaves and shoots. The affected leaves shrivel and die. Preventive action should be taken before the advent of each monsoon by spraying with a copper fungicide. To control the disease once it has appeared spray with Thiovit or Sulfinnete or dust with flowers of sulphur.

Scab and canker are diseases which affect young seedlings. They are very much alike in that they cause spongy eruptions on the leaves which later take on a corky appearance. Spraying with Sulfinnete as for mildew is fairly effective.

Lime *Citrus acida*

The local variety and the imported Tahiti are the best varieties to cultivate because they are both prolific croppers, producing large, thin-skinned, round fruits with a very high juice content. A single bush of local lime when in full bearing could produce as much as 1,000 fruits in a year.

Unfortunately, both these varieties are seasonal bearers, producing only one principal crop annually. Which means that in season you have a surplus of limes and out of season a dearth of limes. To offset this disadvantage and have an uninterrupted supply throughout the year it would be necessary to grow hybrid lemonime too.

Lemonime, which is a cross between lemon and lime, bears all the year round. It comes into bearing in 9 - 15 months in comparison with the other two varieties which take 3 - 5 years. Lemonimes are round but they are a little more thick-skinned than the others and have less juice. These are disadvantages that are compensated by the early-bearing and all-the-year-round bearing habit of this hybrid.

Limes are planted 10 - 12 feet apart. They are given the same attention as orange in respect of manuring and pest and disease control. Remember that lime is just as susceptible to the Tristeza virus disease as orange—that is, the Tahiti and local varieties: the hybrid lemonime is fairly resistant.

Characteristic symptoms of this virus disease are the curling up and yellowing of the young leaves, and the ultimate die - back of the plant from the tips when it is 6 - 7 years old. Some plants collapse quickly. Others stay alive for some years but are useless economically. Because of these symptoms the disease is called 'Tristeza', meaning 'Melancholy' in the Brazilian language. Tristeza has been responsible for the large scale destruction of Brazilian citrus orchards.

In California too where it is an ever-present problem this disease is called the 'quick-decline' virus, or 'bud-union decline' and 'rootlet rot', because a breakdown occurs in the conducting tissues at and below the bud-union, which blocks the transmission of carbohydrates from the leaves to the roots. Consequently the roots are starved of carbohydrates and begin to rot.

There is no cure for this disease. Yet it can be kept under control by keeping the plants growing vigorously at all times. Vigorous growth can be assured by paying particular attention to manuring and pest and disease control measures. The same fertilizers used for orange may be applied here.

NOTE: In the dry up-country e.g. Rahangala, the Philippine Red Lime grows well.

Strawberry *Fragaria vesca*

Strawberries are grown only in the wet up-country above 5,000 ft. "Phenomenal" is an excellent variety from Australia which can give over 5,000 lb of fruit per acre.

In the acid soil of the Nuwara Eliya region a biannual application of finely ground dolomitic limestone should be given at the time of preparatory tillage. Beds are then prepared 6 feet wide and of any convenient length, separated by 1½ feet wide drains. They are manured with 10 tons of cattle manure and the following fertilizer mixture per acre: 87.5 kg (1¾ cwt) urea, 87.5 kg conc. superphosphate and 50 kg (1 cwt) muriate of potash.

PLANTING: Strawberry plants are planted in double rows on each bed as shown below:

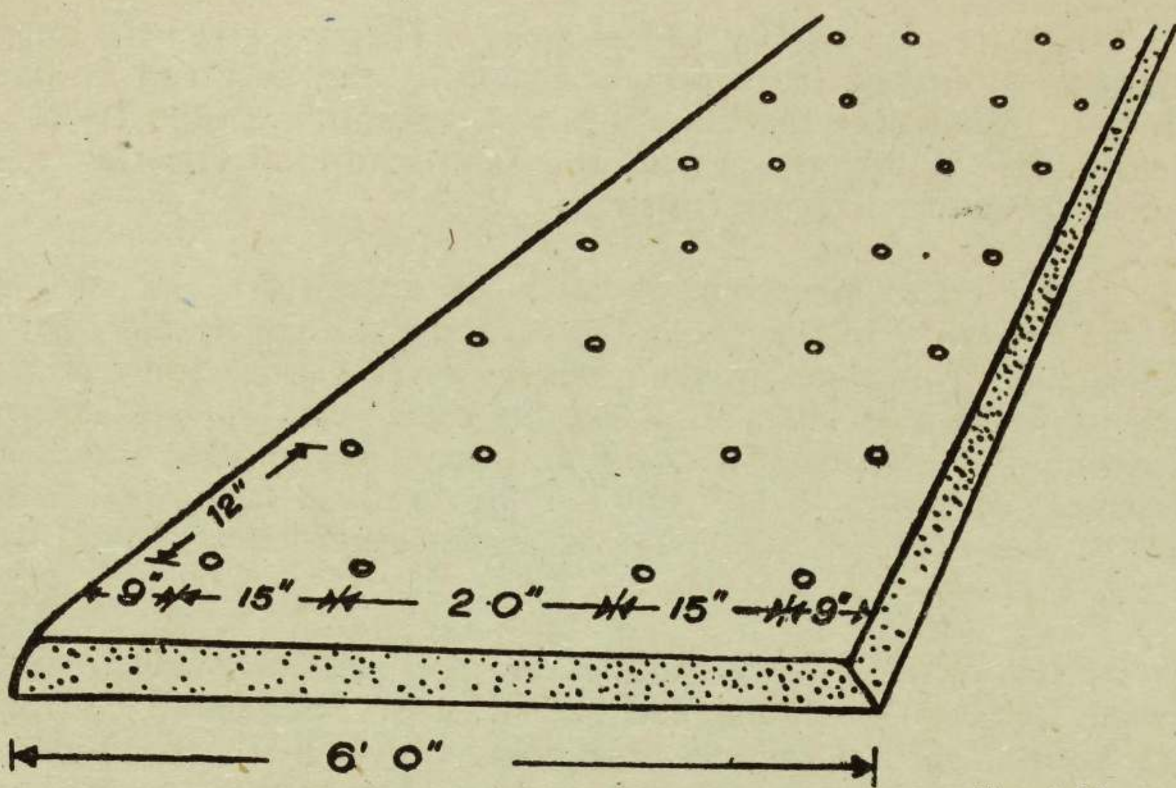


Fig. 4·16

Avoid deep planting and be careful NOT to cover the central growing part of the plant with soil as it will die.

Plants will start flowering early but the flowers should be picked off till the crop is 4 months old. This will give the plant the time to develop a strong root system. Fruiting is helped with a top-dressing of the following fertilizer mixture at 4 months of age: 50kg (1 cwt) urea, 50kg (1 cwt) conc. superphosphate and 25 kg ($\frac{1}{2}$ cwt) muriate of potash. Cover the soil with straw after forking in the fertilizer between the rows of plants.

To maintain vigorous growth and high yields the same mixture should be applied every six weeks during the life of the crop.

PESTS & DISEASES: Cut worms and white grubs may be troublesome soon after planting. Check any damage they may do by spraying with Lannate, Tamaron or Monitor.

A fungus disease causes black spots to develop on the leaves. Antracol is used to control it.

Apples *Pyrus malus*

The traditional apple growing region is Ragala on the leeward side of the central hills between 4000 and 5000 feet where the rainfall is about 60 inches a year. The chief variety cultivated there is the "Ragala Red," a prolific cropper producing about 250 fruits a year — the fruits are large red and juicy but somewhat acid. The greenish-yellow fruits of "Ragala Sweet" on the other hand, are sweet and compare in quality with apples of temperate origin. This variety, however, is a shy bearer. Other varieties doing well are "Rome Beauty", Royal Beauty" and "Tropical Beauty"—three introductions from sub-tropical countries. These introductions have also been successful at Rahangala.

PROPAGATION: Suckers of the "Ragala Red" are used as stocks for budding. They are removed from the mother tree and planted in a nursery. In six-months time when they are of pencil thickness, they are either 'T' budded or cleft grafted with selected scion wood.

Five to eight months after budding or grafting, the young trees are dug up and replanted in the field at a spacing of 10 feet. Cattle manure is mixed with soil when refilling the planting hole, and chemical fertilizer is also used.

FERTILIZER: At planting apply 6 oz of conc. superphosphate. Follow this with 2 oz of urea at 2 months, 2 oz of urea and 4 oz of muriate of potash at 6 months, and 3 oz urea, 6 oz muriate of potash and 2 oz of magnesium sulphate at 1 year.

During the second year in April apply 1 oz urea, 2 oz muriate and 1 oz magnesium sulphate per plant, and follow this in October with 2 oz urea, 6 oz muriate and 3 oz magnesium sulphate. Apply this in shallow trenches at the drip line of the plants.

Trees come into bearing at 3 - 4 years. After this they must be given 2 oz of urea and 4 oz of muriate per plant in April, and 6 oz urea, 12 oz muriate and 8 oz conc. superphosphate in October. This must be repeated throughout the economic life period of the crop, which is 20 - 25 years. Peak bearing is from the 7th - 15th year. Harvesting is usually done in July - August.

It is also advisable to add 2 lb of dolomite per tree every two years.

TRAINING: To hasten fruiting and obtain a good crown you must adopt a special method of pruning and training. When the plant is about 3 feet high, 4 branches are selected to form the framework. These are bent and tied down to a horizontal position with a rope attached to a stake in the ground. This results in a tree with a well developed crown. (Branches of untrained trees grow upward like a broom and make only a few lateral branches). The four main branches are about 2 feet from the ground level when training commences. The pegs are removed after 6 months to one year.

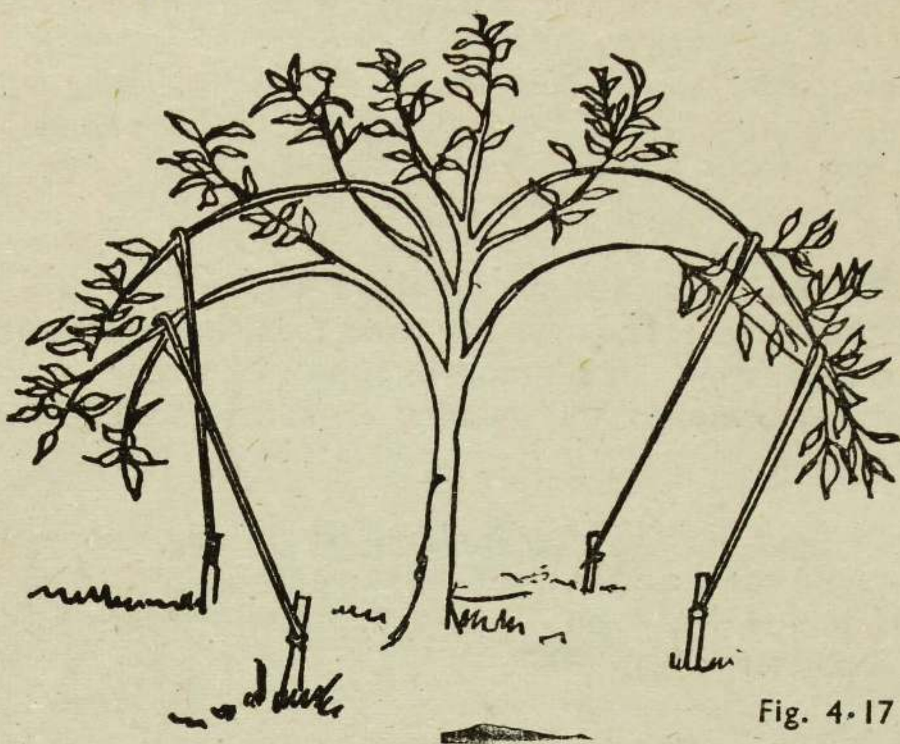


Fig. 4·17

How the branches are tied down

DEFOLIATION: To stimulate simultaneous flowering you may defoliate the trees when they are 2 - 3 years old. About one month later they flower, with apples maturing 5 months later. After harvest the trees may be defoliated again, and the cycle is repeated giving two crops a year. Spraying with a 2% solution of DNOC (eg. Exta—A) prior to the advent of the rains in October produced a satisfactory crop at the Rahangala Farm. Defoliation is not practised at Ragala where good crops are obtained naturally. But at lower elevations in Uva, defoliation is a "must" for successful apple culture.

DISEASE: Two common diseases are powdery mildew and pink disease. Powdery mildew kills the young shoots, leaves and flowers. It must be kept under control by spraying Thiovit during cool weather (but *not* in hot weather). 6 lb of Thiovit in 100 gallons water before flowering, 4 lb in 100 gallons during flowering and 2 lb in 100 gallons after flowering. Spraying is done at fortnightly intervals.

Pink disease has to be controlled by scraping off all infected bark and tissues and applying a copper fungicide on the excised area.

Peach *Persica vulgaris*

A small slender tree, the peach of the tropics is at best no comparison with the luscious fruit of temperate countries. It may, however, be cultivated in the drier parts of the up-country at elevations of 4,000 - 5,000 feet. No systematic cultivation, however, is followed here—the trees are usually propagated by cuttings but with little regard for cultivation and selection. Peaches can also be propagated from seed and as bud-grafts. One-year old seedlings of peach are used as root stock for budding. Shield-budding is the practice.

Peaches are transplanted 15 - 18 feet apart in medium-sized holes filled with 3 - 4 baskets of cattle manure. One to two-year old budded plants should be selected for planting. The application of cattle manure must be given every year, supplemented with artificial fertilizers. Peach is highly responsive to nitrogenous fertilizer. Fertilizer should be applied at the root zone followed by a light hoeing.

Peach starts bearing just after three years. Fruits are borne on one-year old shoots, so the current season branches may be pruned leaving 2 - 3 buds which will produce new shoots for the next year's crop. Manual thinning of the flowers or fruits increases the yield and fruit size. About 50 per cent of the pea-sized fruits are removed from each bearing shoot.

Yields are comparatively low in the beginning owing to the meagre spread of the plants, but a well developed tree about 8 years of age produces 60 - 70 lb of fruit in a season. Since the harvesting and storage period of peach is very short, due care must be taken to see that the fruits are picked only when they develop a vermilion tinge at the base and that they are disposed of quickly.

Aphids are the most serious pest. They suck the sap of the leaves causing them to curl. In very severe infestations the leaves turn yellow and drop after a few days. Spraying with Rogor 40 at intervals of 14 days should check the pest completely.

Pear *Pyrus communis*

A variety of cooking pear is grown in gardens in the Nuwara Eliya area. It has become well established, thriving with but scanty attention and producing during February to April fairly heavy crops of large coarse fruits. Propagation is by cuttings or layers. Plants are spaced 20 - 22 feet apart.

So far no experimental data are forthcoming on the nutrient requirements of pear under sub-tropical conditions. However, a complete fertilizer mixture e.g. 50 kg (1 cwt) urea, 100 kg (2 cwt) conc. superphosphate and 50 kg (1 cwt) muriate of potash may be used to advantage. One pound of the above mixture may be applied per plant at the time of planting; followed by top-dressings at the rate of 1 lb per tree in the first year, 2 lb in the 2nd year and so on up to a maximum of 6 lb in the sixth year and thereafter. Wherever possible apply the above quantities in two equal doses under the edge of the leafy canopy.

Guava *Psidium Guyava*

Common to the wet zone it can be grown in the dry zone too because it is drought resistant and can stand high temperatures up to 115° F.

VARIETIES: There are several common-or-garden varieties, but except for the rare exception, these are not suitable dessert fruits. Of the imported varieties, "Saffeida" and "Allahabad" must be recommended for cultivation in the low-country and mid-country. They make excellent table varieties. There is also a seedless imported variety which produces large luscious fruits, but unfortunately this variety is a very shy bearer. A yield trial carried out by the Department of Agriculture at Kundasale shows "Saffeida" to be the most prolific of the imported varieties producing 15,000 lb per acre in comparison to approximately 7,000 lb of "Allahabad" and 3,500 lb of the seedless variety over the same period of time.

For the up-country there is nothing to beat the "Purple Guava" which is also known as the "Strawberry Guava," the "Calcutta Guava " and "China Guava." This variety thrives from 2,000 - 5,000 ft and produces a very palatable fruit. It is relished raw and makes an excellent fruit for tarts, jams and jellies. In fact, all the varieties of guava mentioned above may be used in the preparation of jelly, which is the chief preserved form in which guava is utilized commercially.

PLANTING: Propagation is normally by seed, although the better varieties mentioned above are also available as grafts. Even though guava seed is known to retain its viability for almost a year after extraction, it is best to sow when fresh. Seedlings take a long time to grow; often 4 months will elapse before they are 2 - 3 inches high. They should not be transplanted to their permanent positions before the plants are 12 inches tall.

Plants are spaced 15 - 18 feet apart, the wider spacing being adopted under low-country wet zone conditions.

Seedlings assume an upright form with the result that the fruits are borne only at the top of the main branches. As this is most unsatisfactory the branches should be pulled down and tied in a horizontal position to induce bearing along their full-length. Grafted guavas do not grow tall like the seedlings. Moreover, their branches adopt a naturally horizontal drooping habit.

Cattle manure must be applied regularly. An annual application of one basket per one-year old tree should be steadily increased till at the end of 4 years and thereafter the tree receives 5 baskets per year.

HARVESTING: Seedlings bear in 4 years, grafts in half this time. A 8 - 10 year old graft should bear about 750 - 1,000 fruits a year. Unless a seedling tree of a similar age has its branches bent down as explained above it will produce only half this number.

Avocado *Persea gratissima*

VARIETIES: Butter fruit or avocado pear as it is called in this country, differs from other fruits in that it is neither sweet nor juicy. It has a high oil content (i.e. about 17 per cent fat) and is also rich in proteins and vitamins.

Three races of avocado are recognised in the world viz., West Indian, Guatamalan and Mexican. The West Indian race is the most promising for the tropics. The Guatamalan may be grown at the higher elevations, but it is doubtful whether the Mexican race will thrive in this country.

The small green variety, which is a variation of the West Indian race, is the most widely grown here. It is found chiefly in the Kandy and Kegalle Districts. A full grown seedling tree of this variety will give about 500 fruits per season, averaging ¾ - 1 lb each.

The following imported varieties have also been tried with success: "Pollock," "Grottfried" and "Purple Hybrid." These varieties produce much larger fruits from 1 - 2 lb in weight, so that an yield of 60 - 100 fruits per tree is considered good.

Fruits of "Grottfried" and "Purple Hybrid" turn purple as they ripen. "Pollock" remains green.

"Grottfried" is the first to come into season in May followed by "Pollock" and the "Purple Hybrid". The local variety generally bears from June to September.

There is a tendency towards alternate bearing in the avocado — that is, the trees will bear heavily one season and skip the next fruiting season. This tendency is said to be stronger in the green varieties than in the purple.

PLANTING: Avocado may be propagated from seed or grafts. Seed should be sown immediately on removal from the fruit as viability is otherwise quickly lost. Planting may be done either singly in large bamboos or preferably in well prepared beds of loose soil at 18 inches between rows and 12 inches in the row. Be sure to plant with the pointed end of the seed uppermost.

Germination is fairly rapid and the seedlings are ready for removal to their permanent positions in 6 - 8 months. Planting distances of 25 ft by 25 ft are usually adequate. Seedlings sometimes have a tendency to shoot up and not spread. This must be discouraged by cutting back the terminal shoot and allowing side branches to develop from buds lower down.

MANURING: Avocado is a rapid grower and gross feeder. It requires liberal supplies of organic manure and fertilizer. Two baskets of cattle manure in the planting hole, three baskets per year up to bearing and thereafter five baskets. Use a prepared fruit fertilizer mixture according to manufacturer's instructions. Or in the alternative mix your own ration: 50 kg (1 cwt) urea, 100 kg conc. superphosphate and 50 kg muriate of potash, and apply as follows: 1 lb per plant at planting, and thereafter at 1 lb per year up to a maximum of 6 lb per tree. Wherever possible apply the above quantities in split doses during the two rainy seasons. Avocado is essentially a fruit tree of the wet zone.

FLOWERING HABIT: Avocado is peculiar in that it is not always self-fertilizing. The flowers are self-sterile or polyandrous which means that the stigmas are usually not receptive when the pollen is ripe or vice versa. This is nature's way of ensuring that the flowers are cross-pollinated. This is why it is necessary to have more than one tree in any place. The orchard system is the surest method of ensuring cross-pollination and fruit set. However, you do come across occasionally trees that are self-fertilizing. Such trees should be used as special "mother trees" from which budwood is taken for propagation.

Sapodilla *Achras sapota*

Essentially a fruit tree of the low-country wet zone. Seedlings take 7 - 10 years to bear fruit. Grafts and layers are therefore preferable because they come into bearing in 3 years. Grafts should be done on Palu (*Mimusops hexandra*) stocks.

When seeds are used for propagation, they should first be sown in a nursery. Germination will take place in 3 - 4 weeks if the seed is fresh. Seedlings may be potted when they are about 2½ months old and removed to the garden for planting 12 - 16 months later. Plants are spaced 30 ft apart.

MANURING: Two crops can be taken per year in July-August and again in February. Consequently the soil needs to be regularly replenished with plant foods. Well-rotted cattle manure is excellent for this purpose and should be used in increasing quantities as the tree grows older. At one year 2½ baskets may be applied per tree and this quantity increased to 5 baskets from the 5th year onwards. The same fertilizer recommended for avocado may be used here too.

HARVESTING: If well looked after sapodilla is a prolific bearer with an economic life span of 25 - 30 years in the case of seedlings. Grafted plants may flower as early as the 2nd year, but they should not be allowed to develop fruits so young since this causes the tree to stunt. A token crop may be taken in the 3rd year and 4th year; real bearing will commence from the 5th year when about 250 fruits can be taken. In its 12th-15th years a well tended sapodilla tree should produce between 1,500 - 2,000 fruits a year.

Custard Apple *Anona squamosa*

This fruit can be grown with success in the wet and dry zones from sea level up to an elevation of 3,000 feet, although in the dry zone irrigation will be necessary unless the tree is grown close to a "tank" or other source of water.

In respect of soil conditions too the custard apple is very tolerant. It grows well in sandy soils and even on rocky ground. Being shallow rooted the tree does not require a deep soil. but the drainage must be good. Custard apple cannot tolerate waterlogging.

Custard apple is grown from seed. Only the biggest and plumpest seeds from selected fruits are sown. Each fruit contains from 20 - 30 seeds, so that there is no shortage of planting material.

Although the seeds are supposed to maintain their viability for some time it is best that fresh seed should be used for planting. Single seeds should be planted at a depth of three-quarter inch in polythene bags.

Seed has a hard coat and takes about one month to germinate. Some growers maintain that this time can be reduced by soaking the seed for three days in water before planting.

Seedlings will be ready for transplanting to their permanent positions in the garden in 9 - 12 months. Planting holes are prepared at a spacing of 12 - 15 feet apart. The closer spacing is recommended in dry climates. Close planting is expected to raise the humidity around the plants and thereby improve the chances of pollination.

The need for manuring custard apple in order to get a good crop is generally recognised, but opinion is divided on what is the best ration to use.

On average soils 3 - 4 baskets of cattle manure (60 - 80 lb) are adequate per tree per year. On very light soils, however, about double this quantity will be required, or the same quantity supplemented with a commercial fertilizer (according to maker's instructions).

The question of whether to allow the custard apple to grow naturally or to prune it to obtain a standard form of tree is a debatable one. Anyway, it has been proved scientifically that pruning is superior to natural growth in respect of yield and quantity of fruits.

If left unpruned custard apple forms a bush with a large number of stems. It is customary to allow the plants to take this shape. Although it may be necessary from time to time to cut away some of the older branches to make room for new shoots.

Trees begin to bear in 2 - 4 years and should produce about 50 - 75 fruits in their 5th to 8th year.

As the trees grow older the size of the fruits begins to decrease so that it is doubtful whether it is profitable to maintain a tree for more than 10 - 12 years.

The time of harvesting is very important because the fruits do not become soft and ready to eat however long they are left on the tree. On the contrary they tend to split open and decay.

For this reason one must know the proper time to pick the fruit even when it is firm. The sign to look for is the change in colour of the skin between the segments from green to creamy-yellow.

Picked fruits must be kept in straw for a few days until they become soft.

A serious fault of the custard apple tree is its tendency to bear few fruits as a result of poor pollination. But this defect can be remedied by hand pollination. Flowers that are borne at the end of the branches are unlikely to set fruit, so these are collected and used for pollen.

The pollen is applied with a camel hair brush (from a student's paint box) to the stigmas of the flowers before they dry out. In this way it is possible to increase fruit set during the rainy season.

Cherimoyer *Anona cherimolia*

Larger than the custard apple this fruit is heart-shaped, 3 - 5 inches in diameter and weighs 2 - 4 lb. Quality wise it is superior to the custard apple. Cherimoyer is best suited to the hills, preferring a rather dry climate. It is cultivated in many up-country gardens in the Udapussellawa region in the same way as custard apple.

Sour Sop *Anona muricata*

A pear-shaped fruit studded with soft prickles and 3 - 5 lb in weight. Suited to the low-country wet zone up to an elevation of 2,000 ft. A crop of two dozen fruits a year from a mature tree may be considered a good yield. Sour sop, however, like custard apple is known to be erratic in its bearing habit owing to poor pollination. The spacing is 15 - 20 feet. Cultivation is similar to custard apple.

Bullock's Heart *Anona reticulata*

Commonly grown in the low-country wet zone. Fruits are brownish red in colour, about the size of cherimoyer. Quality, however, is poor, the pulp being granular or "sandy". Cultivation is similar to custard apple.

Pomegranate *Punica granatus*

The pomegranate is nowhere of much commercial importance, although it makes a good garden fruit tree in dry areas, being extremely hardy and drought resistant. A hot, dry climate is essential during the period of ripening, otherwise the fruits are not sweet.

In the wet zone where the climate is humid fruit quality is not so good, yet home-gardeners continue to grow the pomegranate largely because of its ornamental character, especially when it is bearing bright red flowers.

SEEDS & CUTTINGS: Pomegranate can be grown from seed readily. The seed is sown soon after extraction, and the seedlings are transplanted in 9 - 12 months. But as there is no certainty of the seedlings growing true to type propagation by cuttings is preferred.

Cuttings are taken from mature wood. They should be 9 - 12 inches long and about quarter-inch thick. They are planted deep so that only about one-third of the cutting appears above ground level and left in a shady place till root formation takes place.

Rooting takes place in 12 - 14 days. The rooted cuttings may be transplanted to their permanent positions as early as nine months from the time of planting, although the general practice is to use rooted cuttings that are 1 - 2 years old.

Pomegranates are planted 12 - 15 feet apart.

The value of manuring is recognised. At the time of planting each pit is filled with two baskets of rotted cattle manure mixed with ash. After this an annual application of manure is made at the beginning of the rainy period, especially after the tree has commenced bearing. Bearing begins in 3 - 4 years.

MANURING: Soil is removed to a depth of 6 inches in a circle with a radius of 3 - 5 feet around the tree, depending on the age of the tree. In this trench 2 - 5 baskets of cattle manure are applied and covered with soil, again depending on the age of the plant. 3-4 oz of urea may be added to the cattle manure where soils are infertile.

PRUNING: The plant may be left unpruned, pruned to bush form with 3 - 4 main stems rising from the ground, or pruned to a single stem which is generally allowed to form a rather low head. Scientifically there is no reason to show that one method is better than the other. Pruning, however, produces a more ornamental tree suited for garden purposes. Plants are left unpruned when an impenetrable hedge is desired.

Whether pruning is adopted or not, do not fail to remove the suckers which arise from the base of the main stem in the first few years, since they are unproductive. Also, cut back long, slender branches, remove very low branches and do some thinning when the plant becomes too thick.

Once a year each clump should receive a heavy dressing of rotted cattle manure, which should be "trenched" in round the plants. Eighty pounds or four large basketsful should suffice.

Well maintained in this way each clump should continue to bear fruits satisfactorily for about five years after which it should be uprooted and replanted.

Rambutan *Nephelium lappaceum*

Rambutan is readily propagated from seed, but the best varieties are raised from grafts. In addition to the local "*Malwana*" variety, the Department of Agriculture has three other introductions from Malaya and Java, namely, "Malayan Red" and "Malayan Yellow" and "Java Red." "Java Red" has a sweet fleshy-covered pulp like "*Malwana*." "Malayan Red" and "Malayan Yellow," on the other hand, have dry pulps, but these pulps come away easily from the seed unlike in "Java Red" and "*Malwana*."

Rambutan thrives best in a hot moist climate up to 2,000 feet. It prefers low-lying ill-draind soils. Seedlings and grafts are spaced 25 feet apart. Grafts start bearing in 3 years and seedlings in about 5 years.

Rambutan trees are rarely manured in this country, and this probably accounts for their habit of alternate bearing — that is, bearing only in alternate years, and sometimes every 3 years or so. The trees are exhaused after a heavy bearing period. For this reason they should be given a fertilizer dressing immediately after harvesting. Six to ten pounds of a general fruit fertilizer mixture, according to age, is adequate per tree.

Individual fruit picking is not recommended as this causes the tree to put out a number of small useless branches that give it a "witch's broom" appearance. This is not conducive to bearing, so be sure to break the whole fruiting branch with the fruits suspended from the end in clusters. When this is done the tree bears well again in the following season. The main bearing period is from July-August.

Mangosteen *Garcinia mangostana*

Fruit is in season in the low-country from May to July and at higher elevations from July to August or September to October.

The tree is a slow grower and does not generally come into bearing till 9 - 10 years old, but takes several more years to attain full size. Essential conditions are a hot, moist climate, well-drained soil and a sheltered locality. Light shade is beneficial: in the young stage it is essential.

Propagation is by seed. There are no distinct varieties. Sow seeds in pots or polythene packs under cover. The young seedlings take almost 2 years to reach a height of 12 inches. They are transplanted at this stage to stand 25 feet apart. Mangosteen responds to manuring and may be given the same quantity (6 - 10 lb) of a general fruit fertilizer mixture like Rambutan at the end of every harvesting season.

Durian *Durio zibethinus*

A very large stately upright tree producing large round to ovoid fruit from 6 lb - 8 lb when ripe. The white custard like pulp surrounding the seed is highly relished and regarded as an aphrodisiac.

Durian thrives in the moist low-country up to 2,000 feet and luxuriates in deep alluvial or loamy soil. Flowering takes place in March - April and the fruit is ripe in July or August. Trees vary in productiveness, some being almost barren when they get old. The best varieties, therefore, should be selected for propagation. The large fleshy seed is of short viability, so it should be sown fresh. Germination takes place in about 8 days. Grafts are also available and they come into bearing in 3 - 4 years, while seedlings take 3 - 4 years longer.

To prevent poor bearing the trees should be given an application of fertilizer soon after harvest — 6 to 10 lb per tree, according to age, of a general fruit fertilizer mixture.

PART V

SPICES AND CONDIMENTS

Cinnamon — Pepper — Cardamom — Clove — Nutmeg — Vanilla — Chilli — Red Onion — Bombay Onion — Turmeric — Ginger — Other Condiments.

SPICES AND CONDIMENTS

Spices and condiments are valued in cookery, confectionery, the preparation of beverages and liqueurs, and in perfumary. Several are of special importance in medicine, either on account of their effect in aiding digestion by stimulating the gastric juices, or for disguising nauseous decoctions. The antiseptic and preservative properties of certain spices — owing to their volatile oil — are well known both in domestic and scientific uses.

Condiments and seasoning crops — chilli, onions, turmeric, ginger, garlic, coriander, fennel and cumin — are annuals. The spices—cinnamon, cardamom, nutmeg, clove, pepper and vanilla are perennials. The cultivation of cinnamon is generally confined to the western seaboard. Cardamom is grown in underbrushed jungle at elevations between 2,000 and 4,000 feet. The other spices — nutmeg, clove, pepper and vanilla are generally found in the so-called Kandyan "forest-gardens" in the mid-country. These spices, particularly nutmeg, clove and pepper, are being used as alternative crops in crop-diversification programmes that are designed to upgrade uneconomic tea lands in the mid-country (see appendix).

Cinnamon *Cinamomum zeylanicum*

This locally grown spice — described by historians as the "rich bride of conquest" because it lured western nations to dominate Lanka from medieval times—once supplied the entire world requirement. Subsequent neglect however, owing to the dominance of other plantation crops, has reduced our export output to only 60 per cent of the current total world requirement of bark or quills. But an increasing quantity of leaf oil and bark oil is now being exported, and these developments hold much promise for the future.

Today cinnamon is grown mostly in the Galle and Matara Districts with some old plantations in the Colombo District and some new plantations in the Ratnapura District. The "white sands" areas around Negombo are supposed to produce the best quality cinnamon, but any of the 'cabook' soils in the wet zone below 2,000 feet are suitable for cinnamon cultivation. Here the growth is rapid producing high yields but cinnamon of coarser quality than on sandy soils.

VARIETIES: Five varieties are recognised viz., (i) *Panni Miris Kurundu*, (ii) *Thitta Kurundu*, (iii) *Kahata Kurundu*, (iv) *Veli Kurundu* and (v) *Sevel Kurundu*. The first named produces the best bark and commands the best price.

PROPAGATION & PLANTING: Cinnamon is propagated by seed. Ripe seed is selected from selected "mother" trees with suitable characteristics for smoothness, erect stems, ease of peeling, and relatively resistance to pests and diseases. The outer pulp is removed, the seed washed and dried and planted within two days to ensure good germination. After two days fermentation could set in and interfere with germination.

Seeds (minus pulp) may be planted direct in the field in prepared holes, or first in a nursery or in polythene bags for later transplantation to the field. In nursery beds the seeds are planted 6 inches apart in rows and 4 inches apart within the row. They are planted in distinct lots of 15 - 20 seeds. So that each lot can be transplanted in one planting hole. Similarly, if seeds are dibbled in polythene packs, 4 - 6 inches wide at the top, about 20 seeds should be put in to each pack or bag. Even if seeds are dibbled direct into the planting holes the same number should be used, and the plants later thinned to the most vigorous ten or twelve. The idea of having 10 - 12 plants per planting hole is to give the cultivator a wide range of selection for harvesting. Each hole should be one foot square by one foot deep. It should be filled with cattle manure and top soil.

AFTER-CARE: Regular weeding is necessary until the plants grow up sufficiently to shade out soil. But a word of warning! Do not in the process heap the weeds around each clump of plants. The root stock must be kept exposed to allow new shoots to develop.

Fertilizer is also necessary to encourage stooling. During the first three years apply the following mixture per year in split doses: 50 kg (1 cwt) urea, 25 kg (½ cwt) conc. superphosphate and 25 kg (½ cwt) muriate of potash per acre, i.e. 25 kg urea, 12.5 kg conc. superphosphate and 12.5 kg muriate at the commencement of the rains in the *yala* season and again at commencement of the rains in the *maha* season. After 3 years when the cinnamon is mature double the dose at each application in *maha* and *yala*.

PRUNING & HARVESTING: Cinnamon is ready for harvesting 2½ - 3 years after planting. If the rains are normal harvesting should be in April and August. Two to three months prior to harvesting however, the bushes must be pruned (*Nuhuru-pahinawa*) — that is, unproductive branches must be cut away to facilitate harvesting.

A new reddish flush of leaves follows the first rains of each season. As this flush assumes the normal green leaf colour the sap begins to circulate within the wood and bark.

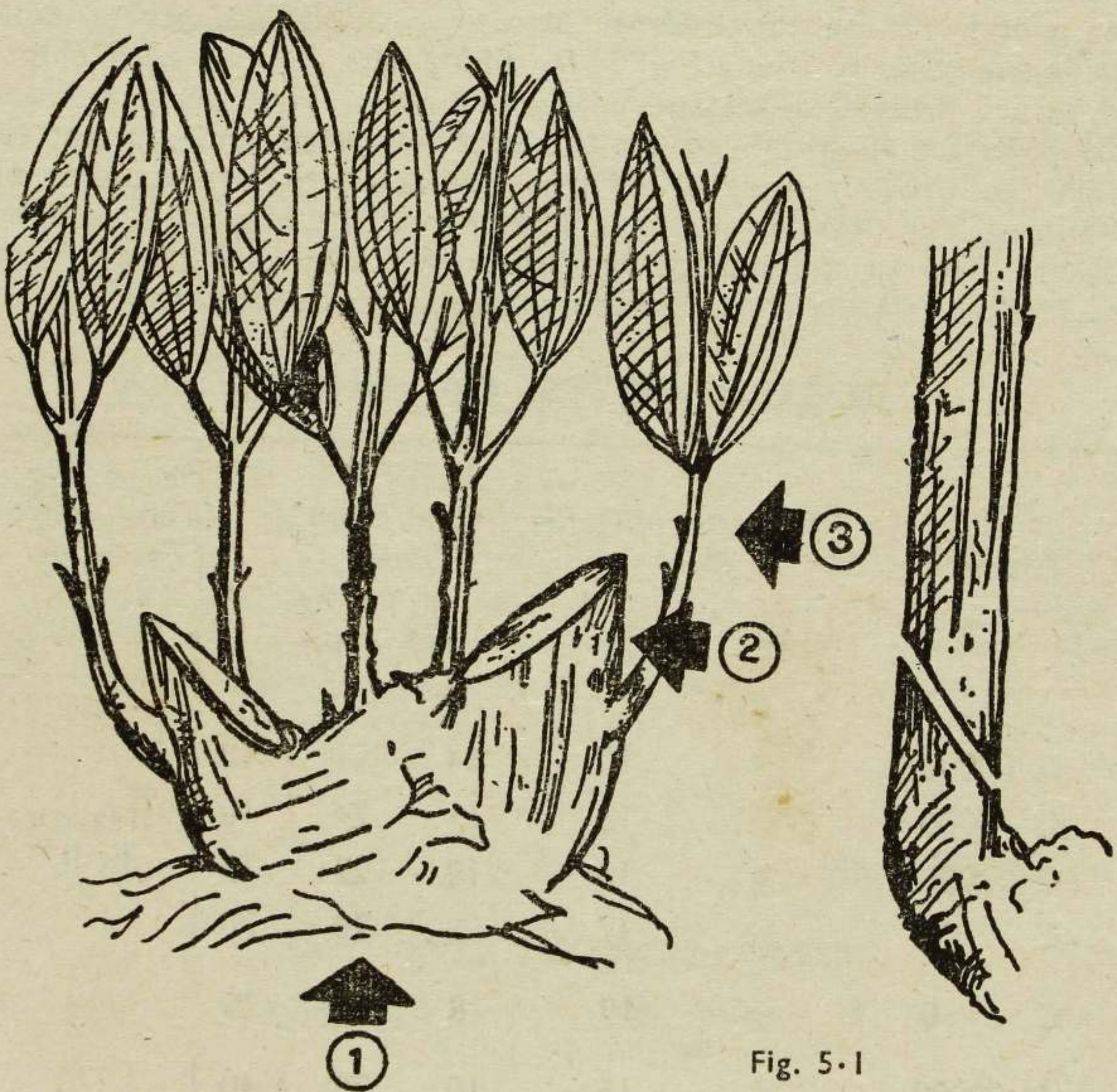


Fig. 5·1

HARVESTING STEMS

(1) Old clump showing how stems have been cut with sloping cut inwards (2) to produce new shoots (3).

This is the time at which the stems are easily peeled. This is therefore the correct time to harvest. The tops of the stems and the branches are first lopped off. Only the mature stems with brown bark are then cut off from the bottom. Cutting is done with a 'kathi' and it is done in such a way that the cut faces the inside of the clump and *not* outwards (see diagram). This has been found to promote re-tillering.

PEELING: Peeling is done with a small knife with a point on one side for ripping. After scraping the sticks the peeler rubs them with a brass block, then makes a longitudinal split from end to end, and works the knife in between the bark and wood till he has raised the bark to about half-inch wide. He then turns the stick and does the same thing on the other side, finally detaching the bark from the wood. These longitudinal pieces or quills are packed one inside the other to a length of $3\frac{1}{2}$ ft. filling the hollow with chips. Edges are pressed down and neatly trimmed. First dried indoors the quills are then moved to the sun and dried under a mat or cadjan to prevent warping. Dried quills are tied in bundles of 100 lb each for easy handling. They should be of a uniform light colour. The occurrence of reddish-brown patches detracts from the market value. There are ten grades as shown below:

REQUIREMENTS OF QUILLS

Grade	*Diameter of Quills Max*		*No. of 42″ (106.7 cm) Quills*		*Permissible Overall extent of Foxing per cent Max.*	
	in	*mm*	*per. lb*	*per kg (app.)*		
C 00000	$\frac{3}{8}$	10	14	31	10	"Malkora-hedi"
C 0000	$\frac{1}{2}$	13	11	24	10	
C 000	$\frac{5}{8}$	16	10	22	15	
C 00	$\frac{11}{16}$	17	9	20	20	
C 0	$\frac{1}{4}$	19	8	18	25	
M 00000	$\frac{5}{8}$	16	10	28	40	"Kora-hedi"
M 0000	$\frac{3}{4}$	19	8	18	40	
H_1	$\frac{7}{8}$	23	5	11	25	"Kora-hedi"
H_2	1	25	4	9	40	
H_3	$1\frac{1}{4}$	32	3	7	65	

(*Source:* Department of Minor Export Crops)

PESTS & DISEASES: The leaves are seriously affected by galls which are caused by the toxic secretions of small bugs. Control is effected by spraying with Dimetheoate 40% E.C. (Rogor 40). If this is too expensive, routine dusting may be done with 10% BHC a week before the new flush appears. This should be repeated a week later.

DISTILLATION OF CINNAMON OIL: Leaf oil is generally found in the petioles and veins of the leaves. It is extracted by steam distillation. Being heavier than water cinnamon oil sinks to the bottom in the collection tank containing water, from which it is drained off through copper tubes. Up to 20 bottles of oil could be distilled in this manner from one acre of leaves.

Bark oil can also be distilled by steam distillation. Where leaf oil contains Eugenol, bark oil contains Cinnamic Aldehyde, which is of very high commercial value.

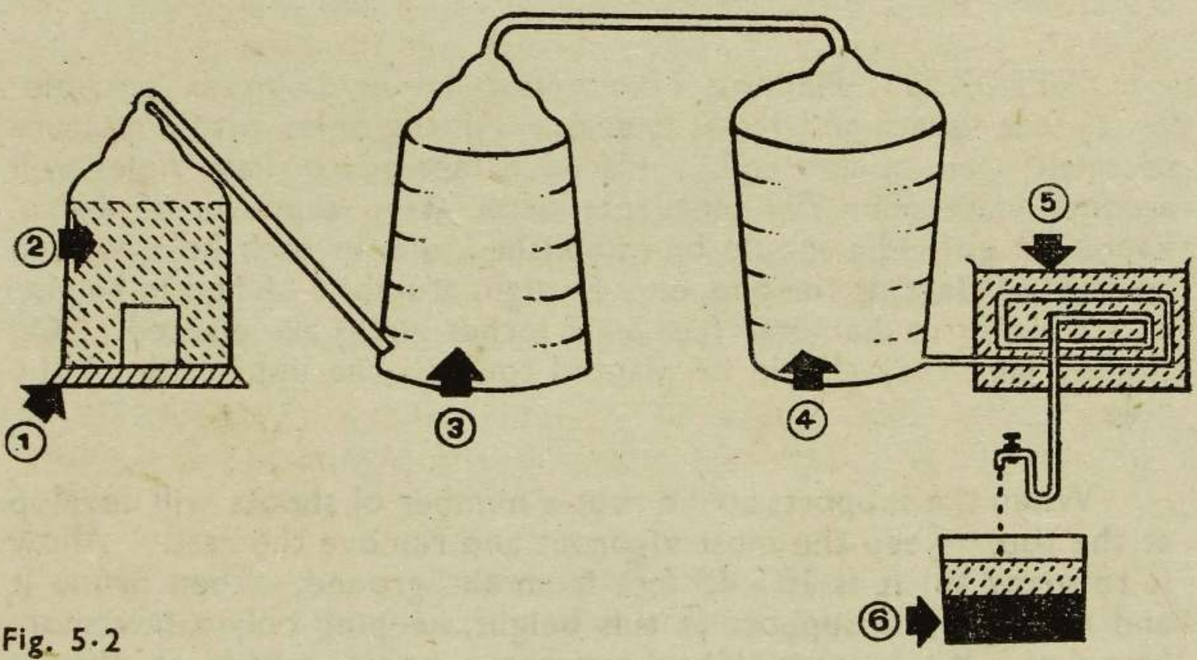


Fig. 5·2

STEAM DISTILLATION PROCESS

1. Boiler 2. Water 3. Leaves 4. Water 5. Cooling Tank 6. Vessel collecting oil

Pepper *Piper nigrum*

Pepper is best suited to areas which have a total precipitation of 70 - 110 inches well distributed throughout the year. It can be grown successfully in such areas up to 3,000 ft.

PLANTING MATERIAL: Pepper is grown from cuttings. Cuttings must be taken from the terminal green portions of the branches that grow out from the main stem. These branches have roots developing at the nodes. Let each cutting have 6 - 8 rooted nodes — the more roots there are the quicker the cuttings will establish themselves and grow vigorously. Since the cuttings wilt very fast, be sure to stand them in water till they are planted in polythene bags of 4" × 9" to 6" × 12" dimensions. Planting should be done within 24 hours.

Polythene bags are filled with a mixture of equal parts of coarse sand, top soil and well rotted cattle manure or compost. Cuttings are planted 3 - 4 nodes deep and the top of the baskets are finished off with a layer of coconut fibre refuse to ensure moisture retention. Keep the bags in the shade for 4 - 6 weeks and after that gradually accustom the plants to field conditions by exposing them more and more to sunlight over the next 4 - 6 weeks. Water as necessary and apply urea as a liquid fertilizer to promote vigorous growth. One ounce of urea dissolved in 3 gallons of water is the advocated dose every 3 weeks until the rooted cuttings are planted out. This is usually done in 3 - 4 months.

SUPPORTS: Planting holes must be as large as possible: 2 - 2½ feet square and 1½ - 2 ft deep. Fill the holes with a mixture of cattle manure and soil. Placed 8 feet apart these holes will accommodate 680 - 700 vines per acre. Live supports of dadap, kapok or gliricidia should be established, one in each hole, well in advance of planting the pepper. Straight stumps 6 - 8 feet in height. 1½ - 2 inches in diameter (i.e. 5 - 7 inches girth) are planted. On sloping land they should be planted towards the upper side of the hole.

When the supports strike root a number of shoots will develop at the top. Keep the most vigorous and remove the rest. Allow it to grow till it is 10 - 15 feet from the ground. Then prune it and maintain the support at this height, keeping only a few short branches. It is essential to keep the support pruned so that it does not compete with the pepper vine.

Rooted pepper cuttings are planted in the hole at an angle with the shoots close to the support and the roots farthest away. Keep the shoots tied to the support till they begin to grip with their own adventitious roots. In the early weeks of establishment the cuttings need to be watered and shaded.

MANURING: Grown as a pure stand as stated above, pepper requires a great deal of nourishment. In addition to an application of 10 - 20 lb of cattle manure per season plus the green loppings which are used as a mulch around the vines, fertilizers too should be applied. If you are unable to procure a prepared mixture, you could make up your own by mixing, urea, rock phosphate, muriate of potash and kieserite as follows:

	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac
Urea	14	26	66	105	78
Rock Phosphate	16	33	82	131	98
Muriate of potash	10	19	49	78	59
Kieserite	03	07	16	26	20
	43	85	213	340	255

(*Source:* Department of Minor Export Crops)

43 lb per acre is the quantity required for plants less than one year old. Approximately, one ounce is applied to each plant, 85 lb per acre are required for vines between 1 and 2 years at 2 oz per vine, 213 lb/acre for vines between 3 and 6 years of age at 5 oz per plant and 340 lb/acre for vines 6 - 15 years old at 8 oz per plant. After the 15th year yields begin to decline, so the fertilizer requirement is less viz., 255 lb/acre at 6 oz per vine. (*Note*: In place of rock phosphate you can use conc. superphosphate as follows: 10 lb, 24 lb, 56 lb, 84 lb and 64 lb respectively).

TRAINING & PRUNING: To ensure high yields proper training and pruning of the vines are essential during the first three years.

When the shoot of the rooted cutting has developed 8 - 10 nodes, prune it back to just above the 3rd node, allowing three shoots to develop from the three remaining nodes.

When these in turn have developed 8 - 10 nodes they are pruned back to the third node. Three more shoots are allowed to develop from each stem.

This process is repeated until the vine reaches the top of the supports 10 - 15 feet above the ground. This height is maintained by pinching out the terminal buds in the topmost shoots.

At the same time, remove all flowering spikes that appear up to the end of the second year. If this is not done the growth of the vine will be retarded. In the third year, however, the spikes may be allowed to develop.

Two harvests can be taken a year. Flowering takes place, in September - November and the crop ripens in March - May. This is the big harvest. A smaller harvest is taken in August - September.

After each harvest defoliate the vines, leaving only 3 - 4 terminal leaves on the branches and main stems. Defoliation encourages the productions of more lateral branches, and this in turn increases the yield.

HARVESTING: Yields will increase from about 2 - 4 lb green berries per vine at the first harvest in the third year, to 10 - 20 lb at about 8 years. Production will remain at this level till about the 15th year, after which it will decline.

The correct stage of harvesting for black pepper production is when a few of the berries in each spike turn red. Each spike is picked off the fruiting branches carefully without loosening the vines from its supports.

PEPPER ON TREES: Pepper vines can also be trained to grow on full-grown kapok and grevelia trees, provided these trees are 10 - 20 feet apart. Three to four rooted cuttings are planted round each tree.

When the vines are in their second year and about 6 feet tall, during the rainy season they are detached from their supports, wound into a spiral and buried in a hole near the base leaving only the top end exposed. Owing to the great multiplication of the root system, vigorous new shoots are produced which quickly climb to a height of 8 - 10 feet and set a full crop in the next season (third year).

PROCESSING: Quality black pepper is produced as follows :

(i) Immerse the spikes in a perforated container of steaming hot water (but NOT boiling water) until berries take on a dull green colour. Time involved is 2 - 3 minutes.

(ii) Dry in a hot-air dryer at 110° - 117° F until all moisture is removed.

(iii) Separate berries from the spikes by beating lightly with a piece of wood. Remove the large pieces by hand and winnow to remove the smaller pieces.

(iv) Put the berries in a tub of clean cold water to separate the good berries from the bad, empty berries float on top.

(v) Remove the good berries that sink to the bottom within 2 minutes and dry them again in the hot-air dryer for 36 hours.

(vi) Finally separate the berries from the pieces of stem that are still left by allowing the berries to roll down an inclined plane.

An easy but crude method of preparing black pepper is to dry the berries in the sun for 5 - 10 days continuously, after they have been separated from the stalks. This separation is effected by heaping the spikes in the shade for 24 - 48 hours, and then treading on them. The quality of the produce so produced is poor as the drying process is slow and consequently moulds develop faster.

About 30 - 33 lb of black pepper are produced from 100 lb of green pepper. The colour of the cured product should be black to brownish black with solid deep-set wrinkles on the surface. The maximum content of light berries should not be more than 2% in Grade I Special, 4% in Grade I and 10% in FAQ. Maximum moisture content should be 12% in Grade I Special and Grade I and 14% in FAQ.

PEPPER WILT: This fungus disease attacks the collar region of the vines causing death in 2 - 3 weeks. It is particularly active during wet weather. Plants growing in poorly drained conditions or without the benefit of fertilizer in an open situation are more susceptible than others.

Control is effected by spraying the vine with Bordeaux Mixture at the onset of the rainy season, or by disinfecting the soil with Ceresan (I oz in 6 gallons water) at I - 2 pints around each vine before every rainy season.

Cardamom *Elletaria cardamomum*

There are two commercial varieties of cardamom viz., the "Malabar" and "Mysore" varieties. Their characteristics are shown below:

	Malabar	*Mysore*
(i)	2,000 - 3,000 ft	3,000 - 4,500 ft
(ii)	8 - 10 ft tall	12 - 15 ft tall
(iii)	Prostrate spikes	Erect spikes
(iv)	Elongated capsules	Round capsules

These varieties are propagated from seed. Since germination takes 4 - 5 months the seed is first planted close (4 inches apart) in a manured nursery and covered with a thin layer of straw or freshly cut grass. The seedlings are then transplanted to another manured nursery at a spacing of 9 inches. This nursery too is mulched with straw or dried grass. To promote growth applications of urea in water (one ounce in 3 gallons of water) should also be given every 6 weeks. Seedlings from the second nursery may be transplanted in the field when they are 12 - 24 months old i.e. when they are 1½ - 2½ ft tall. Planting holes, 1½ - 2 ft in diameter and 2 ft deep, should contain some cattle manure or compost unless the planting is done in soils rich with organic matter under natural forest. Spacing is 6 - 7 feet for Mysore and 7 - 8 ft for Malabar.

Shade is essential for cardamom. Natural jungle is the best. Otherwise permanent shade trees will have to be provided e.g. Jak, Albizzia, Eucalyptus and *Macaranga tomentosa* (*kenda*).

FERTILIZER APPLICATION: The following fertilizer mixture is recommended per acre for the first three years: 37.5 kg (¾ cwt) urea, 37.5 kg rock phosphate, 25 kg (½ cwt) muriate of potash and 25 kg kieserite. It is meant to increase the size of clump.

From then on to the 15th year apply a different mixture low in nitrogen to promote the production of fruiting branches or spikes: 37.5 kg (¾ cwt) urea, 87.5 kg rock phosphate (1¾ cwt), 37.5 kg muriate of potash and 25 kg (½ cwt) kieserite per acre.

These mixtures should be applied as split doses during the two rainy seasons. (If rock phosphate is not available use conc. superphosphate but only three-quarter the quantity recommended for rock phosphate).

HARVESTING: Capsules can be picked right through the year, but the main season is September to January. Pick the capsules with a little piece of stalk before they are completely ripe. Ripe fruits split during curing. Yields vary from 250 - 300 lb/ac when the plants are young to over 1,000 lb of fresh capsules when they are 10 - 15 years old.

Grading is done according to colour. The best grades (Grade 0 and Grade 1) are green cardamom. Grades 2 and 3 are light green and Grade 4 is buff. To obtain green cardamoms you have to heat the capsules in a hot-air barn to 130° F for 3 - 4 hours. Drying is then done for 1 - 2 hours at 105 - 110° F and at 120° F for another 1 - 2 hours. After cooking rub the capsules with rough canvas or wire mesh to detach the stalks, which are separated by winnowing later. Graded capsules should be stored in sacks preferably lined with black polythene to preserve the colour.

Cardamom can also be dried in the sun, but it bleaches and produces a poor quality grade 4 product.

Clove *Eugenia carophyllata*

Clove cultivation is confined to the wet zone where the annual rainfall is an evenly distributed 70 - 90 inches. It is propagated by seed. Recently fallen ripe fruits are soaked for 24 hours in water to soften the outer pulp, which is then rubbed off with the fingers. There is only one seed per fruit. Only olive-green seeds should be selected for planting. Other off-colour types are rejected. Plant immediately in a nursery or the viability is quickly lost. Seeds germinate in two weeks. They should be kept shaded for 8 months. From 8 months they are hardened for the field by gradually decreasing the shade. Vigorous growth is induced by using a solution of urea for watering the plants every 6 weeks (1 oz urea in 3 gallons water).

PLANTING: Large holes are spaced 20 - 24 feet apart (80 - 110 plants per acre). Temporary shade with gliricidia, dadap or banana must be established 6 - 12 months before planting out the cloves. These shade trees can be dispensed with after 3 years.

The plants must be regularly fertilized with a mixture made up as follows: 1 part urea, 2 parts rock phosphate or $1\frac{1}{2}$ parts conc. superphosphate and 1 part of muriate and $\frac{1}{4}$ part of kieserite. One ounce of this mixture should be applied to each plant at the time of planting and 6 months later. This dose is increased to 2 oz at 12 months, 4 oz at 18 months, 8 oz at 24 months and every 6 months thereafter up to bearing. Bearing trees less than 12 years should be given $1\frac{1}{2}$ lb every 6 months and older trees 3 lb.

HARVESTING & PROCESSING: The unopened flower buds are harvested in clusters when they are olive-green in colour. When dried they form the clove of commerce. Harvests of fresh cloves will range from 8 - 12 lb in young trees to 40 - 50 lb in old trees per year. About 1 lb of dried cloves is obtained from 4 lb of fresh cloves. Cloves dried correctly snap easily when bent. They should be reddish brown to blackish brown. Badly dried cloves are soft, pale brown and mealy in appearance. Dried stalks mixed with the cloves should be separated by winnowing. There are three grades: No. 1, FAQ and No. 2.

Nutmeg *Myristica fragrans*

Nutmeg requires the same growth requirements as clove. It is propagated by seed planted in a nursery. Shells are cracked to hasten germination which takes place in 4 - 6 weeks. As in clove the seedlings are kept shaded for 6 - 8 months. They are also shaded in the field for 2 - 3 years. The planting distance should be 20 - 22 feet.

When the trees begin to flower it will be noticed that some plants are male and others are female. For successful cross pollination at least one male tree should be retained for every 10 female trees. Bearing this in mind the stand of trees should be thinned out to about half the number in the original planting. At planting there would have been 90 - 110 trees per acre. This could now be reduced to 45 - 55.

The same fertilizer treatment for clove is applicable here.

HARVESTING, PROCESSING & GRADING: Fruits are picked when they split open. Yields will range from 250 nutmegs a tree at 7 years to over 2,500 per tree at 20 years.

Nutmeg yields two spices viz., the kernel of the seed and the mace, which is the crimson-coloured aril. In processing the mace is first separated from the nut. It must be flattened by hand and then dried slowly in the sun until a bright orange-yellow highly fragrant product is obtained. The nut is then dried till the kernel rattles in the shell. It can be stored in this form. But if the kernels are extracted then they should be dusted with lime powder to prevent fungal growth and weevil attack.

Vanilla *Vanilla Planifolia*

Vanilla is a large creeping orchid. It requires a hot humid climate, protection from strong winds and chequered shade. It has to be supported on low trees with a rough bark and sparse foliage e.g. Dadap (Erythrina), Temple-Flower Tree (Plumeria) or Calabash (*Crescentia Cujete*). In a monoculture the low trees or live supports should be planted 8 ft apart.

Propagation is by cuttings 3 - 4 feet long which are planted *in situ*. Two cuttings are placed against each support, one on each side, and the lower ends are covered with soil or organic matter while the upper ends are tied to the support. It is advisable to leave the tip of the lower end exposed to prevent rotting. The cuttings soon develop aerial clinging roots, after which they require very little attention beyond weeding and regulating shade.

HAND - POLLINATION: 15 - 18 months after planting the vines will flower. The principal flowering season is in April - May. Under natural conditions bees and humming birds pollinate the flowers. Under cultivation, however, it is usually necessary to hand-pollinate to ensure a good crop, because self-pollination is not possible owing to the structure of the flowers. Hand pollination consists of lifting the two pollen masses in each flower on a small pointed stick and bringing it in contact with the viscid stigmatic surface. An experienced pollinator can "marry" 700 - 800 flowers in half a day. Pollination must be done in the morning when the pollen and stigmata are fresh.

Not more than 6 - 7 flowers should be pollinated in a single-cluster. A total of 30 pods to a single vine is considered adequate — half that number if the vine is weak. The pods take about 9 months to develop. They should be picked when a slight yellowing appears at the ends.

CURING: The pods are first dipped in almost boiling water for 25 seconds. They are then placed between blankets to "sweat" and in the sun to dry. Later they are rolled up in a blanket and placed in a closed box to "ferment". In the morning they are put in the sun to dry again for 2 hours. This process is repeated for 14 - 20 days or more until the pods become brown and pliable. They are squeezed and drawn through the fingers to make them pliable. If a pod splits it should be tied up with a fine thread. When curing is complete 'vanillin' (the active principle of vanilla) accumulates as a coating of fine crystals on the pods. The absence of this crystallisation depreciates the value of the market product, so take care to preserve it. There should be 80 - 110 cured pods 7 - 8 inches long to one pound.

YIELD: Yields vary according to levels of management from 100 - 150 lb of cured pods per acre. An yield of 110 lb to an acre containing 600 vines is very satisfactory.

DISEASES: Fungus diseases can become a problem if the vanilla plantation is overcrowded or too heavily shaded. Be sure to lop the branches of the live-supports during the rainy seasons.

Chilli *Capsicum annunm*

This is the dried chilli of commerce. Three varieties are recommended by the Department of Agriculture viz., MI-1, MI-2 and Santaka.

The MI-1 variety has been the backbone of the local chilli industry for the past decade. Among its singular attributes is its capacity to produce high yields of 15 - 25 cwt of dried chilli per acre under irrigation and 4 - 8 cwt under purely rainfed conditions and the desirable qualities of its pods which are 4 - 5 inches long, blood-red in colour and of medium pungency. Its only weakness is a susceptibility to the leaf-curl disease.

In fact, it is because of this drawback that the MI-2 chilli was developed. MI-2 is a mutant strain of the MI-1 variety displaying a higher level of resistance to the leaf-curl disease. The yield is comparable with MI-1, the pods as long but a little narrower and more pungent.

Santaka is an introduction from Japan. It produces a smaller chilli but its quality and pungency are just as good as MI-1 or MI-2. The distinctive feature of Santaka is that the pods do not hang down. On the contrary they stick up. But unlike in the case of MI-1 and MI-2 it is not possible to make a general recommendation for the cultivation of this variety anywhere in the island, because of its extreme sensitivity to rainy weather. Exposed to rainy conditions it is easily diseased. Consequently, any recommendation for its cultivation must be confined to the dry zone only and in the *yala* season only under irrigation. Well irrigated and under dry climatic conditions yields of 15 - 20 cwt per acre may be taken.

SEED RATE: You require 1 lb of MI-1 or MI-2 seed to plant one acre. You can get this quantity of seed from 4 lb of dried chilli. Since Santaka is a smaller plant, planted much closer, it requires a greater seed rate of 8 lb per acre.

NURSERY: 12 nursery beds 10 ft long by 3 ft wide and 4 inches high are required to sow 1 lb of seed of MI-1 or MI-2 (i.e. 360 sq. ft). In the case of Santaka at 8 lb per acre you require a nursery area eight times as large.

Sterilize the beds by burning trash on them. Then apply the Special Chilli Fertilizer Mixture (Fertilizer Corporation) and sow the seeds about quarter-inch deep in rows 4 inches apart. Cover with a mulch of banana leaves, cadjan or straw and remove the mulch in a week, when the little plants appear above the ground.

Watering should be done morning and evening but only just enough to keep the beds moist but never too wet, as chilli cannot stand "wet feet". Start spraying the seedlings against the chilli leaf-curl disease when the plants are 15 - 18 days old.

Transplanting may be done 35 - 45 days after sowing in the case of MI-1 and MI-2. Santaka must be transplanted earlier, preferably at 25 days and not later than 30 days because it has a shorter life period.

FIELD PROPAGATION & PLANTING: After ploughing and harrowing manure the fields with at least 5 tons of cattle manure. Then construct shallow basins 3 ft by 3 ft surrounded by 4 inch high ridges—this is the system followed in the Northern Province. Or prepare ridges and furrows—this is the more favoured practice in other parts of the dry zone. Ridges may be 2 - 3 feet apart depending on the variety planted: MI-I for instance, because of its more sprawling habit requires the greater spacing. Since Santaka is planted very close, ridge construction may not be feasible, but narrow beds 2½ ft wide and 6 inches high could be used instead.

Spacing is 3 ft by 1 ft for MI-1, 2 ft by 1 ft for MI-2 or 1 ft by 6 inches for Santaka with two seedlings at each point. A basal dressing of the Special Chilli Fertilizer Mixture should be given at the time of planting—1½ cwt per acre, and the crop irrigated immediately after.

IRRIGATION: In the absence of rain, irrigate the crop to a depth of 12 inches every 4 - 5 days for the first three months after transplanting and once a week thereafter.

CROP PROTECTION: Spray the crop every 14 days up to 140 days after transplanting in the case of MI-1 and MI-2 and 42 days for Santaka. Mix Water Wettable Sulphur and any one of these insecticides viz., Fenitrothion (Sumithion 100), Carbophenothian (Trithion 2E), Fenthion (Lebaycid), Fenthoate (Cidial, Elsan Papthion) or Mathomyl (Lanate), Methamidiphos (Tamaron, Monitor) or Folimat.

Mix the water wettable sulphur and the insecticide separately with water and pour the contents into the spray tank. To prevent the sulphur powder from settling down at the bottom of the tank see that you agitate the contents regularly while spraying. The sulphur is important because it is the only insecticide that is effective on the mite, one of the four insects which is responsible for carrying the virus that causes the leaves to curl, become small and turn yellow. The other three insects, namely aphids, white flies and hoppers are controlled by the other insecticide.*

Since these insects are usually found on the underside of the leaves, the best results are obtained only when a curved lance is used. This enables the sprayer to reach the underside of the foliage.

WEED CONTROL: Control weeds by spraying a weedicide like 'Lasso' one day after transplanting and again 4 weeks later when the weeds begin to appear. Half-gallon of 'Lasso' in 40 - 50 gallons of water is the recommended dose at each application. Occasional manual weeding may also have to be done.

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* If you use Folimat LC 50 or Actylic 50, you need not use sulphur, provided you use a strong solution viz. 1 oz. in 2 - 3 gallons water.

FERTILIZER APPLICATION: Apply the following quantities of Special Chilli Fertilizer Mixture per acre for MI-1 and MI-2:—

37.5 kg or ¾ cwt	14 days after transplanting
25 kg or ½ cwt	28 days after transplanting
75 kg or 1½ cwt	42 days after transplanting
37.5 kg or ¾ cwt	56 days after transplanting
75 kg or 1½ cwt	70 days after transplanting
37.5 kg or ¾ cwt	84 days after transplanting

If the plants continue to be vigorous and healthy give two more top-dressings of 37.5 kg or ¾ cwt at 98 and 112 days after transplanting.

In the case of Santaka the first three top-dressings given above are sufficient.

HARVESTING: Picking commences 2 - 3 months after transplanting in the case of MI-1 and MI-2. About 6 - 8 picks can be taken in all. But as the pods of Santaka mature uniformly harvesting may be done in one or two picks at the most. Entire plants may be pulled out and the pods picked off later. Because of its early harvesting habit there is a great saving in fertilizers, irrigation water and labour costs for picking.

Avoid picking in rainy weather and in the early morning when there is dew, to prevent the pods from becoming discoloured in patches when they are cured for the market.

PROCESSING: Pods are heaped indoors for two days till they develop a bright red appearance. They are next dried in the sun for 7 days and then packed into gunnies ready for the market. To produce a pound of dried chilli you require about 4 lb of fresh chilli.

NOTE: When chilli is picked for seed it must *not* be heaped indoors as this causes fermentation which affects the viability of the seed.

FUNGUS DISEASES: Anthracnose causes chilli pods to rot in periods of unseasonal rain. Spraying with a copper fungicide is the answer. A more serious disease is caused by *Fusarium rhizoctonium*. When chilli is allowed to grow over and over again on the same land without crop rotation, there is a tendency for the disease organisms to multiply in the soil and cause heavy crop losses. This is what happened not so long ago in the Visvamadakulam Youth Settlement Scheme in the Jaffna District until chilli cultivation had to be abandoned. This problem has now been solved by rotating chilli with rice. The waterlogged conditions of rice cultivation keep the disease organisms in check.

CROP BUDGET: The following crop budget may be used as a guide for the production of dried chillies from the MI-1 or MI-2 varieties in one acre:

	Expenditure	*Rs. Cts.*
(1)	Land Preparation	240.00
(2)	Seed	40.00
(3)	Cattle Manure (5 tons)	600.00
(4)	Fertilizer (50% subsidy)	375.00
(5)	Agro-Chemicals for weed control & pest control	945.00
(6)	Labour (Rs. 8/-)	3,000.00
(7)	Fuel Costs & Incidentals	1,000.00
	TOTAL:	6,200.00
Income:		
	Sale of 15,000 lb dried chilli @ Rs. 8/- per lb	12,000.00
	Envisaged Profit	5,800.00

Red Onion *Allium ascalonicum*

Red Onion, or Shallot, is the most widely cultivated onion in Sri Lanka. On a commercial scale it is essentially a dry zone crop, which is grown successfully under irrigation in the *yala* season from January to July.

PLANTING: Cattle manure is essential for successful onion culture. About 20 cartloads are required per acre. After the soil has been ploughed or turned over with a mammoty, the cattle manure is mixed with it and worked to a fine tilth. Either raised beds 2 ft wide, 4 - 6 inches high and of any convenient length separated by one foot wide drains, or sunken beds 3 ft by 3 ft (Jaffna-style) are used for planting.

About 3½ - 3¾ cwt of bulbs are required to plant quarter-acre at a spacing of 1½ - 2 inches, placing one bulb at each point. Shallow planting is the rule with the tips of the bulbs exposed above the soil. To prevent bulb rot, soak your planting material for about

5 minutes in a fungicidal solution (e.g. one ounce of Cuprous Oxide dissolved in 2 gallons water) before planting.

FERTILIZER APPLICATION: The Corporation Mixture (Special Onion Fertilizer Mixture) is recommended. It should be used according to instructions as a basal dressing before planting and as two top-dressings at 3 weeks and 6 weeks after planting.

In the alternative mix your own ration viz., 25 kg (½ cwt) urea, 50 kg (1 cwt) conc. superphosphate and 25 kg (½ cwt) muriate of potash per acre. Apply this quantity as a basal dressing and follow up with 12½ kg (28 lb) urea as a top-dressing at 3 weeks and again at 6 weeks.

WEED CONTROL: Weeding and the loosening of the soil at the same time is essential. In loosening the soil however, care should be taken to avoid heaping the soil around the developing bulbs. The secret of successful onion culture is to keep the developing bulbs exposed at the surface. They must appear to be 'sitting' on the soil rather than pushed down or buried in the soil. It is necessary therefore, to periodically remove the soil from around the developing bulbs. As an alternative to manual weeding, you could use a weedicide like Ramrod or Lasso. This is sprayed soon after planting.

IRRIGATION: See that the beds are thoroughly wet either just before or after planting. Thereafter give a full irrigation every 2 - 3 days for the first two weeks and every 3 - 5 days later, depending on the weather. Stop irrigation two weeks before lifting the crop. This gives the bulbs time to dryout in the field.

PEST CONTROL: Thrips damage the leaves. They should be kept under control by spraying Fenitrothion (Sumithion), Mathomyl (Lanate), Methamidiphos (Tamaron, Monitor) etc. Recently a caterpillar (*Spodoptera exigua*) has become a troublesome pest. It is kept under control by repeated sprayings of Permethrin 25% EC (Ambush) or Phenoralezate 25% (Sumicidin) every 5 days, starting on the 5th day after planting and going on till the 45th day.

HARVESTING: Once the bulbs are lifted in 80 - 90 days when the leaves begin to die back, they should be allowed to dry in the shade for a couple of days until the outer scales dry out. They are then cleaned by removing the leaves, dried outer scales and the roots. The cleaned product is hung in open-meshed bags or stored on shelves in a well-ventilated room till it is sent to market.

Seed onion, however, for the next season's planting should be selected—the meduim size bulbs are the best—and hung up by the leaves till required. Since there is a dormancy period, to ensure maximum germination only bulbs that are 8 - 10 weeks old after lifting should be used for planting.

Yields of 8 - 10 fold can be expected when the cultivation conditions are satisfactory.

Bombay Onion *Allium cepa*

The 'Poona-Red' variety, imported from Bombay, is now grown successfully in the dry zone during the *yala* season under irrigation. It is propagated from seed—8 lb are required to plant one acre. And since the seedlings are very delicate nursery technique has to be of a high order.

NURSERY: About 1,800 sq. ft. of nursery beds and drains are required to raise enough seedlings to plant one acre. Each bed is 10 ft × 3 ft × 4 in separated by one-foot wide drains.

The nursery must be given a basal dressing of fertilizer. Use the Corporation Mixture (same as for red onions). Seed is sown in shallow drills 4 - 6 inches apart and covered with soil and straw. Germination takes place in 6 - 9 days at which time the straw is removed.

It is advisable to cover the nursery by erecting a double-slope roof of cadjans or polythene about 1½ feet above the nursery beds. This cover may be removed during the day and only used at night, unless there is rainy weather during the day. Its use at night is necessary to protect the delicate seedlings from dew. The dew causes the leaves to die back from the tips. Water and weed when necessary.

'Damping-off' disease could occur. It is caused by certain fungi living in the surface area of the soil. Affected plants suddenly wilt and die. If this disease does occur use a fungicidal solution to water the plants. It might be advantageous to do this anyhow once every 3 - 4 days as a protection against 'damping-off'. One ounce of Captan or Dithane M 45 in 3 gallons water is quite effective.

Seedlings are ready for transplanting in 6-7 weeks when the plants are about 9 inches tall. Select only vigorous plants showing an incipient bulb ½ - ¾ inch long.

FIELD PREPARATION & PLANTING: Even the older seedlings are sensitive to poor drainage or waterlogging at the root.

Hence they are planted on raised flat beds or ridges, after the soil has been manured with at least 20 cartloads of cattle dung. One day prior to planting apply a basal dressing of the Corporation Fertilizer Mixture.

Transplant the seedlings 6 inches apart between rows and 4 inches within the row, with only one seedling at each point. Leave three inches from each edge of the ridge and you should get four rows of plants (see diagram). Be sure to plant shallow leaving the top ends of the incipient white bulbs just above the surface. Avoid deep planting as this discourages bulb development.

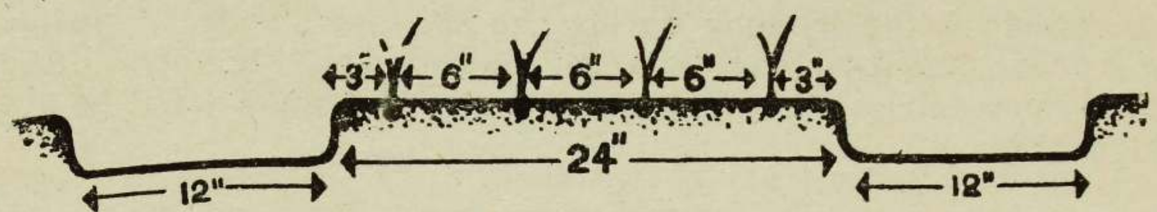


Fig. 5·3

AFTER CARE: Weed control, pest control and fertilizer application are the same as for red onion. If you are unable to procure the Coropration Mixture, mix your own and use it as stated under Red Onion.

HARVESTING: In about 100 days after transplanting the bulbs will be ready for lifting. Once lifted they should be dried in the shade for 2 - 3 days and then hung by the leaves in an airy room. Four tons per acre is a good yield.

Turmeric *Curcuma domestica*

Turmeric produces tuberous rhizomes or underground stems of a bright orange-yellow colour which are ground into a fine powder to give an aromatic condiment. They consist of several segments or "mother sets" carrying two or three projections or "finger sets." It is the "finger sets" that are used for planting. About 10 cwt of this material are required to plant an acre.

The "fingers" are planted on raised beds at a spacing of 12 inches. The beds are covered with a thin mulch of straw or dried leaves to check the weeds and control moisture. Planting is done in March-April in fairly shaded situations e.g. under coconut in the low country wet zone up to about 2,000 ft. The crop takes 9 months to mature and is usually harvested in the dry months of January/February. Yields vary from 7 - 10 fold, depending on the fertility of the soil.

CURING: Fresh turmeric has to be cured for the market. This necessitates the removal of the roots and separation of the tuberous rhizomes into 'mother sets' and 'finger sets'. After sufficient 'finger sets' have been set aside for replanting, the balance 'finger sets', and the 'mother sets' split into four (only the mother sets are split) are washed and placed in a small-mouthed earthen or metal vessel and just enough water is put in to cover the contents. The remaining space in the pot is packed with dried turmeric leaves, and then the mouth of the pot is sealed by tying a piece of gunny firmly over the top to ensure that no steam escapes on boiling. Some people also plaster the top with mud (i.e. fresh earth from a termite mound mixed with cattle dung).

The contents are boiled over a slow fire for about 3 hours. At the end of this period extinguish the fire and allow the vessel to cool. Then remove the boiled turmeric from the pot and spread it out to dry in the sun for 5 - 7 days.

POLISHING: If turmeric cured in this manner is polished prior to sale it will fetch a much better price. Polishing can be done by rubbing the dried turmeric in a serrated earthen vessel if the quantity handled is small. With a large quantity however a special device will have to be used, e.g. a cylinder of expanded metal mounted horizontally and fitted with handles on either side. Dried turmeric can be polished by rotating for about 10 minutes in such a drum. Cured and polished turmeric weighs about one-fifth of the original fresh weight.

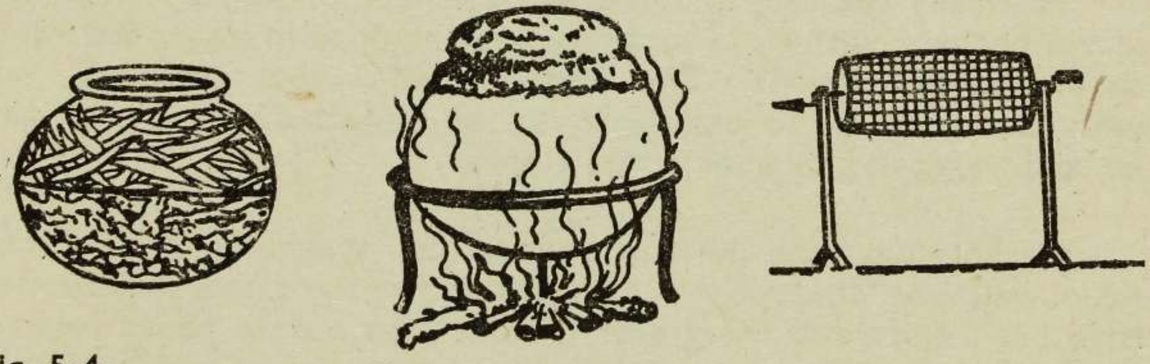


Fig. 5·4

(L–R) Charging the pot, boiling the sealed contents and polishing in rotating drum.

Ginger *Zingiber officinale*

The local variety is fairly common. Practically every village garden has a few plants for domestic use. But this variety is not suitable for curing since it develops small bunched rhizomes with numerous "fingers" which make the job of peeling difficult and expensive. Cochin and Surat ginger however are ideal for curing. They have larger rhizomes with comparatively few fingers. Besides they give a finer aroma.

Like turmeric, ginger is a crop of the low-country wet zone. It thrives under shade, particularly in the mixed gardens found in the Kandy and Kegalle Districts. But as this crop is highly susceptible to soil-borne fungus diseases it should not be cultivated in the same land more than once every four years.

Only well-developed rhizomes from the previous harvest should be used for replanting. But they should not be planted whole—as is the common practice in village gardens—because the rhizomes that subsequently develop will be small and bunched. It is best to break up whole rhizomes and plant small pieces. The rhizomes that develop from small sets are larger in size and much less bunched.

PLANTING: Planting is generally done in mid-March or early April on raised beds at a spacing of 12 - 15 inches apart. The soil is then covered with a thick mulch of straw or dried leaves. The mulch helps to conserve water in the soil and to stifle weed growth. The use of fertilizers will depend on the prevailing market condition. If the market is good manuring with sulphate of potash or muriate of potash at the rate of 5 lb per 1,000 sq. ft. will be remunerative. The fertilizer should be lightly forked in round the plants when they are a few inches high.

Normally the crop is lifted in December or January when the leaves begin to wither. Harvesting may be done in stages according to market fluctuations. The average yield is about four-fold, but with manuring six to eight-fold can be expected. The crop may be sold as green ginger or cured ginger.

Green ginger can be stored up to six months on the floor of a cool well ventilated room. After the decayed or damaged rhizomes have been discarded the ginger is built into a heap about two to three feet high and covered with ginger leaves which are periodically sprinkled with water. The heap should be examined at fortnightly intervals or more often in dry weather. When the temperature in the middle of the heap rises, the heap should be broken up and spread on the floor. Three or four days later and after the decayed ginger has been separated from the good ginger the heap is rebuilt.

CURING: If the crop is to be cured, the fibrous roots and soil adhering to the rhizomes should be removed immediately after harvest and the ginger washed thoroughly in water. After this it is allowed to soak overnight in a fresh supply of water so as to facilitate the removal of the outer skin.

The skin is scraped off with pieces of bamboo improvised as knives. Peeling may be rough or clean. Rough cleaning is preferred because it is cheaper and there is less risk of damaging the oil cells below the skin on which the aroma of the best quality of ginger depends. An experienced woman can rough-peel about 20 to 25 lb a day.

Once the rhizomes have been peeled they are thoroughly washed again and left to soak in lime water overnight. On the following morning the ginger is first washed in lime water before it is spread out on sacks or coir matting to dry in the sun.

Peeled ginger treated with lime keeps better and longer than untreated ginger. But the quality of the lime is important in determining the quality of the finished product. The purer the lime the better the quality of the cured product. One-third bushel of lime should be sufficient to treat one cwt of raw ginger.

Drying should be continued for five or six days accompanied by frequent turning, particularly on the first day, to ensure uniform drying. Cured ginger must be not bagged till it is completely dry or it will become mouldy in storage. Approximately six pounds of green ginger will give one pound of cured ginger.

Mustard *Brassica juncea*

Primarily a *chena* crop of the dry zone, it is usually broadcast sown in fresh *chenas* about November after the heavy rains are over. The seed rate is 6 - 8 lb per acre or 1 oz per 400 sq. ft.

Mustard needs a fertile soil. When not cultivated in fresh *chenas* therefore, if must be given cattle manure at the rate of 40 - 50 lb (two large baskets) per 10 sq. ft. Avoid clay soils.

The small round seed takes 2 - 3 days to germinate. Weed the crop at 3 weeks and again at 6 - 7 weeks.

Flowering commences in 1½ months. The harvest may be taken at 14 -16 weeks. Whole plants are harvested, tied together in small bundles and dried in the sun for 4 - 5 days. The seeds are then collected and dried again for a couple of days. Yields of 8 - 10 lb seed per 400 sq. ft. or 800 - 900 lb/ac. are average.

Other Condiments

Today chillies, onions, ginger, turmeric and mustard are not imported. But we still continue to import nearly 18 million rupees worth of garlic, coriander, fennel, fenugreek and cumin. Of these five crops only garlic is traditionally cultivated, while coriander, fennel, fenugreek and cumin have been tested in the Department of Agriculture Research Stations at Rahangala in the dry up-country (Upper Uva), Tinnevelly (Jaffna Peninsula) and Maha-Illuppallama (near A'pura) in the low-country dry zone. The results are promising and the authorities are exploring the possibilities of expanding the cultivation for a start in the Upper Uva.

Garlic requires a cool moist growing period and a relatively dry spell when maturing. This is why it is traditionally grown at elevations between 3,000 and 4,000 feet in the Welimada, Palugama, Udunuwara and Kandepuhulpola areas of the Upper Uva in the Badulla District and Ragala, Walapane and Hanguranketa in N' Eliya District which also falls within the up-country dry zone.

That this crop is traditionally grown in these areas and yet does not make an impact on the economy could be explained by the fact that it does not figure prominently in commercial cultivation. The money crops of the up-country farmer are vegetables and potato. Garlic cultivations are generally on a small scale and are for the most part for medicinal rather than culinary purposes.

In the circumstances, if a decision is taken by the Ministry of Agriculture and Lands to intensify the production of garlic with a view to self-sufficiency, then the opportunity cost of cultivating this crop must be brought on par with the present money crops of the area viz., vegetables and potatoes. This could be achieved by effecting a total ban on the import of garlic as was done some time ago with chillies and onions.

The total land area involved to produce our full requirements of garlic is about 2,000 acres. Most of this extent can be found in the Upper Uva of the Badulla District and parts of the N'Eliya District, but if more land is required, cultivation could be extended to the low-country dry zone, where experiments carried out at the Maha-Illuppallama Research Centre and in trial plots in cultivators' fields have shown that successful crops can be taken provided they are planted in late December and irrigated thereafter. The cool night temperatures obtaining at that time are essential for bulbing.

What about the other condiments—coriander, fennel, fenugreek and cumin—which are not traditionally cultivated in this country?

What are the prospects of cultivating these crops? If we are to judge by the results of local research, then the prospects are very good indeed for coriander, fennel and fenugreek, which it has been found may be cultivated equally well both in the up-country dry zone and low-country dry zone. Observation plots of coriander at Tinnevelly since 1970/71 have consistently given outputs of 1,000 - 1,300 lb of cleaned seed per acre. Fennel and fenugreek too have done extremely well in these areas — fennel in particular which produces tall vigorous plants, the leaves and stems of which may be cooked as a curry while the seed is used as a condiment.

While coriander and fennel are fragile umbelliferous crops with thin hollow stems, fenugreek is a hardy legume. This characteristic, taken together with its short age (3 months in the low-country dry zone) makes it an excellent "catch crop" — like cowpea or green gram—for paddy fields when there is insufficient water to take a crop of rice but enough for 3 - 4 irrigations of the legume. Provided, of course, that the fields are well drained since fenugreek cannot stand water-logging.

As coriander and fennel are both cross-pollinated crops, it has been observed that they give higher yields where there is a high bee-population as for instance in Bandarawela or Diyatalawa in the up-country dry zone.

The extent of land required for self-sufficiency in these crops is shown in the table below. It should not be too difficult to achieve this if the farmer is given the necessary incentive. This incentive, as in the case of garlic, will have to take the form of drastic reductions leading ultimately to a total ban on the imports of coriander, fennel and fenugreek so as to create an attractive free market price to the local producer.

Estimated Land Extent required on present Imports

	Import in (Cwt.)	*Average Yield (lb)*	*Estimated Land Extent (Acres)*
Coriander	128,000	500-750	21,000
Cumin	25,000	200-250	12,000
Fenugreek	12,000	500-600	2,500
Fennel	10,000	500-750	1,750
Garlic	35,000	1,000-1,500	2,000

Cumin, on the other hand, (also of the Umbelliferrae) has so far defied the efforts of our research officers to produce a successful crop. The problem appears to be poor germination and poor vigour, mainly because it has been difficult to obtain viable stocks of seed. The seed available in the local market it would appear has been subject to pressure, probably to extract an "oil" or "essence". So until such time as viable stocks of seed are introduced and tested here, it would be foolhardy to plunge into the production of cumin on a commercial basis.

GARLIC. *Allium sativum*: Planting is usually done with April/May or October rains in the up-country dry zone or in late December under irrigation in the low-country dry zone. Only the outer segment or "cloves" of the dried bulbs are used as planting material—500 to 600 lb are required per acre. Planting is done 4 inches apart on raised beds 3 - 4 ft wide, the cloves are pushed in upright so that their tops are flush with surface. If there is no rain, watering must be done thrice a week up to 2 weeks before harvesting. Bulbs may be lifted at the end of 4 months when the leaves turn yellow. They are allowed to dry in the sun for 2 - 3 days until the white outer membranes become crisp to the touch. After this they are tied up by the dried leaves in bundles of about 100 bulbs each and hung up in a dark room until marketed. Yields are five-fold i.e. 2,500 lb per acre from 500 lb planted if ample cattle manure or fertilizer is used. Average yields are 1,000 - 1,500 lb.

Note: Large bulbs can be produced if the beds are mulched with a half inch thick layer of straw.

CORIANDER. *Coriandum sativum*: May be planted with the April/May or October rains in the up-country dry zone, or in October with the rains, or in December under irrigation in the low-country dry zone. 10 - 15 lb of seed are required to plant one acre—the coriander fruits have to be broken into two "seeds" or segments before sowing. The spacing is 12 inches between rows and the seedlings are later thinned out to stand 12 inches in the row. Seeds germinate in 10 - 12 days and the plants grow to about 2 ft tall. Weeding and watering should be done when necessary. The crop takes 4 months to mature in the low-country dry zone and 4-5 months in the up-country dry zone. The plants are pulled out and dried for 2 - 3 days before the seed is extracted by beating with sticks or trampling under the feet of bullocks. It is cleaned, winnowed and dried before sowing. Average yields are 500 - 750 lb.

FENNEL. *Foeniculum vulgare*: May be planted with the April/May or October rains in the up-country dry zone. Or in the low-country dry zone with the October rains or in December with irrigation. Seed rate is about 15 lb per acre. Spacing is 18 inches between rows and 18 inches between plants in the rows. Plants grow to a height of 3½ - 4 feet; they start bearing in 5 months and continue for a period of 4 - 5 months. The "umbels" or fruits are picked as they ripen and dried separately while the plants are allowed to grow. The leaves and stems are also used for cooking. Average yield is 500 - 750 lb per acre.

FENUGREEK. *Trigonella Foenum-graecum*: Planting times are similar to coriander and fennel. May also be planted in the *yala* season in the low-country dry zone in paddy fields that do not have adequate water to take a rice crop, but where sufficient water is available in the tanks to make 4 or 5 irrigations. The seed rate is 15 - 20 lb per acre. Spacing is 12 inches between rows, the seedlings being later thinned out to stand 9 - 12 inches in the row. Germination takes place in 4 - 5 days and the plants grow to a height of about one foot. Weeding and watering must be done when necessary. Crop takes 3 months to mature in low-country dry zone and 3½ - 4 months in the up-country dry zone. Plants are uprooted, dried for 2 - 3 days and the seeds threshed by beating with sticks. Average yield is 500 lb per acre.

CUMIN. *Cuminum cyminum*: Planting times are similar to coriander and fennel. Use only "certified" seed for planting. Seed may be sown broadcast at 30 lb / acre or in rows 12 inches apart at 15 - 20 lb/acre. Seedlings are later thinned to stand 9 - 12 inches in the rows. Germination takes place in about 7 days and the plants grow to a height of about one foot. Weeding and watering must be done when necessary. The crop is ready for harvest in 5 months. Plants are pulled out and dried in the sun for 2 - 3 days and the seeds threshed by beating with wooden flails. Average yield is 250 - 300 lb/per acre.

Note: Until such time as definite fertilizer recommendations are made, cultivators are advised to use compost or cattle manure in the cultivation of coriander, fennel, fenugreek and cumin. In the case of garlic, the existing red-onion fertilizer mixtures in the market may be used until new recommendations are available. If fertilizers are used (or in the alternative ample quantities of cattle manure or compost) the average yields stated above may be increased by 1½ - 2 times.

PART VI

MISCELLANEOUS CROPS

Coffee — Cocoa — Coconut — Castor — Citronella — Lemon grass — Gingelly — Kenaf — Cotton — Cigarette Tobacco — Beedi Tobacco — Betel — Sugar Cane — Papaw for Papain — Mushrooms — Anthuriums Dendrobiums — Vandas — Scorpions — Spiders and Hybrids — Husk Culture for Orchids

BEVERAGES

Coffee *Coffea sp.*

The two commercially important types are *Coffea arabica* and *Coffea robusta* (also known as *C. canephora*). "Arabica" is more sought after because of its aroma, but this coffee is more difficult to cultivate. It requires a cool climate (over 2,000 ft elevation) and a definite dry period for concentrated fruiting. It also requires shade and is sensitive to the coffee rust disease (*Hemileia vastatrix*) which was responsible for the demise of the coffee industry in this country.

"Robusta", on the other hand, is a hardy coffee. It is more vigorous than "Arabica" and more resistant to pests and diseases. It requires very little shade and does not demand a definite dry period during ripening. It thrives best in the wet zone below 2,000 ft. As such it is the popular choice.

PLANTING: Propagation from seed is the usual method. Ripe berries are pulped by hand and dried in the sun. They must be planted immediately after as they lose their viability quickly. Planting is first done in sand beds about 10 inches thick. Seeds are placed roundside up in rows 3 inches apart and covered with a thin layer of sand. The beds must be given a thick shade and watered regularly. Germination takes place in 6 - 8 weeks.

When the seedlings develop their first two leaves they are transplanted to normal nursery beds, or polythene bags, 6 inches by 8 inches, filled with a mixture of top soil and compost or cattle manure. The latter procedure is the more favoured. The planted bags are kept under light shade for 2 - 3 months before they are transplanted. At the time of transplanting the bags are slit down the sides and the tap root pruned if it is too long or twisted. Ten days before transplanting the plants are "topped" to a height of 8 inches and the leaves are also cut in half to minimize transpiration. Be careful when planting to see that the tap roots is not bent and that the seedling is planted at the same level as it was in the polythene bag. After planting, a light shade of leafy twigs or cut palm leaves is given for about one month, along with a thick mulch on the ground.

Coffee may be planted 8 feet apart giving 730 bushes to the acre. Holes are dug 2 feet square and $1\frac{1}{2}$ feet deep. They are filled with a mixture of cattle manure and soil.

SHADE: Recent experiments have shown that coffee can be grown quite successfully without shade, provided the standard of management is high, particularly in regard to pruning and fertilizer application. To be on the safe side, however, planters maintain a light shade of about 40 trees per acre. Common shade trees are Albizzia, Erythrina (Dadap), Gliricidia and Senconea. All these trees are legumes and their loppings are useful as mulch or green manure. Shade trees are planted at the same time as the coffee.

In large plantations it is advantageous to grow permanent cover crops to prevent soil erosion and maintain soil moisture. Non-climbing legumes like Desmondium, Indigofera, Pueraria and Stylosanthus—the same cover crops used in rubber plantations—are recommended for coffee. Do not allow the cover crops to grow right up to the stems of the coffee plants. Ring-weed every 2 - 3 months and remove the creepers and weeds, specially grass.

FERTILIZERS: Apply one ounce of urea and one ounce of muriate of potash per plant 3 months after transplanting and the same quantities again at 9 months. Thereafter use 4 ounces every 6 months of the following fertilizer mixture: urea 3 parts, conc. superphosphate $1\frac{1}{2}$ parts and muriate of potash 2 parts. Fertilizer should be spread in a broad band around the stem and lightly forked into the soil.

PRUNING: The multistem system of pruning is very effective. The principle is to allow a limited number of stems or shoots to be in bearing at anytime, and once these have borne fruit for two years they should be cut away and replaced with new productive shoots.

A mature coffee plant should have two shoots in the second year of bearing, two shoots in their first year of bearing, two young shoots coming up to take the place of the two-year old stems when they are cut down and a certain number of very young shoots from which two more will be selected to take the place of subsequently pruned stems.

Only one of the old shoots should be cut back to the base each season. In this way the coffee bush does not become unduly exhausted. Once this framework of 8 stems or shoots has been established you should cut away all new flushes and water shoots that appear.

PESTS & DISEASES: Borers are sometimes troublesome. They damage the stems and the berries. Stem-borers must be controlled by spraying Heptachlor 40% E.C.; berry-borers by spraying BHC. Coffee rust is the only disease of any consequence. It causes yellow and orange patches to form on the leaves. The spores of the fungus may be observed like white powdery dust underneath the diseased leaves. Copper fungicides are effective.

HARVESTING & PROCESSING: Coffee comes into bearing when three years old. At this stage the yield is about 3 cwt per acre. From the 4th year onwards yields increase going up to 7 - 10 cwt per acre. Under very good soil and climatic conditions and a high standard of management yields of 15 cwt/acre are possible. Berries must be picked only when they are red ripe.

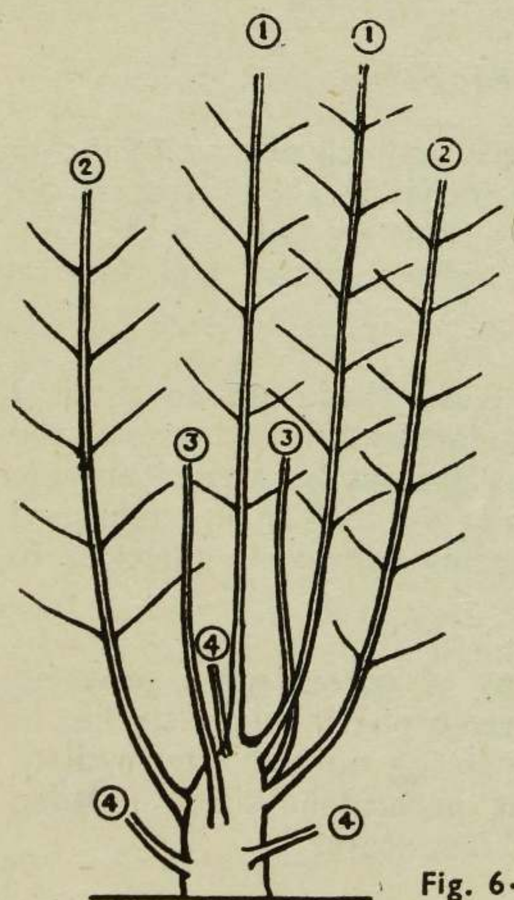


Fig. 6·1

FRAMEWORK OF MATURE COFFEE TREE

(*1*) *Two shoots in second-year bearing*

(2) *Two shoots in first-year bearing*

(3) *Two shoots to come into bearing*

(4) *Young shoots to take place of subsequently pruned shoots*

In the case of "Robusta" the pulp is easy to separate from the seed, so that a fermentation process is not necessary. Placed in a "Rooeing" pulper, with abundant water and pressure, the berries are pulped and washed simultaneously. Thereafter the beans are dried, hulled to remove the outer skin, winnowed, graded and stored.

Since "Arabica" has a hard clingy pulp and mucilage, it has to be pulped first and then fermented to remove the mucilage. Fermentation is done in concrete or wooden boxes with a cover of banana leaves. Fermentation takes 12 - 24 hours and during this time the mass should be stirred and turned often to ensure even fermentation.

The above is the wet method or "Washed Coffee" process. The dry method is simpler and can be used alike with both "Robusta" and "Arabica" but the product does not fetch as high a price as "Washed Coffee". In the dry method the berries are dried in the sun, or artificially. When sun-dried the berries should not be spread in layers that are more than 2 inches thick, otherwise there is the risk of obtaining mouldy, germinated or black beans. During the drying process the mass must be regularly stirred and turned. Thereafter the beans are hulled and the dry pulp removed with the outer skins. The parched coffee is then winnowed, graded and stored.

Cocoa *Theobroma cacao*

Cocoa needs an uniformly distributed rainfall of over 65 inches a year, but it should not exceed 110 inches as this increases the hazard of fungal infections. These conditions are found in the Central, North-Western, Western, Uva, Sabaragamuwa and Central Provinces.

SHADE: Cocoa requires fairly dense shade up to about 3 years of age. In old rubber estates underplanted with cocoa, the rubber trees should be thinned to about 50 trees per acre to provide this shade. In open land temporary shade will have to be established at least one year before cocoa by planting banana or gliricidia 10 feet apart.

After three years the thick canopy of cocoa leaves provides its own shade. But in areas of low atmospheric humidity, i.e. in the drier areas of the cocoa belt bordering on the intermediate zone it may be necessary to have light permanent shade. Dadap is excellent for this purpose planted 40 feet apart.

VARIETIES: Varieties are determined by the colour of the cross-section of the beans, because it is this colour that determines the duration of fermentation in final processing. On this basis there are three recognisable varieties:

Foraestero	—	dark purple
Criollo	—	creamy white
Hybrid	—	intermediate shades

Foraestero is the most widely grown, although the quality of Criollo cocoa is better.

PROPAGATION: If seeds are used they must be extracted from ripe, undamaged, healthy pods only. After the adhering mucilage is washed away the seed must be planted within two days to ensure good germination. Planting is done in polythene bags of 4 - 6 inches diameter by 9 - 12 inches long. Place the seeds—one per bag — either flat or with pointed end up a quarter inch below the soil surface. (Seeds planted upside down give rise to deformed seedlings).

Seeds germinate in 4 - 5 days. To promote quick growth use an aqueous solution of urea when watering the plants every 3 weeks— one ounce of urea in 3 gallons water for every 200 bags. Harden the plants gradually by giving them more sunlight after one month. Transplanting is done in 2½ - 3 months.

If cuttings are used they must be taken from new shoots of not more than pencil thickness. Each cutting should have 1 - 4 nodes. Cuttings are planted in specially prepared polythene bags 6 - 8 inches in diameter and 24 inches high. Nursery soil is firmed down in the bottom 8 inches and covered with a two-inch layer of coir refuse. The soil-holding portion of the bag is perforated. Bags are now watered thoroughly and allowed to drain through the perforations.

The basal end of the cutting is dipped in a rooting-hormone preparation to encourage quick rooting. When the cutting has been firmly planted it is tied to a support which is also fixed in the bag. The top end of the bag is now tied to the support to form a chamber over the cutting. The bags are kept under heavy shade for 6 - 8 weeks until a new shoot and several roots have been formed. No watering is done during this period.

The next step is to harden the cuttings. This is done by cutting half-way around the polythene chamber just above the coir refuse layer. After a week the other half is cut, but the polythene roof is not removed for a further week. Spray the exposed cuttings lightly three times a day, wetting only the leaves. Use an aqueous solution of urea to promote growth as previously described. The cuttings should be ready for planting out 8 weeks after the commencement of the hardening process.

PLANTING: Cocoa should be planted on the contour. The distance between contours varies, being closest at the steeper gradients and farthest apart when the land becomes flat. Mark the contours beginning at the steepest slopes, and plant along them at a spacing of 12 - 16 feet where the contours are close, and closer (8 - 10 ft) where the contours are wide apart.

On level land the standard distances are 10 × 10 ft (435 plants/acre) or 10 × 8 ft (450 plants/acre) for seedling cocoa and 12 × 12 ft (303 plants/acre) or 10 × 14 ft (311 plants/acre) for vegetatively-propagated cocoa. Planting holes should be as large as possible—2 feet square by 2 feet deep. They should be filled with a mixture of soil and farmyard manure.

FERTILIZER APPLICATION: Fertilizers are applied twice a year during the rainy season. The recommended minimum mixtures are shown below:

	1st Year	*2nd Year*	*3rd Year onwards*
Urea	22	44	66
Rock Phosphate	14	28	42
Muriate	14	28	42
Kieserite	06	12	18
	56 lb	112 lb	168 lb

During the first year 2 ounces is applied per plant at each application. In the second year the application rate is raised to 4 ounces per plant and from the third year onwards 6 ounces.

PRUNING: Only the water shoots that develop from the bottom of the stem need to be removed regularly.

PESTS & DISEASES: The helopeltis bug is the most serious pest of cocoa. It damages the pods and new shoots. Pods become brown-spotted, dry up and finally fall off. Control is effected by dusting with 10 lb of 10% BHC dust per acre.

Pod-rot and Stem-canker are two serious diseases, both caused by the same fungus. When the fungus attacks the stem causing canker the earliest recognisable symptom is the oozing of a reddish-brown liquid from the cracks in the bark. When such areas are examined the tissues underlying the bark are found to be dead and claret coloured. When it attacks the pods it causes the young fruit to shrivel and turn brown. In the case of large pods the infected areas become sodden and dark brown in colour. Losses due to pod rot can be as high as 80 percent.

Cankered areas should be scraped till the undiscoloured tissue is exposed and the surface of the wound treated with Brunolinum Plantareum. Spraying as a means of control of pod rot is not always economical. So the disease has to be kept under control by regularly picking the diseased pods and destroying them. In areas where the disease is very severe Bodeaux Mixture may be used as a spray.

Swollen-shoot is a virus disease which at present is confined to the Dumbara Valley. As the name suggests it causes the leaf stalks and the nodes of new shoots to swell. Since there is no chemical control measure the only way to arrest the spread of this disease would be to destroy the infected trees.

HARVESTING, PROCESSING & GRADING: Cocoa can be picked from the 4th year. The main crop is from October to January with a smaller crop in May to July. Picking may be done every 7 - 10 days. Only the ripe yellow or orange pods should be picked. A man can pick up to 1,500 a day. These pods should be opened as quickly as possible using a wooden instrument preferably since a knife often damages the seeds which go bad on fermentation. The wet beans are collected in gunnies or baskets rather than in iron or copper vessels.

It is necessary to ferment the beans to kill the embryos: only then will the flavour and aroma develop. Fermentation is carried out in hardwood boxes. A box 3 ft $\times$ 3 ft $\times$ 3 ft (27 cu ft) takes the beans from 5,000 - 6,000 pods. The period of fermentation varies. White, creamy and light pink beans take 3 days usually. Dark purple beans take 8 - 9 days.

Fermented beans must be dried. This can be done in a heated shed (flue - curing) or in the sun. In the sun drying takes about 6 days, 16 hours is adequate in a heated shed. Do not dry the beans on the soil and see that they are not stored with other material because cocoa fat easily absorbs odours. The finally dried beans should have a moisture content of not more than 7 - 8%.

There are six grades of cocoa viz., Grade I (brown beans), Grade II (reddish-brown beans), Grade III (blackish - brown beans), Grade IV (black beans), Grade V (defective beans) and Grade VI (pieces).

YIELD: The yield varies according to degree of shade and use of fertilizer. From 435 trees per acre under deep shade and without or with fertilizer the yield will vary between 0 - 2 cwt. cured cocoa. Under normal shade (40 rubber trees) 2 - 5 cwt/ac without fertilizer and 4 - 10 cwt/ac with fertilizer. With minimum shade 4 - 8 cwt/ac without fertilizer and over 10 cwt/ac with fertilizer.

OIL PLANTS

Coconut *Cocos nucifera*

Unlike tea and rubber, coconut is predominantly a small holder's crop. As such it has been more neglected. Most plantations today are senile. Very few are systematically manured. In the circumstances, re-planting and after-care, with special reference to the application of fertilizers, requires our primary attention. Two other matters for consideration are jaggery production, and the urgent need to maximise the use of coconut land for other agricultural purposes, which include the diversification of crops and mixed farming.

RE-PLANTING: The economic life period of commercially cultivated tall coconut palms is about 60 years. This should be taken as the dead line for replanting. The new seedlings are planted in between the rows of old palms. In practice, the removal of old palms should start in the sixth year after replanting (the obviously unprofitable trees being selectively removed first) and be completed by the 10th year.

Damage to the underplants is minimized if the old palms are poisoned before felling. Sodium arsenite is the most used poison. A hole is bored with a 7/8 in. augur at a point about 2 feet above ground, sloping downward at an angle ot about 45° to about half-way through the trunk. The poison (4 fl. oz of a 20% solution of sodium arsenite) is poured into the hole. After about 3 weeks the crown begins to wilt, but may not fall until about 2 months later. The bare trunk can then be felled accurately so as to avoid injuring young plants. To minimise the menace of the coconut beetle pest, the trees should be felled and burned as soon as possible after the crowns fall.

SELECTED VARIETIES: Two varieties are used for commercial planting viz., the traditional tall palms and the new TD hybrids

(Tall × Dwarf Crosses). Hybrids combine the early bearing quality of the dwarf variety and the high-yiedling quality of the tall variety. The annual yield is higher than that of the parents, and the nuts are large and heavy, giving copra of good quality. Hybrids flower in 4½ - 5 years and bear their first bunches on broad stems only about 2½ feet tall. Tall varieties flower in 6 - 7 years.

Since there is a direct correlation between the number of nuts produced and the yield of copra or oil, you should make it a point to select nuts for replanting only from palms that bear well. Parent palms should be between 25 and 45 years and the nuts selected of medium size. It is usual to pick two bunches per palm every two months. Nuts in either bunch are suitable for seed provided they are fully ripe.

NURSERY MANAGEMENT: Coconut has a dormancy period of about 6 weeks. Nuts are planted in a nursery at this stage. To allow for the selection of plants for field planting about twice the number required are planted. Since seedlings are generally planted out only after they are 30 weeks old, at which stage only three seed leaves and about seven roots have developed, the nuts may be planted fairly close in the nursery viz., 9 inches between rows and a spacing of 9 inches from centre to centre in the rows. Seed beds should be long and narrow to facilitate watering, and they should be raised 9 inches above ground level to ensure good drainage. The soil should be watered with a solution of Aldrin or Chlordane prior to planting as a precaution against subsequent termite attack.

Seed nuts may be planted straightaway or after soaking in water for two weeks — not longer. Quick germination and vigorous growth is ensured if the nuts are planted in a horizontal position rather than vertically. The explanation is probably that nuts planted upright suffer more from drought as the nut water does not remain in close contact with the embryo. It is convenient to cut long narrow trenches in the nursery 9 inches apart and about 6 ins deep and to bed the seed nuts 9 inches apart partially covered with soil but with the 'eyes' exposed. Nuts in one trench should alternate with nuts in the adjoining trench.

No shade is necessary. No manuring too because the seed nut contains adequate plant food for the seeds of the growing plant to at least the transplanting stage. Daily watering, however, is recommended in dry weather, but mulching for water conservation cannot be recommended as the usual mulching material used e.g., straw, coconut leaves etc, tends to encourage the activity of termites. Nurseries must be kept weed free. In about the 16th week when the shoot comes through the husk, the nut is said to have germinated.

SEEDLING SELECTION: First, late germinations and very slow growers should be discarded. By late germination is meant those nuts that have not put out a shoot by the 20th week. This may account for 5 - 10 percent rejections. At the transplantation stage (7 - 8 months) when there are 3 - 4 leaves on each plant look for the following characteristics which are supposed to be associated with good yield in the adult palm: (i) short, straight robust stem and (ii) broad, comparatively short, dark green leaves with prominent veins spreading out and not up. Leggy seedlings having weak, curved stems, narrow pale green leaves with thin midribs should be scrupulously avoided.

TRANSPLANTING: The concensus of opinion is that planting density should not exceed 64 palms per acre on the worst soils and 55 palms on the best soils. That is a range of 26 - 28 ft on more or less level terrain. On pronounced slopes modifications are necessary.

The usual size of hole is 3 ft × 3 ft. Holes are dug 1 - 3 months before the seedlings are transplanted. It is common practice to burn leaves, husks or debris in the holes, which effects some soil sterilization and possibly checks termite attack. 300 - 400 husks burned in the hole give about 10 lb of ash (rich in potash), which during subsequent filling must be mixed with the soil.

If available, coconut husks are laid in two layers at the bottom of the hole to facilitate good drainage and the mixture of soil and ash is piled on top. There has been much difference of opinion concerning the depth of planting. The practice recommended

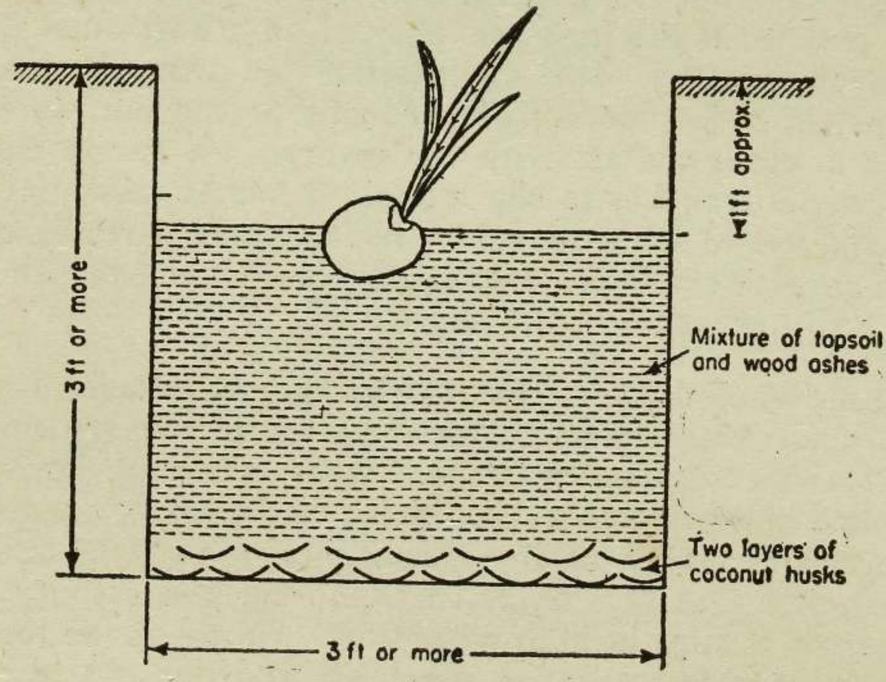


Fig. 6·2

Vertical Section of Planting Hole

here is to plant the seedlings at a depth of one foot. The soil mixture is piled to within a few inches of the top and allowed to subside to a depth of one foot before planting. In planting, pack the soil well around the nut but do not cover the collar of the seedling or let it get into the leaf axils. As the plant develops the trunk may be earthed up until the soil is flush with ground level.

AFTER-CARE: Vacancies have to be filled at the end of the first year. Any noticeably backward seedlings which may have suffered damage from some cause or other should also be replaced by healthy plants. For this purpose a reserve of plants of the same age as the original planting material should have been maintained in the nursery. Five percent of the original number usually suffices.

Although transplanting is done during the rainy season, it may be necessary to water the plants during long dry spells, specially during the first three years. An application of 4 gallons of water per seedling at least twice a week should be aimed at, particularly during the first year. The ground may be allowed to go to grass, but it is essential to see that a circle of 3 - 6 ft radius is kept free of weeds around the palm.

MANURING: While potassium is the dominant nutrient element in coconut, nitrogen and potash too are important. The general recommendations for fertilizer application by the Coconut Research Institute are given below: Fertilizer mixtures could be purchased direct from the Fertilizer Corporation, or from the Regional Fertilizer Stores of the Coconut Cultivation Board.

The CRI General Mixture For Young Palms is made up as follows: 4 parts by weight of sulphate of ammonia, 3 parts by weight saphos phosphate and 2 parts by weight of muriate of potash. It is applied as follows to underplanted seedlings (seedlings in new plantations may be given less):

6	months after planting	1½lb
1	year after planting	1½lb
1½	years after planting	1½lb
2	years after planting	1½lb
2½	years after planting	2 lb
3	years after planting	2 lb
3½	years after planting	2½lb
4	years after planting	2½lb
4½	years after planting and thereafter until bearing at 6 monthly intervals	3 lb

Different fertilizer mixtures are recommended for bearing palms according to soil type. CRI Mixture 'A' which contains 4 parts by weight of ammonium sulphate. 2 parts saphos phosphate and 2 parts muriate of potash may be applied at the rate of 4 lb per palm every 6 months to the deep reddish brown loams, sandy loams and clay soils in the Chilaw, Puttalam, Hambantota, Matara, Anuradhapura, Vavuniya, Mullaitivu, Dambulla and Melsiripura regions.

Mixture 'B' which contains 4½ parts ammonium sulphate, 2 parts saphos and 2½ parts muriate is applied at the rate of 4½ lb per palm every six months to the lateritic loams and lateritic gravels of the Chilaw, Puttalam and Kurunegala Districts which fall within the Intermediate Zone.

Mixture 'C' is applied at 5 lb per palm every 6 months to the cinnamon sands of the Chilaw - Negombo areas and the coastal areas of the Puttalam, Chilaw, Negombo, Batticaloa, Mannar and Jaffna Districts, and to the 'cabook' soils of the Colombo, Kalutara, Galle, Matara, Ratnapura, Kegalle, Kandy and Matale South Districts.

In addition to the NPK fertilizer mixtures recommended above it is necessary that coconut soils should be treated with magnesium fertilizers as well. The addition of ground dolomite limestone is advised at 5 lb per palm once in 3 years in the wet zone, and 3 lb per palm once in 3 years in other areas, particularly on lateritic and sandy soils. Dolomite should not be added along with the fertilizers to avoid inactivating the ammonium sulphate. There should be a delay of at least one month between applications of the fertilizer and the dolomite. (New fertilizer mixtures are under preparation and test by the C.R.I.)

The latest research evidence suggests that fertilizers are best applied to the entire area around the palm up to a distance of 5½ feet from the bole on the surface, forked into the soil and mulched with dried fronds and husks. Trench manuring may be adopted only in very steep lands subject to considerable soil wash and run off.

CULTIVATION: Too frequent cultivation specially in the lighter soils, is not recommended. The common practice is to disc-harrow the land at the end of each monsoon season. If ploughing is done it should only be once a year to a depth of 6 - 8 inches. Do not plough beyond the edge of manuring circles, that is, nearer than 6 ft from the base of the palms.

JAGGERY MANUFACTURE: The sap or sweet toddy that is extracted from the flower is used for making jaggery. It is the tall variety that is generally tapped because it yields toddy over a period of 8 months with a rest period of 4 months, while the short varieties have a shorter sap period of 4 - 5 months.

A tall palm, growing under good conditions, will flower in 6 years. A flower cluster or inflorescence is produced in each leaf axil. An average palm produces 12 new leaves and 12 inflorescences annually under favourable conditions. So you can expect to tap at least 8 inflorescences. Each inflorescence is enclosed in a double sheath or spathe, the whole structure being called the spadix.

The spadix when it is fully grown normally splits down the underside releasing the inflorescence. But this should not be allowed to happen if you are going to tap the flower. The spathe is then tightly bound with fibre or coir rope, and gradually bent over by tapping it gently with a mallet. This early preparation phase takes about 3 weeks.

At the end of three weeks, the bound spathe is ready to produce toddy. At this stage 2 - 3 inches are cut off the end and an earthenware pot or 'chatty' is hung to collect the free flow of sap. The flow of juice gradually increases. When it is in full flow the tapper usually changes the pot twice daily, at the same time shaving off a thin slice from the end of the spathe, tapping slightly with the mallet, and smearing a mixture of bruised leaves. These leaves, which usually contain saponin, are meant to stimulate the flow of juice. A skilful tapper can by careful slicing and tapping keep a spathe going for 30 days or more, and during this time he can bring a second spathe into production.

The tapping process is the same as for the production of toddy. What is different is the preparation of the pots. In the production of jaggery a certain substance has to be introduced into the pots to prevent the rapid fermentation of sucrose which is covered into other forms of sugar which do not crystalise into jaggery when boiled.

It is thought that the addition of certain tanin-containing barks cf leaves e.g. *hal* bark (*Vateria acuminata*) would inhibit fermentation. This is not so. Although *hal* bark may help to clear the toddy of certain albuminous impurities it does not prevent fermentation. But lime is an effective anti-ferment, usually slaked lime (*alu-hunu* or *chunam*). In conjunction with *hal* bark slaked lime gives excellent results.

Pots that are used for collecting toddy must be thoroughly washed and heat-sterilized every time they are used for jaggery manufacture. Sterilization is done by drying the washed pots, open ends down, over a fire of dry coconut fronds. This is essential to ensure that yeast and other fermenting micro-organisms are completely destroyed. Otherwise they will cause fermentation.

Into each pot so sterilized put a tablespoonful of chopped *hal* bark and a teaspoonful of slaked lime. This is the formula recommended by the Coconut Research Institute for an average collection amounting to 1 - 1½ bottles of sweet toddy. Care must be taken to see that the cut end of the spathe does not come in contact with the lime in the pot. If this happens the spathe will be damaged and will cease to produce any sap.

At the end of each collection, the sweet toddy is strained and bulked into a single receptacle. After this it must be tested for its pH value. If clean sterilized pots were used in the first instance together with the correct quantity of lime, then the pH should register over 7.1. If it is less, then the sweet toddy is too acidic for the preparation of jaggery and may be used for the production of treacle instead. This is accomplished by heating it without delay to a temperature of 100 - 110°C when the syrup thickens into treacle. pH is tested with pH paper with a range of 1 - 14.

Only sweet toddy that has a pH value of over 7.1 is used for jaggery manufacture. It is boiled slowly to a temperature of 75°C. This takes 30 - 45 minutes. At this stage we must test the pH again. If it is still over 7.1, then we must proceed to bring it down to 7.1 by the addition of a de-liming agent.

Undiluted lime juice or lemon juice is a good deliming agent. So is a saturated solution of Triple Super Phosphate (TSP) or Conc. Superphosphate. A saturated solution of TSP is previously prepared by mixing one lb of TSP in 2 bottles of water and boiling for one hour. The boiled solution is then allowed to rest for some time and only the clear solution on top is bottled for use. Only a few drops of lime juice or TSP solution should be sprinkled into the boiling mass from time to time till the pH is brought down to 7.1.

The juice is then transferred to another vessel where the lime is allowed to settle as a precipitate, and only the clear juice on top is taken for boiling again up to a temperature of 115 - 118°C. During the boiling process the contents, which keep getting stickier and stickier, must be stirred regularly with a wooden ladle. In the process of stirring when you notice that the sticky contents tend to leave the bottom of the pan and solidify on the sides, you can be reasonably sure that the "strike-point" has been reached.

Another convincing test is to dip a glass rod into the boiling contents and take it out. If the mixture solidifies immediately on the rod instead of remaining in a semi-liquid state the time is right for taking it off the fire. Yet another test is to put a few drops of the boiling mass into a glass of water. If these drops solidify immediately and sink to the bottom of the glass instead of dissolving spontaneously in the water, then it is time to pour the boiling contents into the moulds to harden into jaggery.

A single coconut palm can yield 65 gallons of sweet toddy on the average in the space of 8 months. And from this quantity—assuming a recovery rate of $1\frac{1}{4}$ - $1\frac{1}{2}$ lb jaggery from one gallon of sweet toddy—you should be able to prepare 80 - 95 lb of jaggery.

PESTS & DISEASES: Two pests that are always present are the coconut black beetle and the red weevil. The beetle burrows into the living tissues of the bud and damages the un-opened leaves. When they do open they give a ragged and tattered appearance. Damage to young palms may be severe enough to cause death.

The most effective way to control this pest is to keep the plantation in a clean condition. Supplementary measures are of little use if action is not taken to eliminate as far as possible all the breeding places of the larvae. Such measures include the proper disposal of all decaying refuse. Coconut fronds, logs and stumps should all be burnt.

The red weevil generally lays its eggs in the stem or base of the young palms. Here the tissues are soft enough for the grubs to tunnel in all directions and eventually to hollow out a fairly large cavity. At first the only indications of attack may be a few small boles in the stem from which a brownish liquid oozes out, but later larger wounds appear on the outside. Control measures here too should be aimed at general sanitation.

BUD ROT: This is the most serious disease. It is caused by a fungus that attacks the growing point or bud. Since the coconut palm has only one growing point, if this is killed then the palm also dies. The young leaves first turn brown, then wither and when the rot extends to the base of the leaf stalks, the leaves collapse and remain hanging downwards vertically along the trunk. This disease is most prevalent in localities where there are long periods of continuous wet weather. Palms in the middle of dense stands or in valleys where moist air is stagnant suffer most. Control is effected by the removal and destruction of infected palms.

TAPERING: Tapering is a concomitant symptom of many unhealthy conditions of the coconut palm. Symptoms are a yellowing of the leaves and a gradual reduction of their size, with an accompanying diminution or tapering of the trunk, until the palm finally dies. Waterlogging is one cause of this condition. Hard pans are another cause quite frequent in this country. Soil deficiencies are also responsible for tapering as, for example, in played-out sandy soils. Senility is another reason.

In recent times quick tapering, together with a scorched look in the leaves, has also been noticed in plantations along the southern coast e.g., Gonapinuwela, Hikkaduwa and Dodanduwa. This condition is not due to the usual causes of waterlogging, hard pan, soil deficiency and senility. And since no disease-causing pathogen has yet been discovered the problem remains a mystery. It is generally referred to as the "leaf scorch" of coconut.

CROP DIVERSIFICATION & MIXED FARMING: Coconut plantations provide a wonderful opportunity for crop diversification and mixed farming. Experiments carried out at the Coconut Research Institute have indicated quite definitely that undercropping coconut with productive pastures and fodder grasses and food crops does not adversely affect the yield of coconuts, *provided that the manuring of the other crops and grasses is systematically undertaken in addition to the manuring of the coconut crop.*

There is no question of exhausting the fertility of the soil so long as the fertilizer requirements of coconut and the other crops are separately looked after. The limiting factor, if any, is light. Even when adequately manured the shade cast by the coconut palms would tend to reduce the yield of crops planted between them. From about the 7th year to the 20th year the growth of the palms is luxuriant so that very little sunlight filters through to ground level. During this period no undercropping should be undertaken. In young plantations up to the 7th year, however, and in older plantations after the 20th year crop diversification and mixed farming are feasible propositions.

Since it is likely to be at least seven years before a coconut plantation begins to give an economic return, it is advantageous to grow intercrops during the waiting period. Pineapple is a popular intercrop because its life span of 5 years fits into this waiting period for coconut. Other crops too can be grown successfully, e.g., manioc, dioscorea yams, kurakkan, green gram, sorghum, cowpea and sweet potato.

Between the 20th year and 30th year, although there is enough light for pasture and fodder grasses, there is still not enough for food crops. It is only after the 30th year that food crops can be cultivated successfully. Cocoa, coffee, passion fruit, banana and pepper may be recommended, along with all the short-term crops stated above. Shade-loving crops like ginger and turmeric also do well. But manioc is probably the most successful crop. Even under mature coconut, by cultivating rows 9 ft wide between the palms, yields of 30 cwt per acre have been taken.

Dairy farming is an attractive proposition in plantations which have an evenly distributed annual rainfall of over 75 inches. Sheep-farming may be tried where the rainfall is less. The section under grass could be rotated with the fruits and other crops in such a way as to maintain the fertility of the land and yet get the maximum use of it.

(For further information on mixed farming and crop diversification see section on "Dairy Farming" and also the Appendix.)

Castor *Ricinus communis*

At present castor oil is used in this country only for medicinal purposes. According to the Five Year Plan the domestic demand can be had from an additional 500 acres. While this should be our immediate aim—to expand cultivation to meet the local demand, entrepreneurs will do well to keep an eye on the international market where castor oil is used for the manufacture of several products, the chief of which today are plastics, paints and nylon.

The biggest producers of castor are Brazil followed by India, Thailand and Tanzania. During the 1960s the trend was one of expanding production although output tended to settle down in the seventies at a high level which exceeded 800,000 tons.

At present castor appears to suffer only limited competition from linseed—the other industrial oil—and from synthetic products. And since the industrial uses of castor, already widespread, are gradually being expanded by research into new applications the long-term market prospects for this product may be considered favourable.

In the circumstances, there is every reason to believe that apart from meeting our domestic requirements, castor may be developed into a valuable foreign exchange earner by stepping up the tempo of local production. India had already taken steps to do this by the evolution of improved dwarf varieties which produce more seed in less time and less space. Until such time as our researchers follow suit the introduced commercial variety Hazeera No. 1 which has given good results at Maha-Illuppallama and other places could be made to play a far more significant role in the economy of the dry zone farmer than it does at present.

Because of its highly drought resistant quality Hazeera No. I is able to produce over 1,000 lb of seed per acre per annum on newly cleared *chenas* without the application of any fertilizer. Planted 8 ft apart this variety permits the inter-cropping of short-term food crops such as green gram, black gram, soyabean, cowpeas and groundnut which will yield the farmer a substantial money return in the unproductive phase of the castor crop.

CLIMATE: Castor can be grown in any part of the island but the dry zone is preferable because of the presence of a marked dry period at harvest. It requires a rainfall of about 50″ per year. It is highly drought resistant and is a crop which is suitable for the dry and arid regions.

SOIL: Castor grows well on most soils. Medium textured, deep, well drained and fertile soils are ideal for its growth. It also does well on marginal land which is unsuited for most other crops. It cannot stand waterlogging, so ill-drained soils should be avoided.

VARIETIES: Hazeera No. I is the variety recommended. It grows to a height of about 5 to 10 feet depending on soil type, rainfall and planting density. The oil content of the seed varies from 40 to 50%. The yield of "Hazeera" is much higher than the local varieties.

PLANTING SEASON: The best time for planting castor is with the onset of rain during the *maha* season in October/November. The *chenas* which have been cleared or burnt are suitable for planting castor.

METHOD OF PLANTING: The seed rate is two to three pounds per acre. A pound of seed contains about 1,050 beans. The seeds are dibbled in rows at a spacing of 8′ × 8′ with 2 to 3 seeds per hill. A week after germination the seedlings are thinned out to one seedling per hill and vacancies, if any, must be filled.

FERTILIZER: A basal dressing of 50 kg (1 cwt) of conc. superphosphate and 25 kg (½ cwt) of muriate of potash per acre is applied before or after planting and the fertilizer forked in. A top-dressing of urea at 25 kg (½ cwt) acre is applied three or four weeks after planting. It is not necessary to apply fertilizer on virgin *chenas* but on land which has been previously cropped, or in second and third year *chenas*, fertilizer application at the above rates is essential.

WEEDING: The crop should be kept free of weeds for the first three months.

PESTS & DISEASES: Hazeera No. 1 is generally free of most pests and diseases with the exception of leaf-eating caterpillars which can be easily controlled by the application of Carbaryl 85% W.P. (Sevin). In severe infestations it may also be necessary to dust the soil around the plants with Aldrin dust to kill the caterpillars which drop off to pupate in the soil. Caterpillars feed on the underside of the leaves. For best results therefore direct the spray solution underneath the foliage.

HARVESTING: The crop can be harvested four to five months after planting. Handpick the panicles when about half the pods in a panicle are brown and allow them to dry in the sun. The pods will then shatter releasing the seed. Harvesting can be continued till August/September the next year.

YIELD: Yields of over 1,000 lb per acre per year can be obtained with Hazeera No. 1.

Citronella *Cymbopogon Nardus*

Almost the entire cultivated extent of citronella is in the Tangalla and Matara area. *Lenabatu* is the commonly cultivated variety but its geraniol content is only 55 - 60, compared with the introduced variety *mahapangiri* which has 80 - 85 percent. It is more profitable therefore to cultivate *mahapangiri*. It should be noted however that *mahapangiri* is not as hardy a variety as the local *lenabatu*. As such it needs more attention.

This grass is rapidly propagated by root divisions (fertile seed being rarely produced) and planted 2 × 3 ft in rows. Cultivation is simple, weeding and manuring being the chief requirements. Since yields begin to decline appreciably after the second year of harvest in unmanured crops, a complete fertilizer mixture should be given every year from the third year onwards. The following mixture is effective: $37\frac{1}{2}$ kg ($\frac{3}{4}$ cwt) urea, 25 kg ($\frac{1}{2}$ cwt) conc. superphosphate and $18\frac{3}{4}$ kg (42 lb) muriate of potash per acre. Leaves are ready for cutting about 8 months after planting, and thereafter every 4 months subject to weather. Replanting is necessary once in 4 - 5 years.

The oil is obtained by steam distillation in stills. The low yield obtained at present (about 75 lb/acre) is the result both of poor cultivation and inefficient distillation. Investigations, however, have shown that high oil yields can be obtained by the adoption of improved techniques in distillation practice with no extra expense to the producer. If, for instance, not more than 10 - 12 lb of grass are packed loosely to every cubic foot of still, and the distillation limited to 3 hours while the boiler is fired at regular 10 minute intervals to maintain a steady pressure of steam, a much greater distillation efficiency is achieved.

The oil has a strong aromatic odour and is exploited for use in perfumery, scented soaps etc.

Lemon Grass *Cymbopogon citratus*

Lemon grass resembles citronella grass in general appearance, but is distinguished by the odour of the leaves and its less robust growth habit. Its propagation and cultivation are similar to citronella ; a smaller yield of oil is obtained which, however, commands a higher price. The oil is used for flavouring, and in scented soaps, perfumery, medicine etc. Lemon grass is cultivated to a small extent on the hill sides, under purely rainfed conditions in the mid-country.

Gingelly *Sessamun indicum*

Gingelly is valued for its oil which is used for cooking and other domestic purposes and the manufacture of margarine, soap and perfumes. It is the most reliable *yala* crop in that its water requirements are very low. In fact, heavy rains are definitely detrimental to the growth of this crop.

VARIETIES: To obtain the best results it is essential that you should select a high-yielding variety and cultivate it systematically rather than as a *chena* crop. In this way you can increase the yield from the usual 300 lb per acre to between 600 and 800 lb.

A variety from Burma known as B3 has been the recommendation of the Department of Agriculture for many years. It is a black-seeded variety with an oil percentage of about 40.

Better varieties, however, have been subsequently developed at the Maha-Illuppallama Research Station. These varieties take the same time as B3 to mature—about 80 days, but they give higher yields.

M-1 and M-2 are black-seeded varieties which out-yield B3 by about 15 - 20 per cent. M-3 is an equally good variety although it is white-seeded.

White-seeded varieties are generally preferred for cultivation because they are claimed to contain a higher percentage of oil, and give a better quality of oil than brown and black-seeded types.

PLANTING: Except in *chena* planting, the soil should be well ploughed, manured and harrowed until a fine tilth is produced. Gingelly may either be planted as a single crop or in alternate rows with green gram—another crop that grows extremely well during *yala* in the dry zone.

Seed should be drilled either in shallow rows about 1 ft apart at the rate of 2 lb per acre or in alternate rows 1½ ft apart with green gram. Being small and light the seed should be mixed with dry ash or sand so as to ensure its even distribution in the row. After sowing, the seed should be lightly covered with soil.

AFTER-CARE: Germination will take place in about 5 days. When the seedlings are 2 - 3 weeks old they are thinned out to 6 - 8 inches in the row. The crop should be kept clean weeded. If green gram is inter-cropped with gingelly only about two weedings will be necessary, otherwise it will be necessary to weed about three or four times.

Since weeding is a labour-intensive and time-consuming operation, it may be more economical to use a pre-emergence weedicide like Diuron.

Flowering commences from the base of the plant and proceeds upwards. When the leaves turn yellow and droop and the first pods have turned brown it is time to harvest the crop. If harvesting is delayed the pods are liable to shatter and considerable loss results.

HARVESTING: The crop is harvested by cutting the plants down to ground level with a sickle, after which they are tied in bundles of convenient size and removed to an open shed for drying. If such accommodation is not available, the bundles are stacked in the open but covered with gunnies to protect them from the sun.

The bundles are heaped like this for about 7 days. During this period all the leaves will drop and the pods turn brown.

Most of the pods should burst open with exposure to the sun, shedding the seeds on to the floor. To ensure the removal of all seed however, the pods are beaten with a plank or rolled. Finally the seeds are separated from the chaff and dust by winnowing and then stored in clean bins with tight-fitting lids.

In this country the oil is extracted in a *chekku* or wooden press revolved by bullocks moving round in a circle. The seeds are first soaked and then rubbed to remove the husks. After drying they are subject to pressure in the *chekku*. A bushel of seed of the local varieties yields about 12 bottles of oil or about 35 per cent by this method.

If, however, hydraulic mills are used as much as 45 per cent oil can be obtained. In North India the improved *chekku* will give almost as much.

Gingelly poonac is more nutritious than coconut poonac. It contains about 40 per cent protein, which is almost double that contained in coconut poonac. It is also rich in calcium. Furthermore, it can be safely fed dry whereas coconut poonac must be soaked thoroughly before feeding as it will otherwise swell in the stomach and cause distension.

FIBRES

Kenaf *Hibiscus cannabinus*

Kenaf is an excellent substitute for jute fibre and may be used in the manufacture of burlap bags, sackcloth, carpets, linoleum backing and cordage. It can be grown successfully in the dry zone during the *maha* season. Planting is done with the rains in October. About 10 - 15 lb of seed are required to plant one acre.

PLANTING & AFTER-CARE: The spacing is one foot between rows and 3 - 4 inches within the row with 3 seeds planted at each point. Seedlings are later thinned to a single plant at each point. (If your crop is grown for seed only, then the spacing should be 2½ ft between rows and 6 inches in the row with one seedling at each point).

Prior to planting, a basal dressing of fertilizers should be given at the following quantities per acre: 12½ kg (¼ cwt) urea, 50 kg (1 cwt) conc. superphosphate and 25 kg (½ cwt) muriate of potash. A booster top-dressing of 25 kg (½ cwt) urea is also given 6 weeks later in strips about 3 - 4 inches away from the rows of plants to a depth of 2 - 3 inches.

If caterpillars are a problem use Carbaryl (Sevin) to destroy them. A fibre crop is ready for harvest in about 140 days, at which time the lowermost capsules begin to burst. Plants are cut at the base, the tender top portion lopped off, the stalks tied into small bundles and removed for retting. (In the case of a seed crop, harvesting is done when at least one-third of the capsules on the plant are dry. Stems are cut and stacked upright in bundles. When the entire plants are dry they are threshed for the seed).

RETTING: The bundles of stalk from which fibre is to be extracted are submerged in water for 10 days. The bark is then peeled off and washed clean. It is suspended vertically on a string and dried. This is done manually where only small quantities are handled. A decorticating machine is essential for large scale production.

YIELD: Yields of 1,200 - 1,500 lb of fibre can be taken from one acre, or 400 - 600 lb of seed.

VARIETIES: The introduced variety "Cuba 2032" is the best that has been tested so far as yield is concerned. But local varieties are comparable in fibre quality. Among the promising local types are *Kodigangala*, *Hurigaswewa*, *Ippologama* and *Periyakulama*. The names refer to villages in the vicinity of the Maha-Illuppallama Research Centre.

Cotton *Gossypium sp.*

Cotton is cultivated mainly in the Hambantota and Monaragala Districts and to a small extent in the A'pura and Polonnaruwa Districts during the *maha* season. Recent research has shown that it can also be cultivated fairly successfully in the Vanathuvilla area in the Puttalam District.

A well distributed rainfall of 20 - 40 inches from October to February is essential to good growth. Planting is done in late September or early October with the onset of the rains. Cotton may also be cultivated in these regions during the *yala* season under irrigation, when planting is done in mid- March, 6 - 12 irrigations will be required to supplement the rainfall from March to May 2 acre inches are given at each application. Where irrigation is scarce a considerable saving can be effected by letting the water into alternate furrows each time without disrupting the growth of the crop.

RECOMMENDED VARIETIES: "HC101" is a popular medium-stapled variety (ginning 33.5%) which has been cultivated over 20 years. It is grown under rainfed conditions in *maha* and takes 120 days from planting to 60% harvesting.

Two new American varieties viz. "ACALA 1517D" and "COKER 17 Selection" have also been released for cultivation under irrigation. Coker takes 105 days to 60% harvesting. Acala, which takes 10 days longer, may also be cultivated with the *maha* rains. Coker is a long-stapled cotton (ginning 39%) and Acala medium-stapled (ginning 36%).

PLANTING AND AFTER-CARE: 30 - 40 lb of seed are required to plant one acre at a spacing $2\frac{1}{2}$ - 3 ft between rows and 1 foot between plants in the row. For irrigated cotton raised ridges have to be prepared for planting. Under rainfed conditions planting is done on the flat.

The land must be ploughed, harrowed and worked to a fine tilth, the soil mixed with 3 - 5 tons of cattle manure and the following fertilizers: 25 kg ($\frac{1}{2}$ cwt) of urea and 50 kg each of conc. superphosphate and muriate of potash per acre.

Seed is preferably treated against Bacterial Blight (seed borne) before planting with either Mema 'A' or Ceresan Wet. Use 1 oz of Mema for every 20 lb or $3\frac{1}{2}$ oz Ceresan Wet per 100 lb seed. "Coker" is resistant to Bacterial Blight. This disease causes angular discoloured patches to form on the leaves which finally wither and drop off. 6-8 seeds are planted at each spot and thinned out at 3 weeks to leave two vigorous plants at each spot. Uprooted plants may be used to fill vacancies.

The crop must be weeded regularly and top-dressed at the time of flowering with 25 kg of urea and 25 kg of muriate of potash per acre. The fertilizers are lightly forked into the soil.

PEST CONTROL: Insect pests are a serious problem. Boll worms are the most destructive. They feed not only on the bolls, but also on the stems and shoots. They are pink, brown, green, yellow and spotted. Spray fortnightly to keep these pests under control. Use any one of these insecticides: Azodrin, Tamaron, or Sevin.

Stainer Bugs are also a nuisance. Red in colour, they are found feeding on the bolls and seeds. In the process they transfer a fungus which stains the lint yellow. Control is achieved by spraying with Dimethoate 40% E.C. (e.g. Rogor 40 and Rogor L 40).

Jassids are the most serious leaf-eaters. "HC101" and "Acala" are fairly resistant because of their hairy leaves. "Coker", however, is susceptible. The first signs of damage are the curling of the leaf margins. Green caterpillars sometimes roll up the leaves and feed inside. Along with the Jassids they can be controlled by spraying Dimethoate 40% E.C.

HARVESTING & YIELDS: Picking commences 3 - 3½ months after planting. It is done every 2 weeks in sunny weather. Only fully-opened bolls must be picked.

After the cotton is dried thoroughly in the sun the lumpy and stained product is separated from the clean white cotton and marketed separately. Grade I cotton fetches Rs. 340/- per cwt under the Guaranteed Price Scheme.

Yields of 3 - 5 cwt per acre are average under rainfed conditions, going up to 8 cwt in favourable seasons. 12 - 15 cwt may be obtained under irrigation.

LEAF CROPS

Cigarette Tobacco *Nicotanium Tabacum*

Cigaratte tobacco is cultivated in the Jaffna Peninsula on highland irrigated during the *maha* season. In Amparai and Polonnaruwa Districts it is taken as an irrigated crop in paddy fields during the *yala* season. In the Matale and Kurunegala Districts it is cultivated as a rainfed crop, commencing with the *yala* rains in May/June. A little cultivation is also done in the Monaragala District during the *maha* season, and in Andigama in the Chilaw District during *yala*.

In the major tobacco-growing areas in the N'Eliya, Kandy and Badulla Districts the season starts in November, December and January on highland as a rainfed crop. The finest quality of flue-cured tobacco is produced from crops grown in these three Districts. The poorest quality comes from Jaffna leaf which has an excessive chloride content which affects burning quality and aroma — the tobacco growing areas in the Jaffna District are in close proximity to sea and lagoon.

NURSERY: "North Carolina 95" and "White Gold" are the recommended varieties. Seed being minute and delicate with hardly any food reserves at all must be planted in a nursery first, and the seedlings gradually "hardened" for field planting. 180-200 sq. ft. of nursery are required to raise enough seedlings to plant one acre. Beds are prepared, sterilized by burning trash on them and then given the following fertilizer dressing (lightly forked into the soil) a day or two prior to sowing the seed. 3 lb sulphate of ammonia or 1½ lb urea, 5 lb conc. superphosphate, 1½ lb sulphate of potash and ½ lb magnesium sulphate.

One teaspoonful of seed is enough to sow this area. It is mixed with 2½ lb of sand and sprinkled uniformly on the beds, after which the beds are rolled or the soil pressed down firmly with a plank to prevent seed displacement. Beds must be covered with jutehessian, polythene or even cadjan built into an inverted V frame. A certain amount of ventilation must be provided by punching holes in the polythene cover, otherwise too high a humidity will promote fungus growth and increase the disease hazard.

Beds are watered generally twice a day, once in the morning and again in the evening. But after 3 - 4 weeks this should be reduced to one watering only as part of the hardening process. "Damping-off" fungi sometimes kill off the small seedlings. Spraying with a copper fungicide will arrest such damage.

In three weeks the seedlings should be about one-inch high. At this stage the "hardening" process should begin by removing the covering in the morning and replacing it after a few hours. The period of exposure should be gradually lengthened till at the end of the 4 weeks, no further shelter is required. Seedlings will be ready for transplanting in 5 - 6 weeks from sowing when they are about 5 - 6 inches tall.

FIELD FERTILIZER APPLICATION: Ploughed and harrowed the field must be given the following basal dressing of fertilizers per one-fifth acre:

Rainfed Highland Cultivation

25 lb	Sulphate of Ammonia (or 12 lb Urea)
43 lb	Conc. Superphosphate
15 lb	Sulphate of Potash
08 lb	Muriate of Potash
08¼ lb	Dolomite
00¾ lb	Borax
100 lb	

Irrigated Paddy Fields

25 lb	Sulphate of Ammonia (or 12 lb Urea)
43 lb	Conc. Superphosphate
32 lb	Sulphate of Potash
100 lb	

Note: The use of Muriate of Potash (potassium chloride) is kept down to a minimum because excessive chloride can damage the burning quality and aroma of the cured product.

The above quantities are for one-fifth acre to be given in two doses viz., half at time of planting and the balance 21 - 30 days later. The basal dressing should be applied to the planting holes one day prior to transplanting. The holes are made 5 inches deep and 5 inches wide. Fertilizer is sprinkled at the bottom of the hole and the soil filled in. The spot is marked with a stake. Spacing between holes is $3\frac{1}{2}$ ft $\times$ $2\frac{1}{2}$ ft. The balance top-dressing is given 21 - 30 days later in two side bands 4 inches away on either side of the plants and 5 inches deep.

PLANTING: Only sturdy seedlings, 5 - 6 inches high and quarter-inch thick are planted out. The planting season is November/December or early January in *maha* and April/June in *yala*. Shade the plants for a week. Water every day for about 5 days if there is no rain. When tobacco plants begin to wilt in the morning and do not recover until nightfall it is a sign of water stress. This is the time to irrigate the crop. Usually 3 - 4 irrigations will suffice in a season. But in periods of continuous dry hot weather it is essential to irrigate at least once a week.

PRIMING, TOPPING & SUCKERING: Remove the first few leaves at the bottom as they are without value. These leaves are usually small and diseased. When removed they reduce the hazard of disease and improve the ground circulation of air.

Later on when 10 - 15 percent of the crop is in flower it is necessary to 'top' or pinch off the terminal bud. This is done to promote the development of the leaves and strengthen the stalks. An average plant should have 18 - 22 leaves at the time of topping. The topmost leaf after topping should be 9 - 10 inches long and 3 - 4 inches wide.

It is also necessary to remove all the suckers or side growths that arise from the bottom of the stem and the leaf axils after topping. If this is not done food and energy that is required for leaf development will be unnecessarily diverted to these suckers.

PICKING: Generally tobacco takes 60 - 65 days to flower and 70 - 75 days to the first pick. Ripening commences with the bottom leaves and progresses upwards. Signs of ripening are a change of colour from the deep green of light textured leaves to greenish yellow. In heavy textured leaves the colour change is not overall, but only confined to portions as yellowish flecks. About 2 - 3 leaves per plant ripen in a week. Picking can be continued for 5 - 7 weeks. Restrict your picking to two leaves at the first pick and not more than 3 leaves during the subsequent picks. Picking should always be done in the early morning.

Picked leaves should be bundled loosely in jutehessian or gunnies with the stalks at either end and taken to the tying shed before the sun gets too hot and wilts the leaves. In the tying shed the leaves are separated into fully matured ripened leaves of good texture (should be about 90% of pick) and undermatured or overmatured leaves of good texture. After weighing, these two grades are tied separately on sticks about 4 ft long and sent to the barn for curing. There should be about 25 - 30 lots of leaves (75-90 leaves on each stick). This is about the right density for good "curing". (*The curing process will not be discussed here as this is a specialized function carried out by recognised barn owners*).

GRADING: After curing the leaf is untied from the sticks and graded according to colour, texture and blemishes. There are ten market grades V/1 - V/10. The leaves are then packed in bales of about 60 lb each and marketed.

Average yield of cured cigarette leaf tobacco per acre is 800 - 1,000 lb.

PEST CONTROL: Since the commercial product of the tobacco crop is the leaf, insect pests and diseases that damage the leaves are the most important. Caterpillars, green bugs, aphids and other insects which feed on the leaves can generally be controlled by spraying Fenitrothion (Sumithion), Mathomyl (Lannate), Methamidiphos (Tamaron, Monitor), Dimethoate (Rogor 40) or similar insecticides. Diseases, however, are a bigger problem.

Some diseases e.g. "Frog-Eye" and "Brown Spot" may be controlled by spraying a copper fungicide. "Frog-Eye" causes circular brown spots with a white centre to appear on the leaves. "Brown Spot" has no white centre.

Virus diseases, however, like "Mosaic" and "Leaf Curl" and the "Bacterial Wilt" disease have no control measures. The only way to keep them under control is to promptly identify and destroy diseased material and follow up with a strict crop rotation routine. A three-year rotation on highland and a two-year rotation in paddy tracts should be adopted. Avoid the cultivation of other solonaceous crops like potato, tomato and brinjal which are also susceptible to the "bacterial wilt" disease.

Beedi Tobacco

Beedi tobacco is generally grown as a *maha* crop in the following districts: Matale, A'pura, Hambantota, Jaffna, Mannar, Batticaloa, Monaragala, Ratnapura, Badulla and Kandy. The popular varieties are "K49" and "K20". Recently new varieties like "S-20", "3-1" and "3-6" have also shown good results.

Cultivation is similar to cigarette tobacco except that the basal dressing in this instance should be 50 kg (1 cwt) urea, 50 kg (1 cwt) conc. superphosphate and 50 kg (1 cwt) sulphate of potash per acre. A further top-dressing of 50 kg (1 cwt) urea may be given one month after planting if the crop is not doing too well.

HARVESTING & PROCESSING: It is here that beedi tobacco differs from cigarette tobacco. The "sand" leaves are primed in the usual way, but the plants are topped when they have 9 - 10 leaves in good weather or about 6 leaves in dry weather. Topping as usual promotes the growth of side shoots, which have to be nipped off as soon as they develop.

Unlike in cigarette tobacco where the leaves mature from the bottom upwards, in beedi tobacco the reverse is true. Top leaves mature first. Maturity is indicated by the leaves puckering and turning slightly yellow. The formation of spangles (reddish-brown spots) on the leaves commences 3 - 4 weeks before harvest. Mature leaves turn a greenish-yellow colour and develop a number of spangles. As the upper leaves are superior in quality they should be cured and marketed separately.

Curing means drying the leaves, strung individually on a rope, for three days in the sun. Once the leaf blades are dry the leaves are dried for a further 10 - 14 days in the shade till the midribs are completely dry. During the curing period, remove the leaves to a shed at night and during rainy weather.

The cured leaves are now tied into "hands", containing about 25 leaves each, and stored. There are five grades:

No. 1 Top-leaves, greenish-yellow in colour with numerous spangles

No. 2 Top leaves, brownish-yellow in colour with fewer spangles

No. 3 Bottom leaves, yellowish to yellowish-green in colour

No. 4 Leaf pieces from the above three grades. These should be more than 3 inches in size.

No. 5 Leaves not accepted in grades 1 - 3 because of poor colour and spangulation.

Note: All leaves in grades 1, 2, 3 and 5 should not be less than 6 inches is size.

After grading the leaves are packed in bales weighing about 80 lb each for transport to the markets. Yields of 600 - 800 lb of cured leaf may be expected from one acre.

An alternative method of harvesting is to cut down whole plants when the majority of leaves have matured fully. Cut plants are stacked in 'bundles' upside down in the field and allowed to dry for 3 - 4 days. The leaves are then picked off and cured separately as described for a further 10 - 14 days till the mid-ribs are dry. As all the plants do not mature at the same time; a field may have to be harvested in two or three instalments at weekly intervals.

Betel *Piper Betle*

Betel is an important cash crop in the wet zone. The recommended varieties are:

(i) *Kahamaneru* — leaves large and yellowish green

(ii) *Ratadallu* — leaves large with buds at alternate nodes; about 10,000 leaves can be picked from 1,000 vines

(iii) *Galdallu* — leaves large; relatively tolerant to dry conditions.

Apical cuttings are taken for planting from vines which are not more than two years old. Each cutting should have five nodes.

Cuttings are planted in well manured beds. Beds should be 3 feet wide separated by 3 feet wide pathways. Well rotted cattle manure is incorporated in the soil along with some bone meal at the rate of 1 cwt per 100 vines. Planting holes are spaced 10 - 12 inches apart. Four cuttings are planted in each hole buried to a depth of two nodes.

During the early stages of growth, the cuttings must be shaded with cadjans and the beds watered twice a day (if there is no rain) for the first week and thereafter once a day in the evenings.

For about 5 months the soil should be lightly mulched. Dry *keppetiya* leaves (*Croton lactiferus*) are generally used. They have to be renewed at six-weekly intervals.

The vines must be trained to grow on stakes. The most vigorous in each hole (the others are removed) are trained to each stake. Stakes are 5½ feet high above ground level. The following stakes may be used because they resist decay and are rough, thus permitting the roots of the vines with secure climbing facilities:

(i) *Veraniya* (*Hedyotis fructiosa*)

(ii) *Malkera* (*Ochna squarroso*)

(iii) *Bokera* (*Ourateo zeylanica*)

(iv) *Kebella* (*Aporosa lindleyana*)

(v) *Korakaha* (*Memacylon unbellatum*)

(vi) *Godapora* (*Dillenia retusa*)

Vines should be tied to them at about 10 points. Ultimately, a trellis is built on the supports at a height of 5½ feet to allow the vines to rest on it.

Picking can commence 5 months after planting. At the first harvest it should be possible to gather 10,000 leaves from 1,000 vines. Picking is possible every two weeks. Leaves should be pinched off with the finger nails. Profitable crops can be taken over a period of 6 months.

DISEASE CONTROL: Successful betel culture ultimately depends on how well you control disease, particularly "bacterial leaf spot" which can ruin the market value of the leaves.

The first indication of the 'leaf-spot' disease is the appearance of small, water-soaked spots between the veins on the underside of the leaves. These spots become visible on the upper surface and look like "oil-spots". As the disease progresses the spots coalesce to form large irregular dead areas, which eventually fall off and leave a hole in the leaf. In wet weather the leaves become slimy on the undersides. This slime is composed of bacteria which have developed in the leaf tissue.

Since the bacteria are easily carried on the hands of the pickers, it is essential that strict hygienic measures should be adopted to prevent the spread of disease. Diseased leaves should be picked first and burnt. Hands should be washed thoroughly before the healthly leaves are picked for market. The use of good stakes, destruction of all rubbish and the adoption of a wide spacing between beds (3 ft at least) will help in controlling the disease. It is suggested that betel should not be replanted in the same soil for at least one year after a plantation is uprooted.

OTHER CROPS

Sugar Cane *Saccharum officinarum*

Our total annual sugar cane requirement is estimated at 300,000 tons. About 55,000 tons were imported in 1975. The two factories at Kantalai and Hingurana should not be able to produce more than 80,000 tons. The balance 165,000 tons will have to be met from locally available sources of coconut, kitul, palmyrah and sugar cane, particularly sugar cane because the profits from this crop are most lucrative when imported sugar is in short supply.

The manufacture of good quality sugar from sugar cane requires large sugar factories of the scale of the Higurana and Kantalai plants with crushing capacities rated in hundreds of tons per hour. Crude sugar could be produced at the cottage industry level, but it is not an economic proposition. At present, therefore, it is recommended that:

(i) Sugar cane processing for sugar production should remain the monopoly of the Sugar Corporation under assured irrigation in the dry zone;

(ii) Sugar cane processing for jaggery and *sakkarai* should be conducted as a cottage industry in the intermediate zone (Badulla & Monaragala Districts);

(iii) Sugar cane processing for syrup (to be used in the manufacture of potable alcohol) should be confined to the low-country wet zone in the Galle District etc.

VARIETIES: The recommended introduced varieties for the production of sugar, jaggery and syrup are "Co 527 and "SI". The former is recommended for cultivation anywhere in the country, while "SI" is best grown in the dry zone under irrigation. Both varieties are resistant to the 'smut' disease. Local varieties presently cultivated in the traditional sugar cane areas are well adapted to local environment and may also be used wherever possible. 2 - 2½ tons of cane stalks are required to plant one acre.

PLANTING: The general practice is to plant in furrows. Broad ridges 3 - 5 ft apart are prepared with intervening furrows 6 - 9 inches deep. Cane cuttings are planted flat and end to end in the furrows and covered with 1 - 2 inches of soil. If germination is good a shoot should develop at every 1½ ft. As the plants grow the furrows are filled by taking earth from the ridges.

In certain areas in the Intermediate zone e.g. Haldamulla and Koslanda, and even in the Colombo area planting is done in holes $2\frac{1}{2} \times 2\frac{1}{2} \times 1\frac{1}{2}$ feet spaced 3 - 4 ft apart. Four cuttings or cane tops are placed in the hole—one at each corner. They are planted at an angle and covered with about one foot of soil.

The planting seasons are as follows: June - July in the Wet Zone, September to January in the Intermediate Zone and mid-April to mid-July in the Dry Zone. In the wet and intermediate zones no irrigation is necessary. But in the dry zone the first irrigation should be given immediately after planting, followed by another 7 days later, and thereafter at 10 - 14 day intervals up to 4 - 6 weeks prior to harvest if there is no rain.

PRINCIPLES OF CULTIVATION: The life of the sugar cane crop can be divided into four important phases viz., germination, tillering, cane elongation and maturation. It is on these phases that the principles of cultivation depend.

PHASE I — **Germination**:

OBJECTIVE: To achieve quick and uniform germination within 16 - 18 days of planting and the appearance of a primary shoot every $1\frac{1}{2}$ ft in the rows.

HOW TO ACHIEVE: (i) By planting canes that are 8 - 10 months old when the buds are soft and green or greenish - yellow in colour. In the case of older canes the buds become hard and brown in colour and their capacity to sprout quickly and uniformly is seriously affected. The buds at the top, however, remain young and soft. Where canes are older than 8 - 10 months therefore, the tops should be used in preference to the lower portions of the stalks.

(ii) By cutting the canes into pieces containing 3 - 4 nodes placing them end to end in furrows which have been dug 3 - 4 ft apart. (When whole canes are planted the buds at top germinate first and inhibit the germination of the buds lower down).

(iii) By stripping the leaf sheaths around the buds and placing the pieces in the furrows so that the buds *face sideways*.

(iv) By forking into the furrows a basal dressing of NPK fertilizers prior to placing the pieces of cane.

PHASE II — **Tillering**:

OBJECTIVE: To promote maximum tillering in a single flush.

HOW TO ACHIEVE: (i) By keeping the furrows open and not choked with weeds and too much soil.

(ii) By applying a top-dressing of nitrogen fertilizer 3 - 4 inches away from the stem and covering lightly with soil 4 - 6 weeks after planting.

PHASE III — **Cane-elongation**:

OBJECTIVE: To promote uninterrupted growth of the stems.

HOW TO ACHIEVE: (i) By applying a second and heavier top-dressing of nitrogen fertilizer at 4 - 5 months.

(ii) By earthing up the plants immediately after the top-dressing to prevent them lodging, since the growth of lodged stalks is seriously retarded. The earth is thrown against the clumps with a mammoty and pressed firmly against the stalks. At the end of this operation, the original furrows in which the cane was planted would have been built-up into ridges, leaving the original ridges as shallow furrows from which soil has been scooped.

PHASE IV — **Maturation**:

OBJECTIVE: To achieve the highest and the most even content of sugar throughout the length of the stalks.

HOW TO ACHIEVE: By harvesting the crop before it flowers, when the top leaves begin to "yellow" and die back. In the recommended varieties e.g. CO 527 the plant crop or first crop takes 13 - 14 months while the succeeding ratoon crops take 12 months to mature. Other varieties take 14 - 16 months.

HARVESTING: In 12 - 16 months, depending on variety, when there is gradual yellowing and dying of the upper leaves, cut the stalks as close to the root as possible, lop off the top portions with leaves, remove the trash clinging to the stalks and transport to factory for crushing. (Note: In the Haldamulla - Koslanda area only selected stalks are harvested at any one time—not all the stalks. These plantations are carried on for many years). 20 tons of cane is an average yield.

RATOON CROPPING: Several crops of sugar cane can be taken on the same root stock. So after harvesting you should prepare the crop for a new life by shaving the stubble with the onset of the rains. What you do is to use a mammoty to cut the butts or stumps down to original planting level. Then you collect all the trash and burn it between the rows. Then apply the fertilizer and follow the same cultivation procedure as before. Several ratoon crops may be taken depending on the yields. It is customary, however, to take one plant crop and two ratoon crops. 15 tons of cane from each of the ratoons is satisfactory.

Fertilizer Application.

WET ZONE — RAINFED

Plant Crop

Basal Dressing: (Before planting)	14 lb Urea ($6\frac{1}{4}$ kg) 56 lb Conc. Superphosphate (25 kg) 84 lb Muriate of Potash ($37\frac{1}{2}$ kg).
First-Top Dressing: (4 - 6 weeks)	28 lb Urea ($12\frac{1}{2}$ kg)
Second-Top Dressing: (4 - 5 months)	56 lb Urea (25 kg)

Ratoon Crops

Basal Dressing: (After stubble shaving)	56 lb Urea (25 kg) 56 lb Conc. Superphosphate (25 kg) 84 lb Muriate of Potash ($37\frac{1}{2}$ kg)
Top-Dressing: (2 - 3 months after stubble - shaving)	112 lb Urea (50 kg)

DRY ZONE (IRRIGATION)
(Batticaloa and Amparai Districts Only)

Plant Crop

Basal Dressing: (Before planting)	28 lb Urea ($12\frac{1}{2}$ kg) 112 lb Conc. Superphosphate (50 kg) 112 lb Muriate of Potash (50 kg)

First Top-dressing: (4 - 6 weeks)	84 lb Urea (37½ kg)
Second Top-Dressing: (4 - 5 months)	84 lb Urea (37½ kg)

Ratoon Crops

Basal Dressing: (After Stubble-shaving)	84 lb Urea (37½ kg) 84 lb Conc. Superphosphate (37½ kg) 84 lb Muriate of Potash (37½ kg)
Top-dressing: (2 - 3 months after stubble-shaving)	112 lb Urea (50 kg)

DRY ZONE (IRRIGATION)

(Excluding Batticaloa and Amparai Districts)

Plant Crop

Basal Dressing: (Before planting)	28 lb (12½ kg) Urea 112 lb (50 kg) Conc. Superphosphate 112 lb (50 kg) Muriate of Potash
First Top-Dressing: (4 - 6 weeks)	56 lb (25 kg) Urea
Second Top-Dressing: (4 - 5 months)	84 lb (37½ kg) Urea

Ratoon Crops

Basal Dressing: (After stubble shaving)	84 lb (37½ kg) Urea 84 lb (37½ kg) Conc. Superphosphate 84 lb (37½ kg) Muriate of Potash
Top-Dressing: (2 - 3 months after stubble shaving)	112 lb (50 kg) Urea

INTERMEDIATE ZONE (RAINFED)

Plant Crop

Basal Dressing: (Before planting)	14 lb ($6\frac{1}{4}$ kg) Urea 56 lb (25 kg) Conc. Superphosphate 84 lb ($37\frac{1}{2}$ kg) Muriate of Potash
First Top-Dressing: (4 - 6 weeks)	56 lb (25 kg) Urea
Second Top-Dressing: (4 - 5 months)	84 lb ($37\frac{1}{2}$ kg) Urea

Ratoon Crops

Basal Dressing: (After stubble-shaving)	56 lb (25 kg) Urea 56 lb (25 kg) Conc. Superphosphate 84 lb ($37\frac{1}{2}$ kg) Muriate of Potash
Top - Dressing: (2 - 3 months after stubble - shaving)	112 lb (50 kg) Urea

WEEDING: This can be done manually or by spraying a chemical herbicide e.g. Diuron (Karmex) at 3-4 lb in 40-60 gallons/acre with a spreading agent such as Surfactant or Rino. One application should keep the crop weed-free from 6 - 8 weeks.

INTER-CROPPING: Since the sugar cane crop does not grow tall enough to shade out the soil in between the rows till it is about 4 months old, short-aged intercrops may be taken for an added income e.g., soyabean, sweet potato, green gram, bush sitao etc.

PEST CONTROL: Fortunately pests and diseases are not a serious problem. Shoot borers (*Sesamia inferens*) and sucking pests (Pyrilla) are present in the crop but they are usually kept under control by natural predators. Smut (Ustilago) could be a serious disease among local varieties. The significant symptom is the production of a whip-like shoot from the growing point, first white in colour and then black. The answer to this disease is to grow resistant varieties like "CO 527" and "SI". Ratoon-stunting disease is caused by a virus. As the name suggests it causes a retardation of growth in the ratoon crop. The suggested treatment is to immerse cuttings prior to planting in hot water maintained at 51°C for 2 hours. The buds are not damaged, but the virus is eliminated. Yellow Spot (Carcorpera) is another serious disease. Yellow spots appear on the leaves, coalesce and become irregular. Infected leaves assume a reddish tinge, finally become straw coloured and die. There is no control measure.

MANUFACTURE OF JAGGERY: Mature cane stalks, after the tops and leaves have been removed, must be crushed within 24 hours of harvest. Further delay causes inversion of the sugars and this lowers the quality of the jaggery.

The extracted juice is passed through a sieve to remove extraneous matter and boiled immediately to prevent microbial inversion of the sugars. Shallow boiling pans are recommended. A pan of 30 gallon capacity should be adequate for a cottage industry. 60 and 100 gallon pans are more suitable for production on a larger scale.

When the juice reaches a temperature of 60 - 65°C a green scum will begin to rise to the surface. At this time it is necessary to add a vegetable or chemical clarificant to coagulate the other solid substances (excluding the sugars) present in the juice. This scum should be removed from time to time until the formation of a white foam indicates that clarification is complete.

The popular vegetable clarificant that is used is a mucilage extract from the stems of *bandakka* crushed in water. About 3 lb of this mucilage should be added to 30 gallons of juice. If a chemical clarificant is added Triple Superphosphate at the rate of $1\frac{1}{2}$ oz per 50 gallons is recommended.

The juice must now be boiled vigorously and stirred continuously to prevent caramalization or charring. If frothing is noticed the addition of a little 'milk' from crushed castor seeds will smother it. As the syrup thickens into a semi-solid state, bubbles appear and burst in the pan. This is the stage at which the semi-solid mass in the pan should be transferred into moulds for cooling. The 'strike' temperature is between 115° and 118°C. While stirring the contents at this stage it will be noticed that there is a tendency for the semi-solid mass to leave the bottom of the pan and solidify on the sides. If a few drops of the sticky contents are allowed to fall into a glass of water they will solidify immediately and sink to the bottom instead of dissolving in the water.

This is the time to pour the contents into wooden moulds moistened with water or aluminium moulds glazed with coconut oil.

The time taken for the boiling process is usually $3\frac{1}{2}$ - 4 hours in a 30 gallon pan. Be sure to separate the immature, damaged and diseased canes from the good canes and crush them separately, using the juice for the preparation of syrup or treacle. Only the juice from matured, undamaged and undiseased canes should be used for preparation of jaggery.

A ton of cane should give 22 gallons of juice, and from this it should be possible to obtain 2 cwt of jaggery i.e. 10 lb of jaggery from 1 gallon of juice.

NOTE: Since the open furnaces used locally are wasteful of fuel, resulting in low recoveries of poor quality jaggery, an improved furnace may be used as shown in the accompanying diagram, (Courtesy of Sugar Corporation). The innovations in this furnace are a raised chimney to improve draft and ensure complete combustion, the provision of an iron gate to improve draft and facilitate ash disposal, a baffle wall for better heat retention and the lining of the inner wall with fire bricks to increase furnace temperature.

SUGAR CANE CRUSHERS: In its simplest form the processing of sugar cane requires a set of rollers to crush the stalks and extract the juice. A wide variety of rollers is available for this purpose, ranging from the simple hand-operated models which can handle about 150 lb of cane per hour through the larger bullock-drawn types with a capacity of 300 - 350 lb of cane per hour to the power-driven crusher of 5 and 10 H.P., which can crush about 1,500 - 3,000 lb per hour.

CROP BUDGET: The following budget for cultivating and processing one acre of sugar cane for jaggery production may be used as a guide:

Inputs:	Rs.
1. Tractor ploughing, harrowing & ridging	250.00
2. Planting material (tops)	600.00
3. Fertilizers (50% subsidy)	130.00
4. Labour @ Rs. 8.50	
(*a*) 20 to assist in land preparation & planting	170.00
(*b*) 30 to assist in weeding, applying fertilizer & earthing-up	255.00
(*c*) 30 to harvest & haul canes	255.00

5. Transporting to Processing Point	500.00
6. Miscellaneous	140.00
7. Processing 20 tons of cane @ Re. 1/- per lb of jaggery produced	4,000.00
Total cost of production	6,300.00

Income:

From sale of 4,000 lb of jaggery @ Rs. 3/- per lb jaggery	12,000.00
Profit	5,700.00

Ratoon Crops (12 *months*):

Inputs:

1. Fertilizers (50% subsidy)	150.00
2. Labour @ Rs. 8.50	
(*a*) 12 for stubble shaving & trash mulching	102.00
(*b*) 30 for weeding, applying fertilizer, earthing-up etc.	255.00
(*c*) 24 for harvesting & hauling	204.00
(*d*) Transporting to Processing Point	100.00
3. Miscellaneous	89.00
4. Processing 15 tons of cane @ Re. 1/- per lb jaggery produced	3,000.00
Total cost of production	4,200.00

Income:

From sale of 3,000 lb of jaggery @ Rs. 3.00 per lb	9,000.00
Profit:	4,800.00

Note: The above cost data would apply to the Wet Zone and Intermediate Zone. In the Dry Zone the cost of irrigation has got to be taken into account and also a higher cost of fertilizer. But this extra cost of production is cancelled out by the slightly higher output and income that is possible under sustained irrigation. All in all therefore, the profit per acre from all three zones is about the same.

SMALL SIZE JAGGERY PLANT
SINGLE PAN

CAPACITY 30 GALLONS JUICE PER BOIL

CROSS SECTION ELEVATION

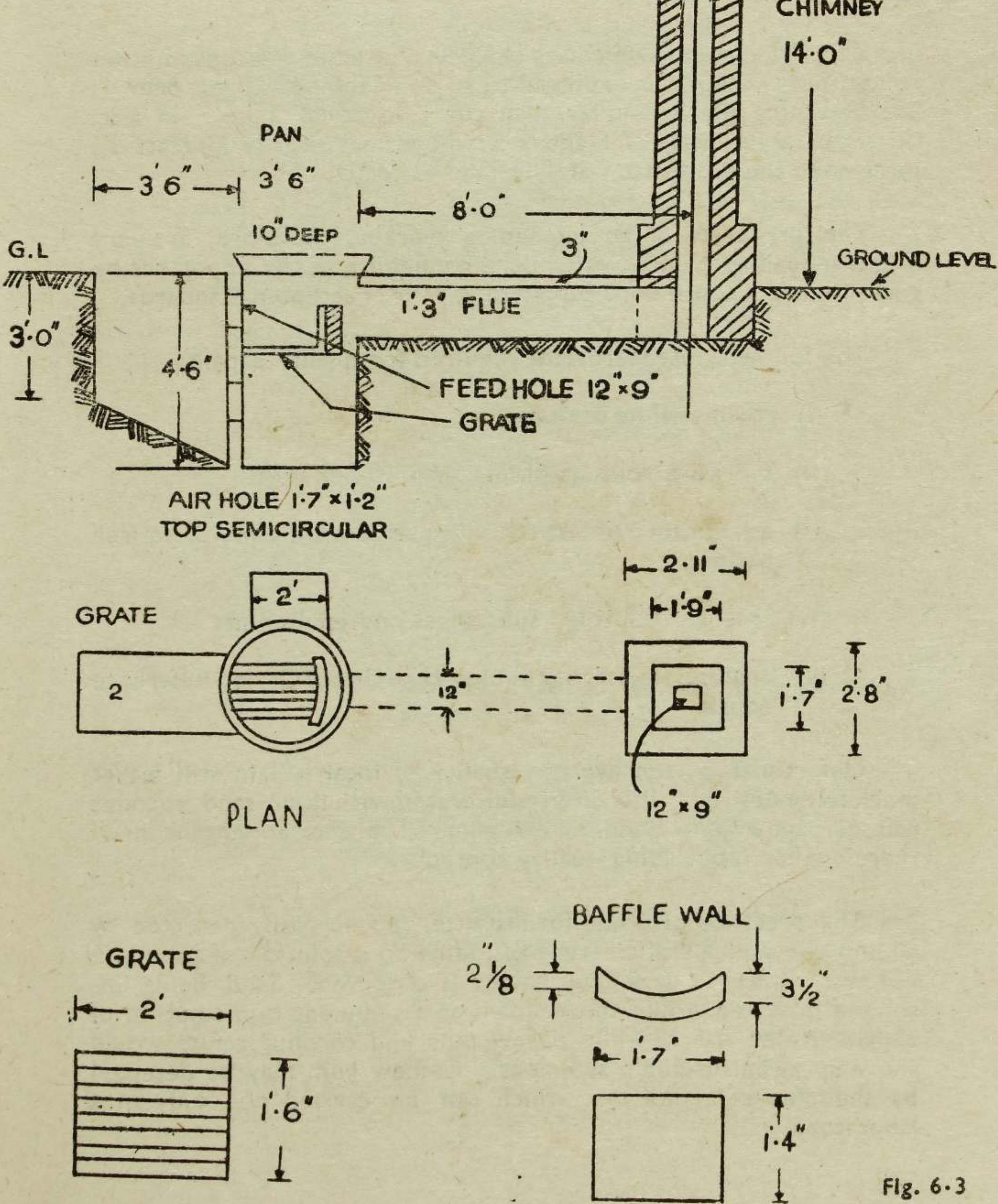


Fig. 6·3

Papain from Papaw *Carica Papaya*

Japan has become the biggest buyer of Sri Lanka papain. Our Trade Commissioner reports that we now supply about 75 per cent of that country's requirements. Starting with 100 cwt in 1972 our papain exports to Japan have rapidly increased to 1,059 cwt in 1975. This figure represents more than 80 per cent of our total exports in that year.

This rising trend, which has been attributed to the consumption of light beer in Japan, is expected to go on unabated as light beer is fast becoming more popular than the traditional 'sake'. In fact, the Japanese Ministry of Trade and Industry has already forecast an increase in the production of light beer annually.

The prospects of an expanding market, therefore, are very bright indeed, provided we win the confidence of the importers by guaranteeing a continuous supply of papain of accepted standards.

The following standards are required for quality papain:

(i) creamy-white colour

(ii) moisture content of less than 10 per cent

(iii) ash content of less than 11.1 per cent on a moisture free basis

(iv) absence of foreign substances and adulterants

(v) proteolytic activity not less than that of Ceylon Reference papain.

Unfortunately, the average quality of local papain still leaves much to be desired. It is often adulterated with flour, sand, coconut refuse, papaw pulp and cashew gum. There is an urgent need therefore for intensifying quality control.

The presence of flour, for instance, can be easily detected by adding a few drops of tincture of iodine to a solution of papain in hot water when a dark blue colour is observed. Sand being insoluble in water would settle down as a sediment in a solution of papain in hot water, while papaw pulp and coconut refuse would show up as an insoluble sediment. Cashew gum may be detected by the phloroglucinol test which can be carried out only in a laboratory.

CULTIVATION: A profitable papain enterprise must aim to achieve an average yield of 175 lb of commercial papain from one acre of papaw in one year. Higher yields upto 300 lb are possible if the standard of management is high. Here are some guide lines:

(1) Plant only varieties of papaw that bear oval-shaped fruits rather than round or long types, since oval types give the highest yield of papain;

(2) Use the following planting distance viz., either 8′ x 8′ or 10′ × 6′ which gives about 680 or 726 plants to one acre respectively;

(3) Allow two plants to develop in each hole and after these have flowered and you are able to distinguish male and female plants, thin out to one plant per hole ensuring that there is at least one male plant to every 10 female plants—this will permit maximum pollination and fruit set;

(4) Use the following fertilizer mixture:

1 part Urea
2 parts Conc. Superphosphate
2 parts Muriate of Potash

Apply 8 ounces of this mixture per plant—six inches round the base — at the following times:

1 week after planting
2 months after planting
6 months after planting & thereafter at 3 - monthly intervals.

Note: No fertilizer is required if the first-crop is in newly cleared jungle land.

(5) Start tapping the fruits for latex only 8 - 12 months after planting;

(6) Tap only mature fruits (i.e. fruits 2½ months after flowering) since the latex from immature fruits is of poor quality;

(7) Tap each fruit at 4-day intervals for a period of 45 days, giving it four lancings or incisions at a time—fresh incisions being made at each collection (use a sharp-edged rustless iron or steel implement fixed to a pole);

(8) Tapping should be completed before 10 a.m. to ensure maximum yields of latex. Yield of latex on wet days is higher than yield of latex on dry days;

(9) Quick coagulation and drying is essential to prevent decomposition of the latex. About 4 hours after collection the latex develops an offensive smell and gives a dark brown colour which reduces its market value considerably.

Quick coagulation can be achieved in 10 - 20 minutes by stirring the latex vigorously with a wooden spoon. After this it should be dried quickly in the sun or in an oven to reduce the moisture to about 8 - 10%. Higher moisture levels will cause discolouration of the commercial product and consequent loss of market value.

To achieve a moisture level of not more than 8 - 10% the coagulated latex should be first passed through a colander or string-hopper squeezer and then sun-dried from 10 - 24 hours, or oven-dried from 6 - 8 hours at 50° - 55° C. The "dryness" of the product is judged by its crispness and ability to crumble to a powder when passed between the fingers. (*Note*: Use an aluminium, brass or stainless steel colander or string-hopper squeezer since iron promotes oxidation of the papain).

(10) The dried product should be stored immediately in air-tight bottles and kept in a cool place.

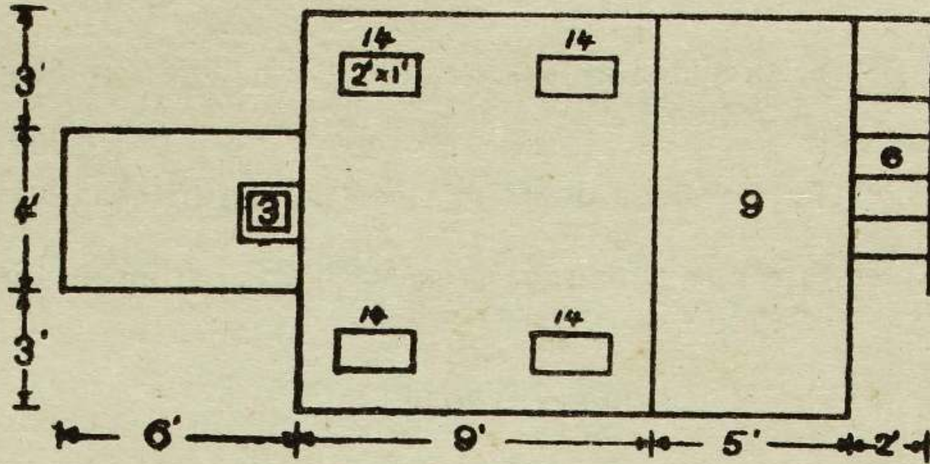
DRYING APPARATUS: The simplest type of drier consists of a single tier of trays overlying a fire-place with a sheet of iron carrying a two-inch layer of sand interposed between tray and fire. In this type of drier a non-smoking fuel like coconut shell charcoal should be used.

In a larger drier, hot air will have to be drawn through iron pipes heated by a furnace into a drying chamber containing a number of tiers which are staggered to allow an even flow of air. Temperature is maintained at 50 to 55°C or 122 - 131°F by controlling the cold air drawn through the ventilators at the bottom of the drying chamber (see diagram).

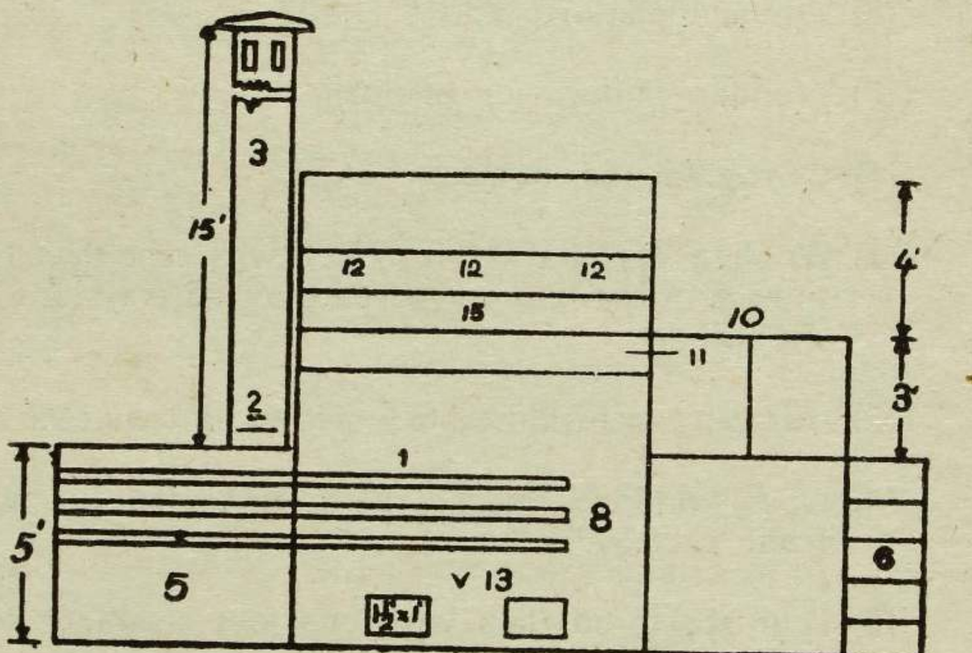
Explanatory Index for Figures 1 - 4:

(1) Air holes of ¼ in. diameter each and 3 in. apart on either side of each pipe within the drying chamber only

(2) Iron baffle plate to control draught



3'
4'
3'
3
14
2'×1'
14
14
14
9
6
6'
9'
5'
2'



3
15'
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12
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12
15
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8
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V 13
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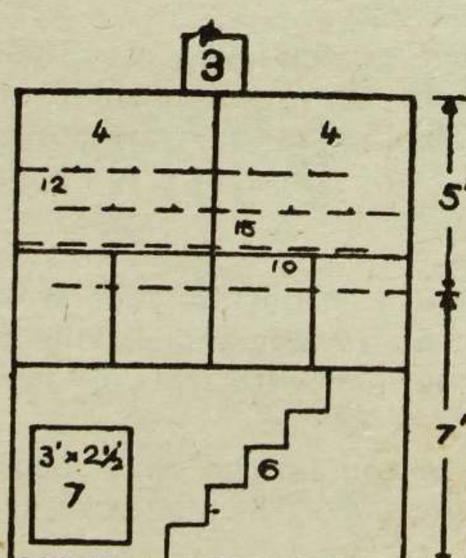
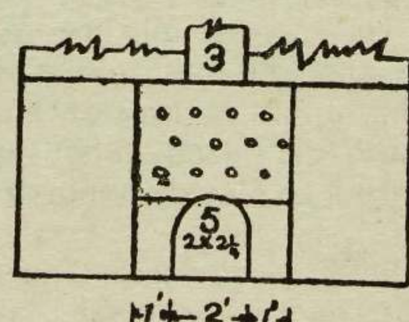
6



3
4
4
12
15
10
5'
7'
3'×2½
7
6



3
2
5
2×2½
1' 2' 1'

Fig. 6·4

(3) Brick chimney with two smoke holes on each side (four sides)

(4) Two wooden doors to close the drying chamber

(5) Fire box built separately with an arch inside the drying chamber to present cracks

(6) Wooden ladder 7 ft long

(7) Man-hole with air-tight door

(8) 12 iron pipes 13 ft long and 4 in. diameter each

(9) Wooden platform above ladder

(10) Wooden railings for platform

(11) Centigrade thermometer

(12) Wooden drying tray 3 ft by $1\frac{1}{2}$ ft with cane slats (18 trays in each of the four staggered tiers—3 trays one behind the other).

(13) Air vent with adjustable windows, two on each side.

(14) Open windows on roof of drier to let out moist air from chamber.

(15) Four staggered tiers with one foot clearance to allow flow of air.

Mushroom *Volvaria esculenta*

The straw mushroom is grown commercially in Thailand, India and the Philippines. It has been grown successfully in the warm, humid regions of this country. It is called the straw mushroom because it is raised on beds of paddy straw. The spawn is imported, cultured and sold in bottles.

SITE: Mushroom may be raised in an outside shed which is protected against bright sunlight, strong winds and driving rains. This could be achieved by covering the sides with straw or sacking.

A gantry must be constructed to contain the straw beds. It should be at least six inches off the ground. The four corners may be of brick on which strong pieces of timber are placed lengthwise with crosswise supports of reepers or bamboo splints to take the weight of the moistened straw bed. 32 bundles of straw are required. This number weighs 100 lb unwetted.

PREPARATION OF BEDS: Clean, well-dried, undecomposed straw is a prerequisite for successful cultivation. Do not use straw fresh from the field as green stalks are inevitable. Straw that has been stored in a protected place is best. If it has been stored well straw up to 6 months old can be used with good results.

32 bundles each 9" × 12" thick, are required to lay a bed for one bottle of spawn. It is preferable but not absolutely necessary that the butt ends of the bundles should be arranged at opposite ends, so long as an uniform thickness is maintained. Each bundle should be tied tightly using a few strands of straw.

The bundles must be soaked for 24 hours in water before they are used. (Be careful not to use heavily chlorinated water). Thereafter they are taken out, allowed to drain, and then laid out in layers on the gantry. First, 4 bundles are laid closely on one side with the butt ends outside. Another four bundles are laid on the opposite side with the butt ends out. This comprises the first layer. This layer is well compacted and sprinkled over slightly with water.

SOWING THE SPAWN: The bottle of spawn is now broken open and small lumps of spawn 1 - 1½ inches thick are placed at intervals of 4 inches along the periphery of the layer up to 4 - 5 inches from the ends.

A second layer of 8 bundles is laid over the first in the same way. It is compacted, sprinkled with water and sown with spawn in the same way.

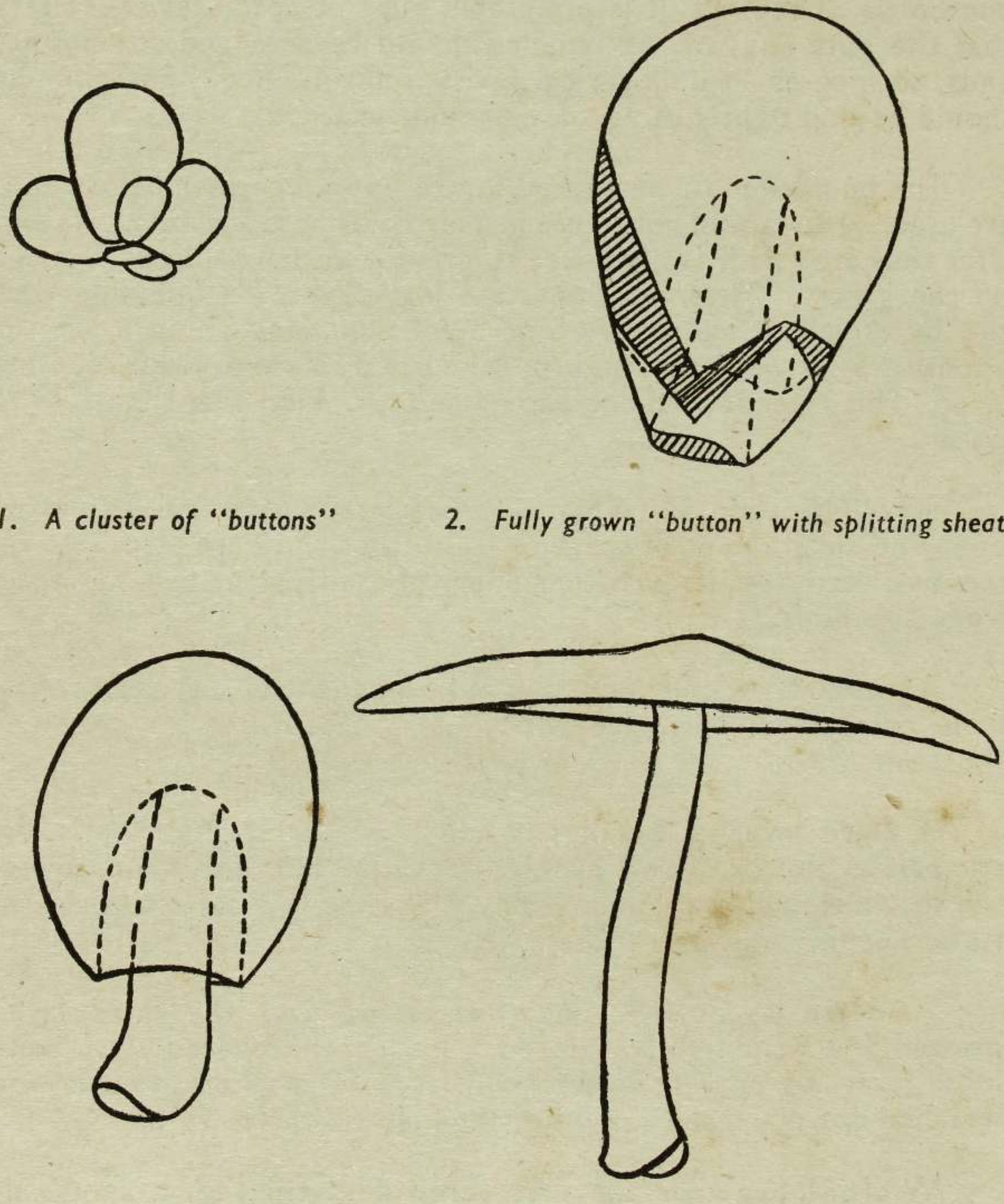
A third layer of bundles is laid over the second. It is also compacted and sprinkled over with water, but instead of sowing the spawn along the periphery only, this time it is sown all over the surface at intervals of 4 inches.

A fourth layer of 8 bundles is placed over the third layer, pressed down and lightly watered. It is then covered with some loose straw to prevent excessive driage. The whole mass is now weighed down and the weight maintained till the third day.

WATERING: For the first three days till the weights are removed no watering is done. Then water is sprinkled lightly again over the top and splashed on the sides once in three days.

While a certain degree of dryness accelerates the growth of mushrooms, excessive watering is definitely harmful, so beware overwetting the straw bed. In fact it is more advantageous to underwet rather than overwet the bed. Watering must cease after the "buttons" develop and recommence after harvest.

HARVESTING: The tiny "button mushrooms" emerge in clusters. They are covered with dark grey sheaths. The buttons grow to full size and burst through the sheaths. Thereafter the crown gradually opens and the stalk elongates. The dark grey buttons become greyish-white when the crown opens, but the



1. A cluster of "buttons"

2. Fully grown "button" with splitting sheath

3. "Button" without sheath (good stage to harvest)

4. Open crown

Fig. 6·5

underside remains white till it reaches the semi-open state. Thereafter it turns brown. The underside of the fully opened crown is a bright brown. It takes about 8 - 10 hours for a mushroom to emerge from the sheath and open out fully.

The best time to pick the mushroom for the fresh market trade is before the umbrella or crown opens. The first harvest in the low-country wet zone may be taken 10 days after sowing. In the mid-country it takes about 14 days. Four or five small picks can be taken up to 21 days from the date of sowing. In all about 6 lb of mushrooms can be harvested from a single straw bed of 32 bundles. If 2 bottles of spawn are used instead of one, the yield can be increased to 8 - 9 lb.

PRESERVATION: The ideal stage to harvest mushrooms for canning is when the sheath begins to break round the "buttons". Canning must be done within 12 hours. Fully developed "buttons" can be kept under normal refrigeration (50 - 60°F) for 24 hours without spoiling. They can be kept in deep freeze for two weeks, but in this case they must be cooked for 2 hours before placing them in a freezer. "Buttons" kept in deep freeze cannot be used for canning.

Semi-open crowns may also be used for canning, but not the fully opened crowns. Fully opened crowns cannot be kept even under deep freeze. They must be cooked or dried within 12 hours of harvest.

Another method of preservation is dehydration. Sun-drying takes several days, during which the material undergoes some spoilage and a very unattractive dark product is obtained. Therefore some device for artificial drying is necessary. It is not economical to have an expensive dehydrator: a home-made contrivance should be sufficient for the local market. This could consist of a cabinet of convenient size, preferably of asbestos, with provision inside to place the drying trays at intervals of 9 inches. An electrically heated hot air blower is used to lead a current of hot air into the cabinet at the bottom.

A small fan kept in the cabinet in the bottom shelf, circulates the hot air over the material. Moist air is allowed to escape through a vent at the top. (see diagram)

Trays may be made of wood with slat bottoms or with wooden frames and a wire mesh bottom. All-wood trays are preferable.

The temperature of hot air entering the cabinet should be 55 - 65°C. Higher temperatures result in darkening of the product.

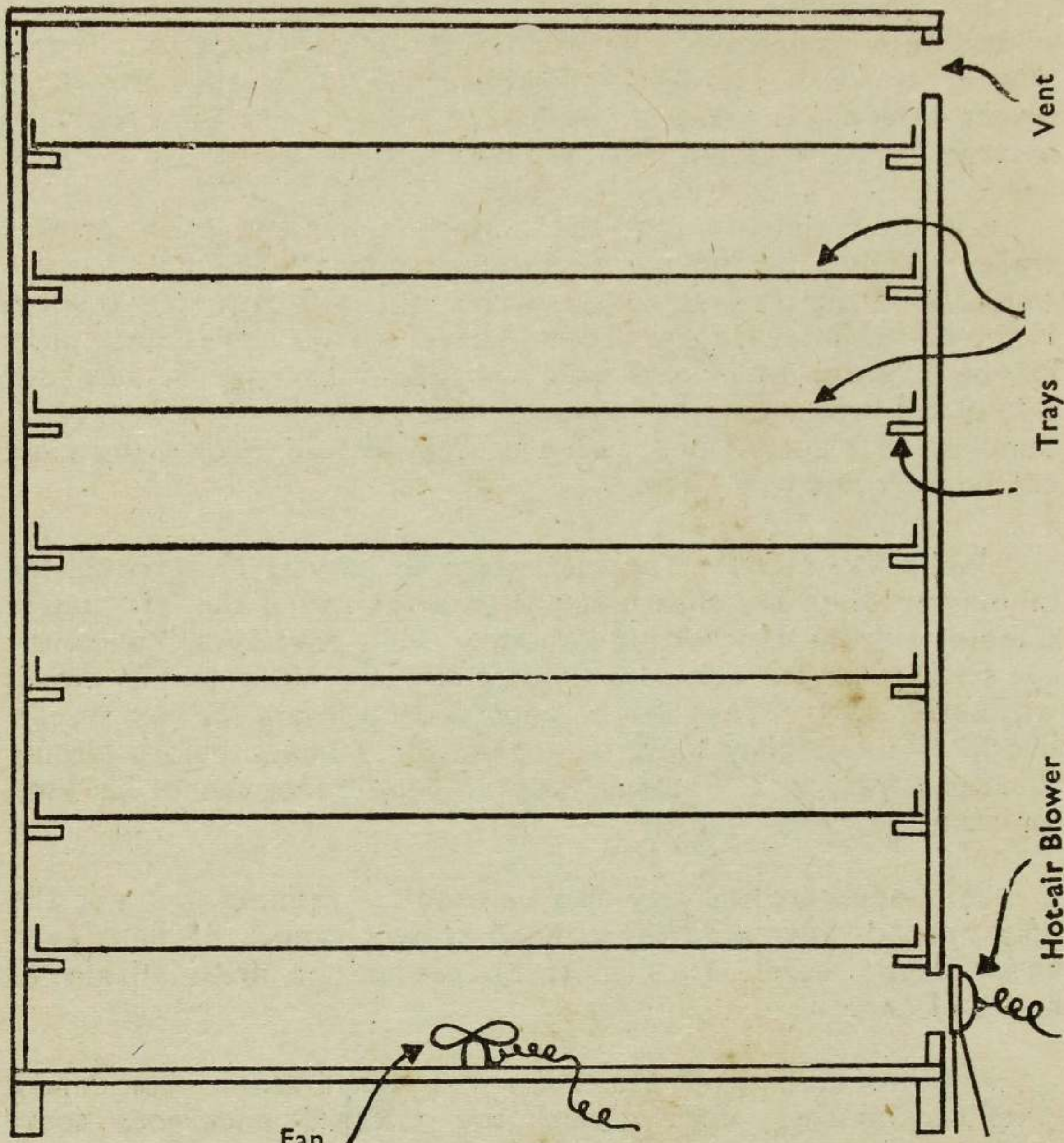


Fig. 6·6 *Diagram (front view) of drying device*

Harvested mushrooms are trimmed free of any adhering straw. The buttons can be dried whole or cut vertically in halves or quarters. In the case of open crowns, the stalk is cut off, leaving a portion not longer than the diameter of the crown intact. The stalks are cut in $\frac{1}{2}''$ pieces for ease of drying.

Prepared material is then dipped in a solution containing $1\frac{1}{2}$ ounces of potassium metabisulphate in 10 gallons of water for 5 - 10 minutes. This treatment improves the colour of the material and also reduces the bacterial population normally present on the mushroom.

Dipping may be done in wire baskets so that they can be taken out and allowed to drain. Open crowns are too delicate to stand this treatment and they may be dried as whole crowns under hygienic conditions of handling.

The dip-treated material is placed on trays at the rate of approximately one pound to a square foot of tray space and placed in the cabinet. The door is closed and hot air circulated till the material is dry. The drying time varies according to the load, air velocity and temperature. In general the process takes 6 - 8 hours.

Fresh mushroom contains around 90% moisture. Since the moisture content has to be reduced to about 10% for safe-keeping, this means that only about 10 lb of dry mushroom can be obtained from 100 lb of fresh material. Dry mushroom is hygroscopic, so it must be packed immediately in large tin containers, capped and sealed off with wax for bulk storage. Small retail packs, however, could be marketed in heat-sealed polythene.

EXOTIC CUT FLOWERS

I. Anthuriums

The Anthurium is not a flower; rather it is the coloured spathe that acts as a protection to the whole inflorescence. The inflorescence is comprised of a number of little inconspicuous flowers that are found in the long sticky projection that is referred to as the spadix or candle.

It is the colour, shape and size of the spathe that determines the money value and demand for the anthurium. Dark pink, orange and chilli red are the colours that are demanded by the international market. There is no demand for bicolours which are too delicate to stand transport and handling, and for white anthuriums which tend to discolour easily.

Cut at the proper time—that is 7 - 10 days after the spathe has fully unfurled, these blossoms may be kept in good condition in water from 15 - 30 days. All sizes are acceptable in the trade, but the most favoured is the medium-sized spathe which is 5 - 6 inches long. It should be heart-shaped with slightly overlapping lobes.

The position and length of the spadix or candle is also important in deciding flower quality. It should be in a reclining position taking the same curve as the spathe but a little shorter. Erect or upright candles, and candles that are longer than the spathe, are not favoured by the trade.

COMPOST MIXTURE: A special compost mixture is necessary to produce top quality anthuriums. It is prepared as follows:

equal parts of leaf mould and grass roots and soil from the under-side of grass sods and well-rotted cattle manure. Mix these with some river sand and broken pieces of charcoal and burnt brick to give the compost bulk and porosity.

This mixture may be placed in pots or specially dug garden beds. If pots are used they should be 10 - 12 inches in diameter across the top and at least 9 inches deep. A layer of crocks and coconut fibre is placed at the bottom of the pots to ensure good drainage, and then the compost is heaped around the plant to the top of the pot. It is finished with a layer of powdered cattle dung and leaf mould, which acts as a mulch to preserve a uniform level of moisture in the pot. This mulch should be replaced from time to time.

Beds are dug as trenches 9 inches deep and any length and width that is convenient. In this instance too the bottom layer is comprised of crocks and coconut fibre, and over this the compost is heaped up to ground level to be finished off with a mulch of cattle manure and leaf mould. Anthuriums are planted 2 feet apart in a triangular fashion to avoid crowding.

FERTILIZER APPLICATION: Unless fertilizer is applied regularly the size of the spathes will become progressively smaller. Special anthurium fertilizers are available for this purpose and may be used according to instruction. In the alternative you could use your own mixture made up of equal parts of urea, bone meal and muriate of potash. One to two ounces of the mixture could be sprinkled on the surface of the bed per square yard whenever the spathes show signs of becoming smaller. There is no need to disturb the mulch by forking the fertilizer into the soil. It could be sprinkled on top and gradually absorbed when the plants are watered or when there is rain.

LIGHT INTENSITY: Texture of the spathe and stalk length are determined by light intensity. With too much sunlight the spathes lose their rich gloss and turgidity and take on a scorched appearance. Stalks also do not grow to the desired lenght. This is why it is essential to control the sunshine so that 60 - 70% is cut out and the plants are grown almost in shade. Only when this is done do the flowers develop long stalks and take on a smooth glossy texture.

Shading can be achieved naturally by growing the anthuriums under specially planted shade trees. The common-or-garden jam fruit tree, *Mutingia calabura*, makes an excellent fast growing shade tree when it is planted 20 feet apart in a triangular system so that sunlight is uniformly diffused.

Or sunlight can be controlled artificially by the use of *kitul* or arecanut reepers which are placed as laths on the roof of the anthurium shed and moved apart to adjust the light intensity. A special type of woven plastic material called SARAN may be used instead if available in the market.

PLANTING MATERIAL: On the commercial scale, the smallest economic unit will be quarter-acre. This area should carry about 2,500 - 3,000 plants. To supply such a large number of plants by vegetative propagation is difficult, so the rule today is to invest in seedlings. You can purchase your seedlings from outside or raise them yourself. About 150 - 200 seeds can be taken from a single plant if pollination is done manually. The only disadvantage is that seedlings take 20 - 24 months to "flower", whereas stem cuttings "flower" in 5 - 6 months. Also propagation by seed is a little more complicated.

Pollination is carried out 7 - 10 days after the spathe unfurls or opens. At this stage the candle becomes sticky. Pollen from an older spathe 10 - 15 days old is taken on the finger and gently rubbed on the sticky candle. If the pollination is successful and fertilization takes place, the candle will soon swell and takes on a green colour. Small yellow or orange-coloured berries will then appear and these berries will take 5 - 6 months to ripen.

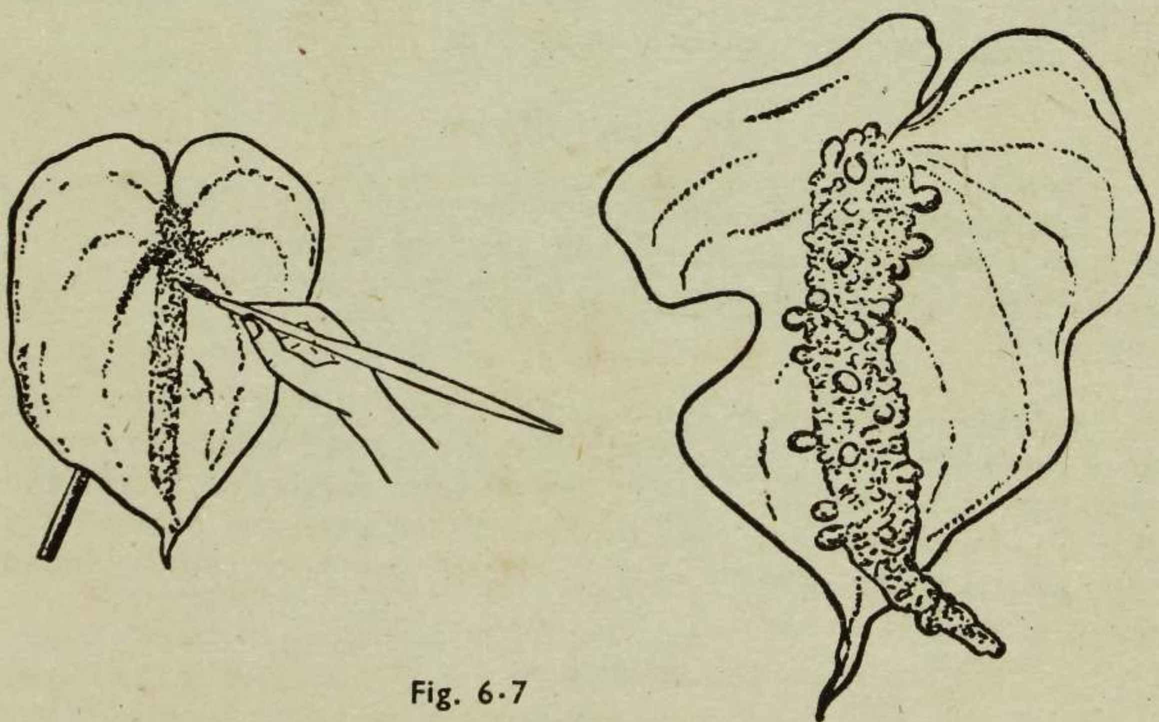


Fig. 6·7

(Left) Applying pollen to sticky spadix with aid of brush. (Right) Successfully pollinated anthurium showing enlarged spadix with protruding berries in which the seeds are contained.

The seeds when extracted (there are two in each berry) by gentle pressure in water are washed in several changes of water, disinfected by immersion in a dilute condys solution and sown immediately after in small clay pots. The clay pots are filled with the same special compost topped off with a surface layer of small brick pieces and charcoal in equal proportions. Seeds are sown on this surface layer and the pots placed in a shallow receptacle of water in the shade. Germination will take place in a day or two.

When the plants are about two inches high the clay pots are removed from the receptacle of water and watered in the usual way. Seedlings are pricked out and planted in polythene bags when they are 6 months old. They will begin "flowering" about 12 months later.

COLOUR INHERITANCE: To produce hybrids suitable for the cut-flower trade you must know something about colour inheritance. If, for instance, white is crossed with red, the resulting hybrids will be pink or coral coloured. But if white is crossed with orange the hybrids will be predominantly coral coloured. If orange and red are crossed the off-spring will produce a mixture of red and orange coloured spathes.

So much for crossing different colours! If the same colours on the other hand, are crossed you would expect to get the same colour in the offspring, but this is not always so. Orange and white are true breeders, but red crossed with red sometimes gives a mixture of red and orange spathes.

2. Dendrobiums

Cane dendrobiums and Intermediates are the "darlings" of the cut-flower trade because they produce colourful, long-lasting flowers (4 - 6 weeks after cutting) which stand transport and handling well.

CANES: The cane types have strong upright stems from 3 - 6 feet high. They have no dormant phase and produce flowers at least two to three times a year. The flowers, although colourful and borne in large numbers, tend to be small with twisted petals. Yet they have a charm of their own. The following are recommended for cultivation:

D. undulatum

D. veratrifolium

D. stratiotes

D. schuleri

D. superbiens
D. Gouldi
D. Tokai
D. Ursula
D. Joanne Sayers

INTERMEDIATES: To offset the twisted appearance of the flowers in the cane types, the canes have been crossed with *D. Phalaenopsis*, another species which produces short-caned plants carrying large moth-like flowers. The resulting hybrids or Intermediates produce far more graceful sprays than the canes, yet preserving their floriferous character. Consequently, they fetch a higher price in the market. The following hybrids are recommended for cultivation:

D. Pompadour
D. Caesar
D. May Neal
D. Louis Bleriot
D. May Queen
D. Jean
D. Bankok
D. Louisea
D. Pauline
D Hawaii

"Pompadour" and "Caesar" deserve special mention for their very floriferous nature. "Pompadour" bears a new flowering spike every month, while a well grown four - stemmed variety of Caesar may be expected to carry anything from 2-3 dozen flowering stalks in the course of a year.

POT CULTURE: To ensure healthy vigorous growth and floriferousness provide good drainage, sufficient sunlight and ample fertilizer.

Rule number one is to provide good drainage of the roots since excessive dampness causes root rot. This is why dendrobiums are best grown in porous clay pots containing a compost mixture of broken brick and charcoal or gravel and charcoal.

Pot size will vary according to the size of the plants. Phalaenopsis and hybrid types which do not exceed 2 to 3 feet in height do very well in small pots with a diameter of 3 to 5 inches. The large hybrids and cane types which grow from 3 - 6 feet require larger pots with a diameter of 9 to 12 inches.

The compost in the pots has to be arranged as follows: large pieces of charcoal, brick and gravel (about three-quarter inch wide) are placed in the bottom half of the pot over an inverted piece of tile protecting the main drainage hole.

The plant is now held in position at rim level and smaller pieces of the same compost mixture (about quarter to half-inch wide) are filled in to cover the dangling roots till the horizontal stem and the erect pseudo bulbs appear to ride on top of the compost (see diagram).

Be sure to place the plant at one end of the pot, thus allowing maximum space in the pot for the stem to grow horizontally and produce successive pseudo bulbs for several years without the necessity for repotting. It is wise to tie the plant to a stake in the compost till such time as the roots get a secure hold.

When the plant eventually outgrows the pot it must be removed and repotted. As soon as new growth appears at the end of the horizontal stem and before the new pseudo bulb has time to put own roots into the compost, the whole plant is carefully removed. Old pseudo bulbs at the back of the stem are now cut off, leaving only 3 to 4 on the main stem. Dead roots are removed and the stem with its 3 to 4 remaining pseudo bulbs is placed in a new pot of suitable size.

Dendrobiums should never be overwatered. Young plants may be sprayed twice a day—morning and afternoon—while adult plants should be watered once a day if the compost shows signs of drying out. No watering or spraying is required in rainy weather.

Rule two: Dendrobiums are sun lovers and want as much sunlight as you can give them. The robust cane types can be exposed to the full sun the whole day long without any ill effects. Phalaenopsis types and their hybrids, however, require some protection from the sun. They may be given full sun up to 12 noon after which the light should be diffused by laths to give about 75 per cent of full sunlight.

New plants, only just potted, require about one week of full shade before they are gradually accustomed to the sun. The colour and condition of the leaves is a good guide as to whether the plant is getting too little or too much sunlight. Brittle, yellow leaves mean too much sunlight. Dull green and pulpy leaves are a clear indication of too little sunlight. When the sunlight is just right the leaves will be firm and shiny green.

A final word of advice. Do not let anyone tell you that it does not take food to produce floral growth. If you do not provide the food for the root system to use the plant has no alternative but to draw on its own reserves.

When this happens you end up the flowering season with a zero balance, and the poor spent plant has got to start the next season on an empty stomach. This results not only in poor flowering but also leaves the door open for disease and other troubles to get a hold of the plant.

The regular application of an artificial fertilizer is therefore absolutely necessary. This is rule number three.

Hyponex 20-20-20 is an excellent orchid fertilizer. It should be used dissolved in water at the rate of one teaspoon per gallon for adult plants, or half teaspoon per gallon for young plants.

The best way to give the fertilizer is to soak the clay pots in a solution prepared as above, and also to drench the leaves with the same solution.

This should be done once a week in the case of young plants and fortnightly for adult plants. Fertilisers should always be given when the weather is bright and sunny, and never on dull days or during rainy weather.

Pay attention to all these details, and if you have a green thumb, you should be able to flower your dendrobiums perfectly.

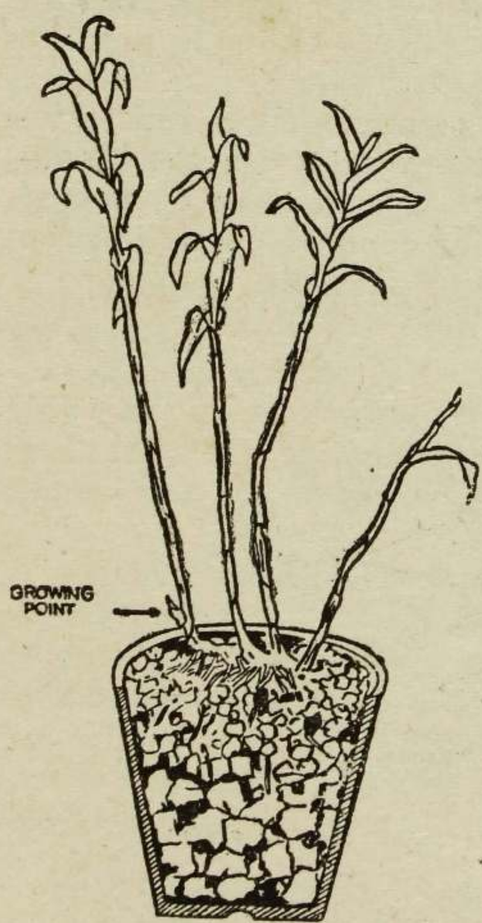


Fig. 6·8

Potted Dendrobium: *Note the position of the horizontal stem and the four erect pseudo bulbs on top of the compost mixture.*

3. Vandas

Vanda orchids may be grouped as follows:

(i) "Strap-leaf" Vandas which have broad strap-like leaves e.g. *V. sanderiana, V. suavia, V. tessellata* and hybrids like *V. Manila, V. Rothschildiana, V. Ellen Noa* and *V. Tatzeri.*

(ii) "Terete-leaved" Vandas which have more or less cylindrical fleshy leaves e.g. *V. teres, V. hookeriana, V. Agnes Joaquim* and *V. Cooperii.*

(iii) "Semi-Terete" Vandas which have been developed by crossing the "strap-leaf" and "terete-leaf" vandas. Leaves in this instance are intermediate in shape between strap-leaves and terete-leaves. Outstanding examples are: *V. Josephine van Brero, V. Marguerite Maron* and *V. Emma van Daventer.*

(iv) "Quarter - Terete" Vandas have been produced by back-crossing the "semi-teretes" to the "strap-leaf" vandas. The leaves here are stockier and wider than in the "semi-teretes." Famous examples are *Vanda T.M.A., V. Tan Chay Yan* and *V. Nelli Morley.*

POT CULTURE: From a cut-flower point of view and considering an export market the most suitable varieties are the "semi-teretes" and "quarter-teretes." These varieties may be potted in the same compost mixture suggested for dendrobium, but as the

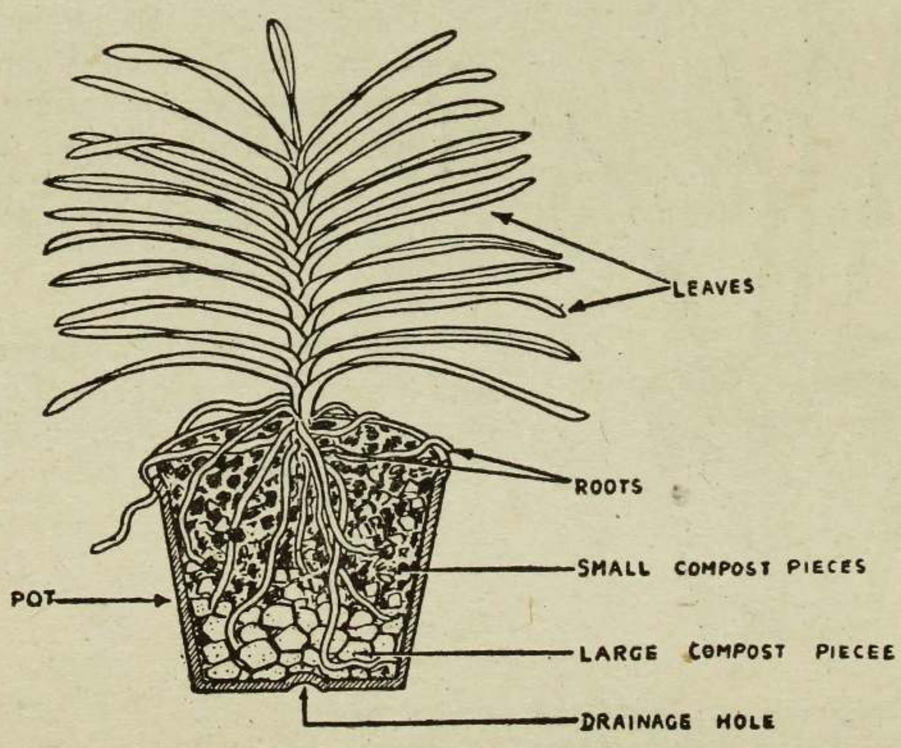


Fig. 6·9

Potting a strap-leaved Vanda

plants are bigger they will have to be repotted every 6 - 8 months until at maturity they occupy pots measuring 10 - 12 inches in diameter. Since their growth pattern is upright there is no need to transfer them into larger pots after this. New roots will appear at intervals higher up on the stem. Instead a tree fern stump may be inserted as a support to the plant. Plants that grow too tall should be "topped" and the "topping" used as planting material.

Unlike the dendrobiums the vandas do not have pseudobulbs to store water. The thick leaves serve this function to a certain extent and the aerial roots are capable of absorbing moisture in a short time. But yet this is not enough, so watering has to be done frequently—once a day at least and preferably in the morning so that there is the whole day for the leaves to dry off.

Regular applications of manure are also necessary. Inorganic fertilizer like Hyponex 20-20-20 is more desirable than liquid cattle manure because the latter can harbour disease organisms. Hyponex may be applied to the plants every one to two weeks between heavy waterings. The solution is prepared by dissolving one teaspoonful of the fertilizer in one gallon of water for well established seedlings and half teaspoonful per gallon for young seedlings. If cattle manure is used it is best soaked in a bucket of water to form a thick liquid and kept covered for a week. The seasoned manure is then diluted with 10 - 12 parts of water before application. Cattle manure is not recommended for seedlings.

The best time to manure is on a bright sunny day when the plants are in active growth. They must not be manured during gloomy weather or during prolonged rainy spells. In pot culture, the pots must be thoroughly flushed with water in between fertilizer applications so as to prevent the accumulation of excess salts which can be injurious to the roots.

Light intensity varies according to the type of vanda grown. "Strap-leaf" vandas, for instance, require a certain amount of shade. This is why they are mounted on trees or raised in pots under controlled shade. Laths may be used to regulate the light intensity which should be 50 - 60 per cent of full sunlight. Or a layer of one-inch coir mesh or Saran plastic shading cloth if it is available.

"Quarter-teretes" will take about 75-80 per cent sunlight. But the "teretes" and "semi-teretes" produce a good crop of flowers in the open in full sunshine. All these varieties have to be grown in shade, however, in the seedling stage and they have to be gradually accustomed to the sun.

4. Scorpions, Spiders & Hybrids

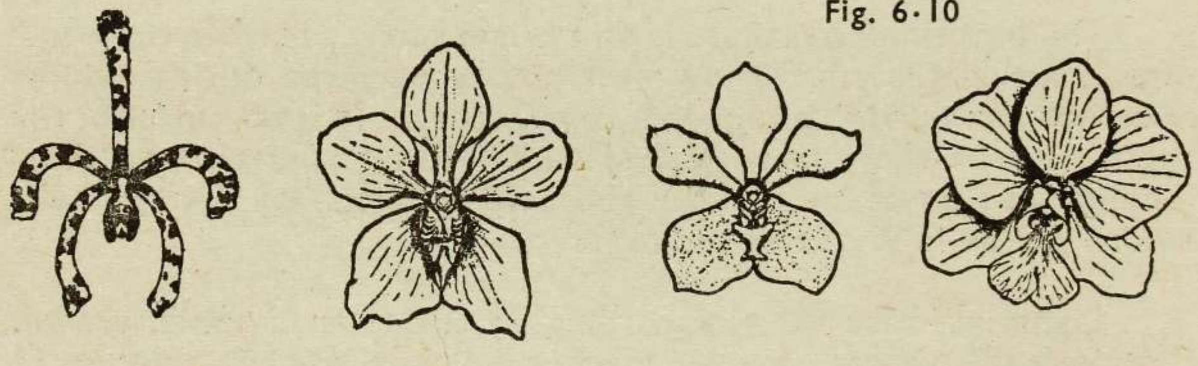
Natural scorpion orchids (Arachnis sp) and spider orchids (Renanthera sp) are free flowering, long lasting types. Good examples are *Arachnis maingayi*, *Arachnis flos aeris*, *Arachnis hookeriana* and their better known hybrids *Arachins Maggie Oei* and *Arachnis Ishabel*. But it is the hybrids that have been produced by crossing these types amongst themselves and with the vandas that are most demanded in the cut-flower trade.

For instance, there are the "Arandas" (Arachnis × Vanda) of which *Aranda Wendy Scott* is a fine example. They are available in all the colours of the rainbow, are very hardy and extremely tolerant of air travel. The "Arantheras" are also important (Arachnis × Renanthera), specially *Aranthera James Storie* which produces long branching spikes of bright scarlet flowers. So also the "Renantandas" (Renanthera × Vanda), some of which produce long, branching spikes of bright orange-red flowers like *Renantanda Ammani*.

BED CULTURE: All these varieties tolerate full sunshine so that they can be grown in open beds. A shallow trench 6 - 9 inches deep and 3 feet wide is dug facing east. *Kitul* or hardwood stakes, 3 - 5 ft in height, are planted along the trench in 3 rows 18 inches apart. The trench is now filled with a compost of large brick and charcoal pieces, over which are scattered pieces of coconut

DIFFERENT FLOWER SHAPES

Fig. 6·10



(L–R) Scorpion, semi-terete vanda, strap-leaf vanda, and terete vanda

Fig. 6·11

(L–R) Aranthera, Aranda and Renantanda

husk and tree fern. The plants are now anchored to the stakes, burying about 2 inches of the stem in the compost surface. A horizontal trellis may be constructed over the stakes to serve as a support for the climbing plants.

Husk Culture — An Alternative Method of Growing Orchids

Irwin L. Dassanaike, well-known orchid grower, has successfully operated the coconut husk method as an alternative to pot culture and bedding. The use of coconut husk as a culture medium is not new, but the manner in which Mr. Dassanaike has handled this material is certainly an innovation which warrants consideration.

WHOLE HUSK & SHELL METHOD : (Fig. 6·12 & 6·13)

Any epiphytic orchid plant from the individual seedling stage to adult or top cutting can be grown by this method.

Use a well dried, but not old or decaying husk, with all segments attached. Place the lower half of a coconut shell—the half without the 'eyes' or holes—inside and at the bottom of the husk and wrap the segments around it, to appear as a complete coconut. It is preferable to choose a husk with well-fitting segments to prevent pests such as cockroaches, slugs, snails or tree frogs from seeking refuge within.

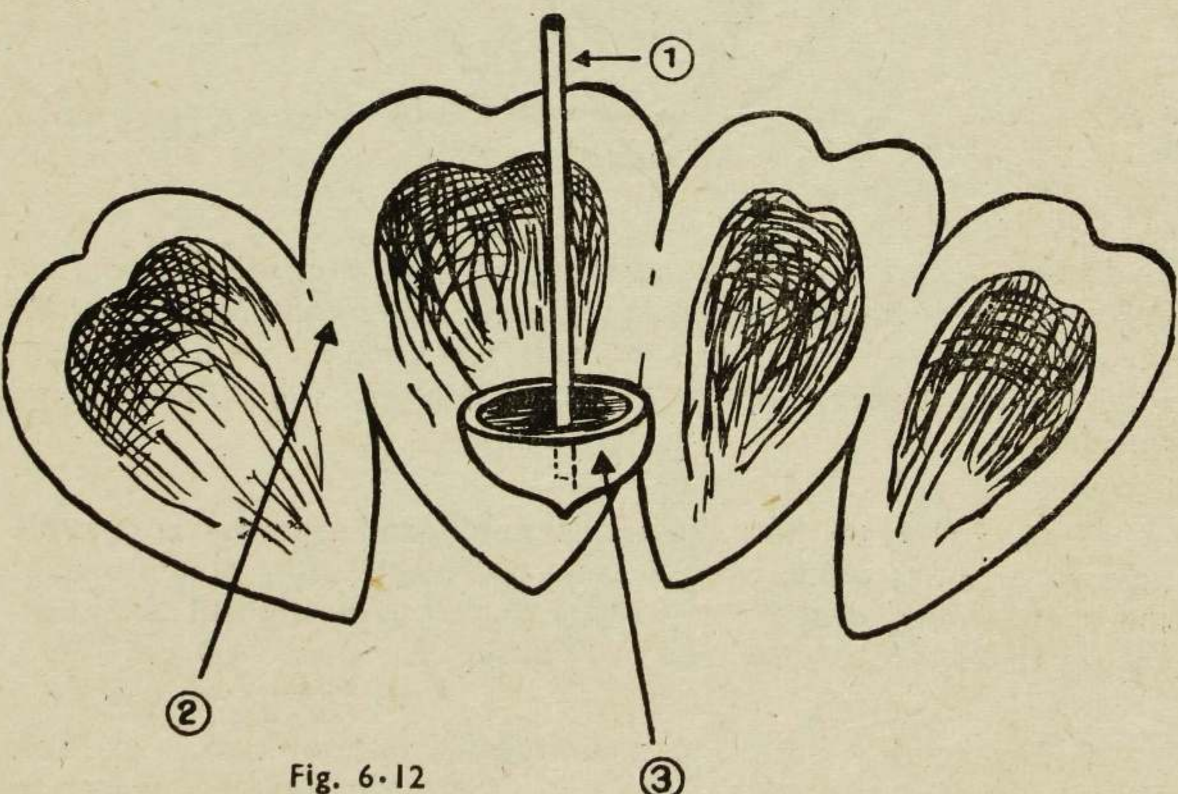


Fig. 6·12

(1) Stake (2) Joined husk segment (3) Half-shell without holes

Make a notch on each of the three vertical ridges on the outside of the husk just above the line of broadest circumference and tie the segments firmly together with wire, rope, gunny string or even strips of dried plantain bark or fired fresh coconut leaves. Keeping the husk segments firmly in place until the roots bind them together is important, for it helps prevent pests from creeping inside.

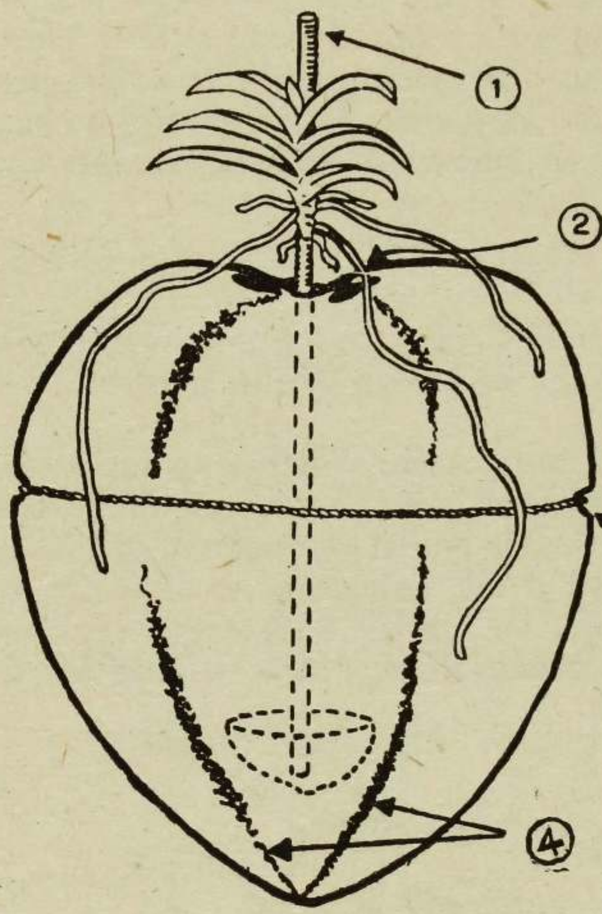


Fig. 6·13

Next, insert a narrow harwood or miniature (*bata*) bamboo stake, ½″ to 1″ in circumference and of convenient length, firmly through the top of the husk to reach the coconut shell placed inside, leaving a sufficient length exposed above the husk to stake the plant.

Tie the plant to the stake very carefully and as firmly as possible (at two or more points if necessary) preferably using gunny string; the roots should drape down and around the outside of the husk. Ensure that no roots are inside the husk.

Before staking the plant, make a small hole or two in the soft fibrous tissue at the top of the husk and pour sufficient water to fill the enclosed coconut shell. This would also facilitate re-filling of the coconut shell during the normal course of watering.

The purpose of the coconut shell filled with water is to provide each plant with the necessary humidity. The absence of sunlight will prevent the breeding of mosquito larvae; and a husk with well fitting segments will reduce evaporation to a minimum.

The whole husk, coconut shell and stake may be treated with an insecticide and/or fungicide (either by spraying or dipping) before staking the plant. This precaution has, however, been found to be superfluous when clean, uncontaminated husks are used. Placing all the whole husks close together helps increase the concentration of humidity in the vicinity of the plants. If the husks are to be placed on staging after the plant is staked, they can be kept upright as follows:

(1) On bamboo rings; (2) with wooden blocks or pieces of brick placed in tripod-fashion; or, (3) on one or two-inch thick layers of fibre dust or paddy husk. The discarded pots may be used to prop up the husks until the plants are ready for transfer to the husk bed.

If the husk is to be hung, use a sufficient length of wire, wind one end of it firmly round the exposed part of the stake close to the top of the husk: traverse the husk longitudinally, wind once more round the stake below the first winding, and with the balance wire fashion a hook or loop as required.

THE HUSK BED : (Figs. 6·14 & 6·15)

The husk bed should always be prepared at ground level, never in a trench or below ground level. Separated segments of husk should be placed in rows close to each other, the convex sides facing up, to any desired length. The width of the beds, however, should not exceed three feet for reasons of accessibility. Three or four layers of husks can be laid, packing or arranging them in such

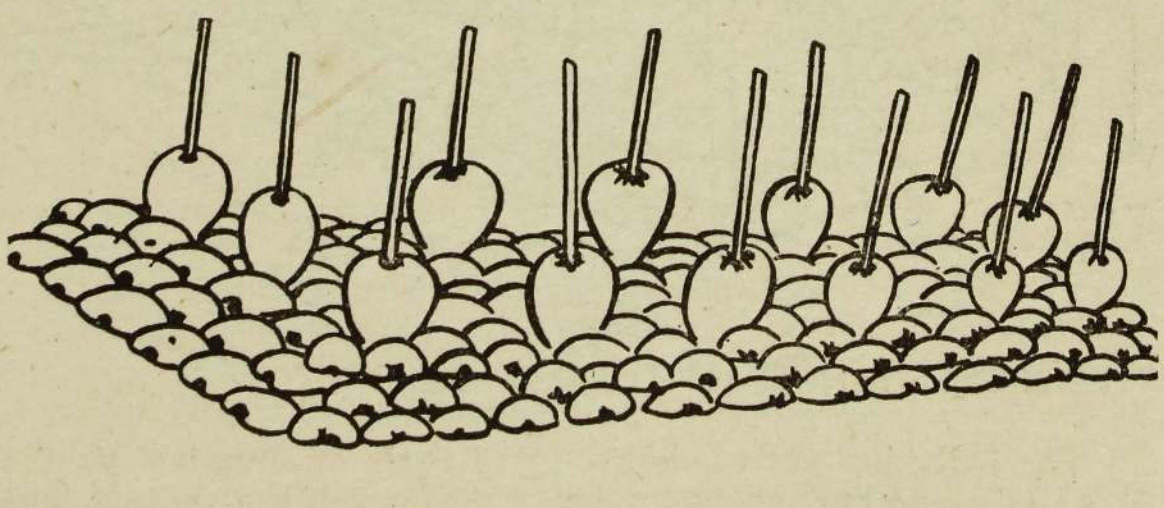


Fig. 6·14

a manner so as to keep them firm and avoid empty spaces, to a total height of approximately 6 or 9 inches. These ground-level beds are suitable for the taller growing varieties such as Arachnis, Arandas, Teretes, Semi-Teretes, Quarter Teretes etc. The husk bed should have along its length and within its width two rows of hardwood stakes up to 2 to 3 feet high, about a foot or two apart, spaced out alternately at one foot to two feet intervals, depending on the varieties to be transferred. The plants should preferably be placed in the husk bed facing either east or west to obtain maximum benefit from the morning and evening sunlight.

The whole husk, with the plant, is now placed and propped-up against the stakes in the husk bed. If necessary another layer of husk segments can be placed around the whole husk to provide more support.

Beds of about two or three feet in height above ground level can also be constructed in the same way, buttressed by cross supports tied or nailed to firm uprights at the corners and on the sides, every six feet or so. These tall beds are ideal for the growing of Phalaenopsis, Cane, Intermediate and Phalaenopsis-type Dendrobiums, Strap-leaf Vandas, Ascocendas, Cattelyas etc. and are of a convenient height for inspection and attention to the plants.

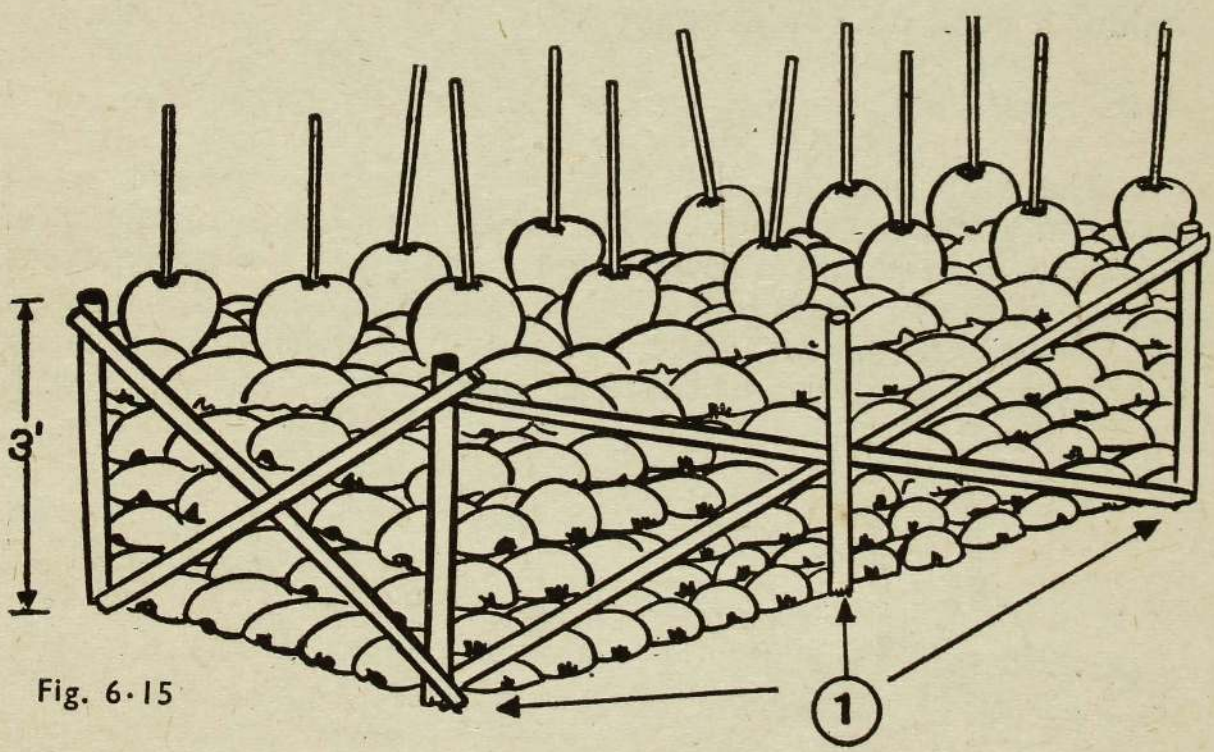


Fig. 6·15

THE SEGMENT HUSK METHOD : (Fig. 6·16)

For individual-pot seedlings, particularly of strap-leaf Vandas, Ascocendas and Phalaenopsis, a broad segment of the coconut husk can be used peeling off most of the smooth outer "skin" to expose the fibrous tissue, but retaining a small area of skin at the top to prevent the wire used for hanging from ripping loose. The husk segment, with the seedling tied to about the middle of its convex surface, can be floated on water for providing extra humidity to encourage faster growth of new anchorage roots. Once the seedling has established itself, the husk segment should be hung up so that when watering a thorough wetting of the concave surface is possible. When the plant is about to outgrow the husk segment it can be tied to a whole husk without disturbing the plant, and either hung up or placed in a husk bed.

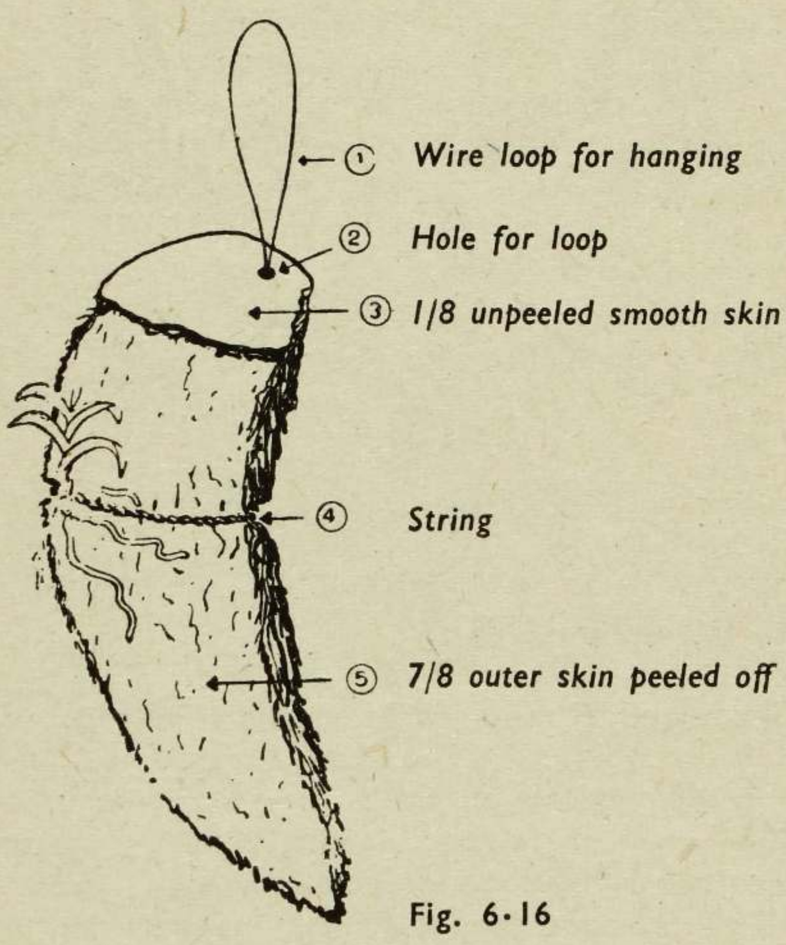


Fig. 6·16

SEEDLING : (Fig. 6·17)

For transferring compost seedlings to single containers, the top or upper half of a coconut shell—with the holes cleaned out—can be used as a receptacle. A small piece of husk (about 1 inch thick and 3 inches long) is placed vertically in the coconut shell together with some one-inch rubble and/or tile for support. The seedling is then placed leaning against the husk. To steady the seedling a few more one-inch pieces of rubble or tile and/or charcoal can be arranged carefully around the roots of the seedlings. The seedling should not be tied to the husk to avoid injury or damage which could lead to the fatal "Black Rot" or other types of fungus attack.

The placing of the piece of husk in the coconut shell, with the curvature either to the left or right, can serve as a means of identification of a particular variety (or batch) of seedlings. The coconut shell can be placed on large chicken-mesh or on a thin layer of fibre dust or paddy husk.

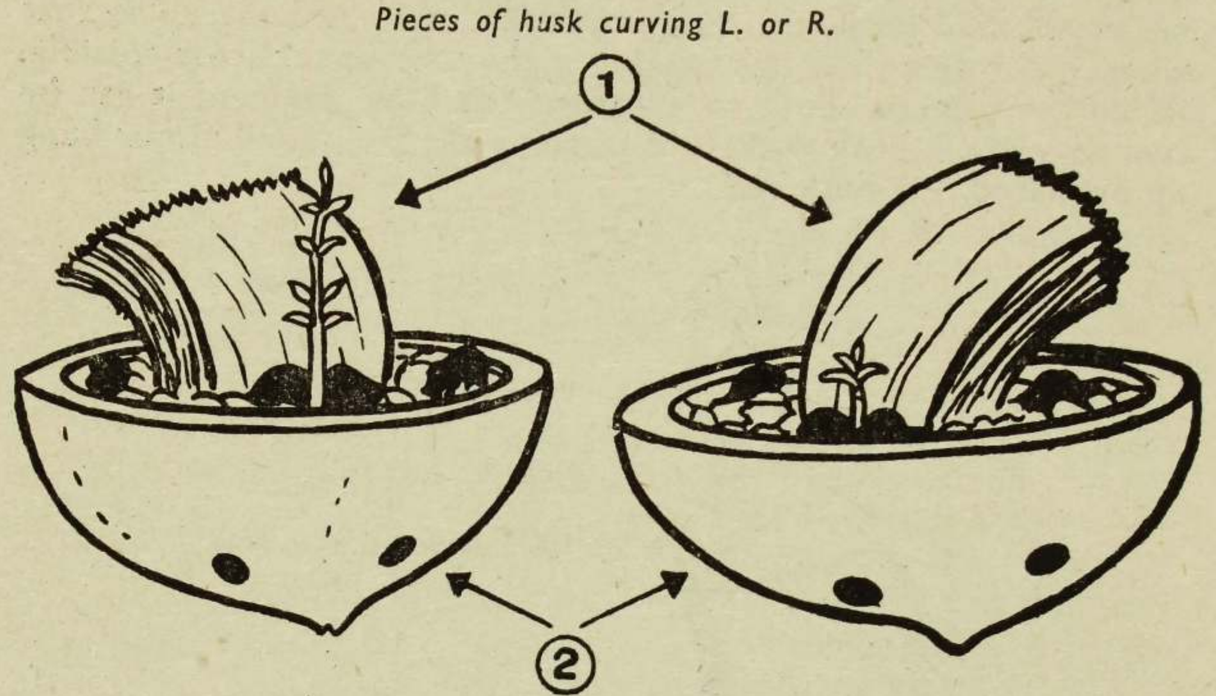


Fig. 6·17

ECONOMIC ADVANTAGES :

The advantages of the coconut husk system of cultivating orchids are fairly obvious. The present-day cost of one two-to-ten inch clay or cement pot is anything from 50 cents to a few rupees. A similar sized crate costs more. But for the price of one pot or crate, you can get 1,000 coconut husks; and the substantial savings thus effected can be used to purchase plant material, which is truly a more productive investment than buying 1,000 clay pots.

OTHER ADVANTAGES :

A. For all the popular tropical varieties of epiphytic orchids, grown particularly for the cut-flower trade, ample aeration and humidity are essential requirements. The husk method undoubtedly provides both. The layout of the coconut husk bed allows for more effective aeration at all times and at all levels of root growth. In addition, it provides much needed humidity—particularly during drought periods; whereas wood shavings and paddy husk tend to pack tightly when settling down, thereby reducing or even preventing aeration. The result is excessive moisture at the root which can be harmful.

B. The roots penetrating the husk layers into the surface soil have a constant supply of nutrients both organic and inorganic readily available at different levels, whereas in wood shavings and paddy husk (and even brick-bats) the nutrients tend to get trapped and stagnate on the surface.

C. Since the new roots prefer to adhere to the smooth, convex, outer surface of the husk they are conveniently exposed to all spray applications of fertilizer, pesticides etc.; hence pests can be easily and effectively controlled with applications of both contact and systemic pesticides. In the "brick-bats" in the pot and crate method, however, visibility and accessibility are so poor that pest control can be no more than superficial at best and consequently ineffective. Dipping the entire receptacle would be the only effective method but then this is not always practicable.

D. Re-potting at least every two years with pot culture is eliminated for, unlike in the "brick-bat" and pot or crate methods, no souring takes place because there can be no injurious accumulation of chemical deposits due to the smoother surface of the husk. The husk and husk bed, if correctly constructed, should last for over five years. And even then, as the bottom layer of husk naturally disintegrates with time and subsides into the soil, one has only to "top-up", so to speak, with a fresh layer or two of husk.

E. This system greatly reduces planting time for both seedlings and plants compared to the time required for potting or re-potting.

F. The husk bed also promotes effective biological control of pests such as slugs, snails and cockroaches by providing ideal living conditions for the black carnivorous ant, the '*kadiya*'. In fact, the '*kadiya*' should be encouraged to live among the husk beds by providing them now and then, with a tasty morsel of meat. The resulting advantage far outweighs the only possible disadvantage—the occasional ant bite. But even this unpleasantness can be easily avoided with a little care, for these ants normally display a laudable sense of discipline when on the move—an apparently endless line, single-file or in a column several deep, and close to each other. So if you watch your step, the ants wont need to remind you to!

G. The coconut husk itself contains natural nutrients which are not only beneficial but essential to plant life.

PART VII

LIVESTOCK

Dairy Cattle — Buffaloes — Mutton Goats — Milch Goats — Sheep — Pigs — Rabbits — Chickens — Broilers — Ducks — Turkeys — Bee – Keeping

LIVESTOCK

DAIRY CATTLE

SCALE OF ENTERPRISE: Obviously the scale of enterprise will depend on the grassland that is available, because grass—good grass—is the most natural and the cheapest form of cattle feed that you can exploit. In fact, a high efficiency of grass feeding is a *sine qua non* of successful dairying.

The number of cattle your grassland can support will depend largely on the climate, method of cultivation and manner of feeding. In the rigorous climate of the dry zone only one "cow equivalent" can be maintained on an acre of grass. In the dry up-country i.e., the Bandarawela - Diyatalawa area two "cow equivalents" can be kept per acre. In the wet zone, on the other hand, the stocking rate is much higher viz., 2.2 per acre in the up-country above 3,000 ft and 3 - 5 per acre in mid-country from 1,000 - 3,000 feet, except in the coconut triangle where the stocking rate is about 1.5 because grass is grown in between and under the shade of the coconut palms.

Cattle when grazed generally need more grassland than when the grass is cut and fed to them in their stalls (zero grazing). Also if grass is grown as a monoculture out in the open it will feed more animals than if it were to be intercropped with coconut and grown under the shade of this crop.

Let us assume that the envisaged dairy project is to be started in the mid-country; that you have 5 acres available for the monoculture of grass; and that you expect to zero-graze your herd. The stocking rate then on the low average would be 3 "cow equivalents" per acre or 15 "cow equivalents" for the 5 acres. The total number of animals i.e. cows, heifers and calves, in a herd of 15 "cow equivalents" would be $15 \times \frac{100}{80} = 18.7$ or approximately 19 animals.

Since the ratio of cows to followers (i.e. heifers and calves) is usually 4:3, you could expect to have 13 cows and 6 followers in a herd of 19 animals. And to ensure the annual replacement of old and milked-out cows with young heifer cows your herd should at any time be as follows: 13 cows, 2 heifer cows (2 - 3 years old), 2 heifers (1 - 2 years old) and 2 calves (0 - 1 year old).

Once your herd composition is established on the existing grass resources, you will know how many animals to purchase and what their cost would be according to prevailing prices. You could also calculate the annual quantity and cost of concentrate feed required. And you could also work out the space required to house these animals. When you have all this information at your finger tips, you have a factual picture of what your enterprise is going to cost in rupees and cents.

GRASS: Grass is the natural feed of cattle. It is also the cheapest cattle feed. These are two reasons why it should be exploited by dairy producers who are presently faced with the short supply and high prices of other feedstuffs. Fed entirely on grass Cape cows and temperate crossbreeds are capable of giving 6 - 8 pints of milk a day. A cow of this type will eat anything from 100 - 140 lb of grass a day. To achieve this result the dairy farmer must know what grasses to grow and how to manage them.

A list of the grasses recommended by the Department of Agriculture is given below:

(1) **Up-Country (Over 4,000 ft)**:

Kikuyu (*Pennesitum clandestinum*) and *Paspalum urvelei* in the depressed or low-lying areas:

(2) **Mid-Country (1,000 - 4,000 ft)**:

(*a*) Wet mid-country (over 60″ rain annually) Ruzi grass (*Brachiaria Ruziziensis*)

Guinea Grass (*Panicum maximum*)

Var. A

Var. B

Var. VRI 435

Hybrid Napier NB21

(*b*) Dry mid-country (less than 60″ rain)
e.g. Teldeniya, Kundasale and Nalanda

Signal Grass (*Brachiaria brizantha*)

Guinea Grass (*Panicum maximum*)
Var. A
Var. B
Var. VRI 435

(3) **Low-Country (0 - 1,000 ft):**

(*a*) Wet Low-Country (Over 60″ rain)

Signal Grass (*Brachiaria brizantha*)

Water Grass (*Brachiaria mutica*)—low-lying areas

Ruzi Grass (*Brachiaria Ruziziensis*)

Hybrid Napier NB21

Guinea Grass (*Panicum maximum*)
Var. A
Var. B
Var. VRI 453

(*b*) Coconut Plantations (Over 60″ rain)

Cori Grass (*Brachiaria miliformis*)

Ruzi Grass, Guinea Grass, Hybrid Napier and Pangola Grass (*Digitaria decumbens*) also grow fairly well.

(*c*) Dry Low-Country (less than 60″ rain)

Signal Grass (*Brachiaria brizantha*)

Water Grass (*Brachiaria mutica*)—Low-lying areas

Guinea Grass may also be grown.

Let us take an example in the mid-country wet zone, which is really the best area for dairy-development in this country. Say you have only one acre of land and that you have decided to keep

3 cows and followers on the zero-grazing or cut and carry system. Grass is usually cut once in 40 days. This means that you will have to divide your one acre of planted grassland into 40 portions of approximately 1,000 sq. ft. each. Every day (in rotation) you will cut one of these portions and feed the grass to the cows. By the time you come to the 40th portion the grass in the first portion will be ready for cutting again, so that you can repeat the cycle.

To be sure that the grass reasserts itself with its usual vigour in a continuous cycle of cutting you must manure it regularly with the cattle dung and urine voided every day to each 40th portion of your grass plot. But this is not enough: grass must be supplemented by an annual application of 1 cwt of conc. superphosphate and $\frac{1}{2}$ cwt of muriate of potash per acre, once a year in the main rainy season and six top-dressings of urea at two-monthly intervals, using 1 cwt per acre each time.

Cut the grass when it is the pre-bloom stage. At this stage the total digestible nutrient content is 50 - 55 per cent. If you wait any longer the grass matures and becomes coarse so that cattle reject it. Cutting and feeding grass to cattle in their stalls (zero grazing) is a more labour expensive method but the management problems are less than under a system of free grazing.

Grass is planted at a spacing of 2 ft × 2 ft. 20,000 cuttings will be required to plant one acre, placing two cuttings at each point. The land, of course, should be first ploughed and harrowed. A rainy period of at least one month is necessary following planting to give the cuttings a chance to establish quickly. Provided weeding and manuring are done the grass should be ready for cutting in 3-4 months. The height of cutting should be about 4 inches above ground level. (See Appendix for more information).

Grasses need to be rejuvenated every 3 years. This is usually done by allowing them to grow freely during wet weather for 2 - 3 months, after which they may be cut again. In the case of the Hybrid Napier variety however, (NB21) it has to be replanted every 3 years.

CATTLE SHED: The cattle shed must be so constructed as to allow the maximum sanitary conditions. There should be plenty of light, ventilation and the floor should be cemented to facilitate regular washing and cleaning. This is important if the bacterial count in milk is to be kept down to a minimum: a high bacterial count causes poor keeping qualities and this leads to rejection when the milk is subjected to the methylene-blue test.

The availability and cost of building materials will ultimately decide what is used in construction. It does not matter whether sawn timber or round timber is used for the supports and whether asbestos, aluminium sheets, G.I. sheets, tiles or cadjan are used for the roof, but it is essential that the floor be cemented.

In the accompanying diagram a cross-section of a cattle shed with double-slope roof is shown, inclusive of central alley, drains on either side, stalls with tie-points for the animals, feeding troughs, and short wall all round.

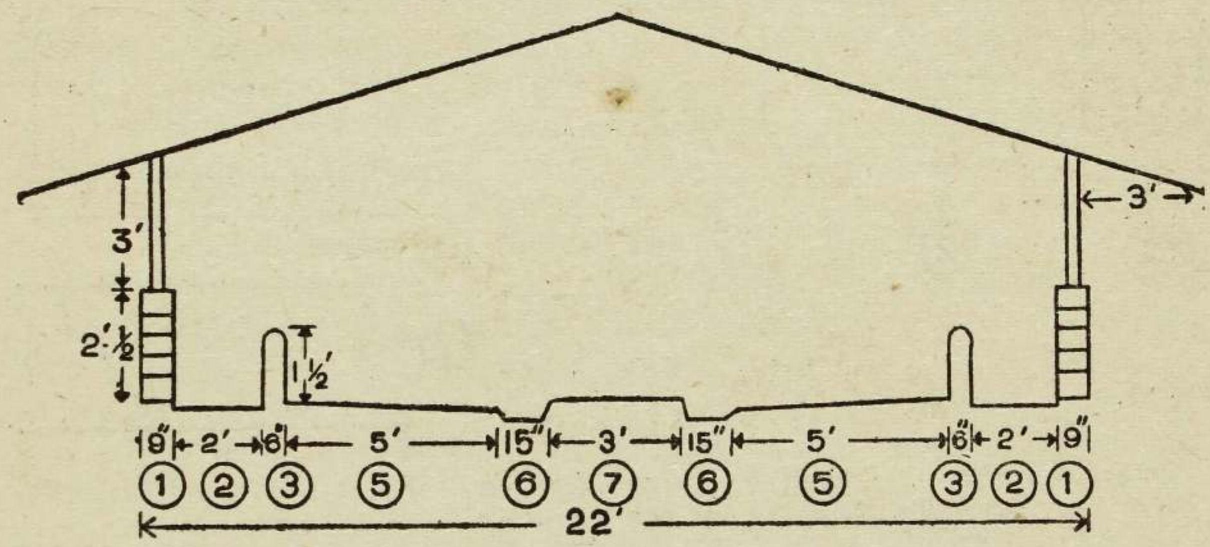


Fig. 7·1 *Cross-section of Cattle Shed.*

The standing space required for an average-sized cow of (650-850 lb) is 3′ 3″ wide by 5′ long. Larger animals of 1,000 lb (e.g. Friesian) require 3′ 6″ by 5′ 3″. Each animal is tied to an iron ring buried in the floor about 3″ away from the short concrete wall that separates the stall from the feeding trough. This wall (1½′ high and 4″ - 6″ thick) should be constructed of concrete. The stall floor should be sloped downwards to the drain with a drop of 1 in 40. It should be rough-plastered on the surface to prevent the animals slipping and hurting themselves.

The cattle shed shown in the diagram is 22 ft wide. It is for average-sized cows (650 - 850 lb) that require a standing space of 3′ 3″ wide by 5' long. Two such cows standing opposite each other across the central alley will take up 72 sq. ft. inclusive of stall, feeding trough, drain and alley. The space required by a single animal therefore will be 36 sq. ft. This space must be provided for all animals over 1 year of age. Calves do not require more than 20 sq. ft. each.

So, if you have a herd composition of 13 cows, 3 heifers and 3 calves, as in the example given before, you must provide 16 animals

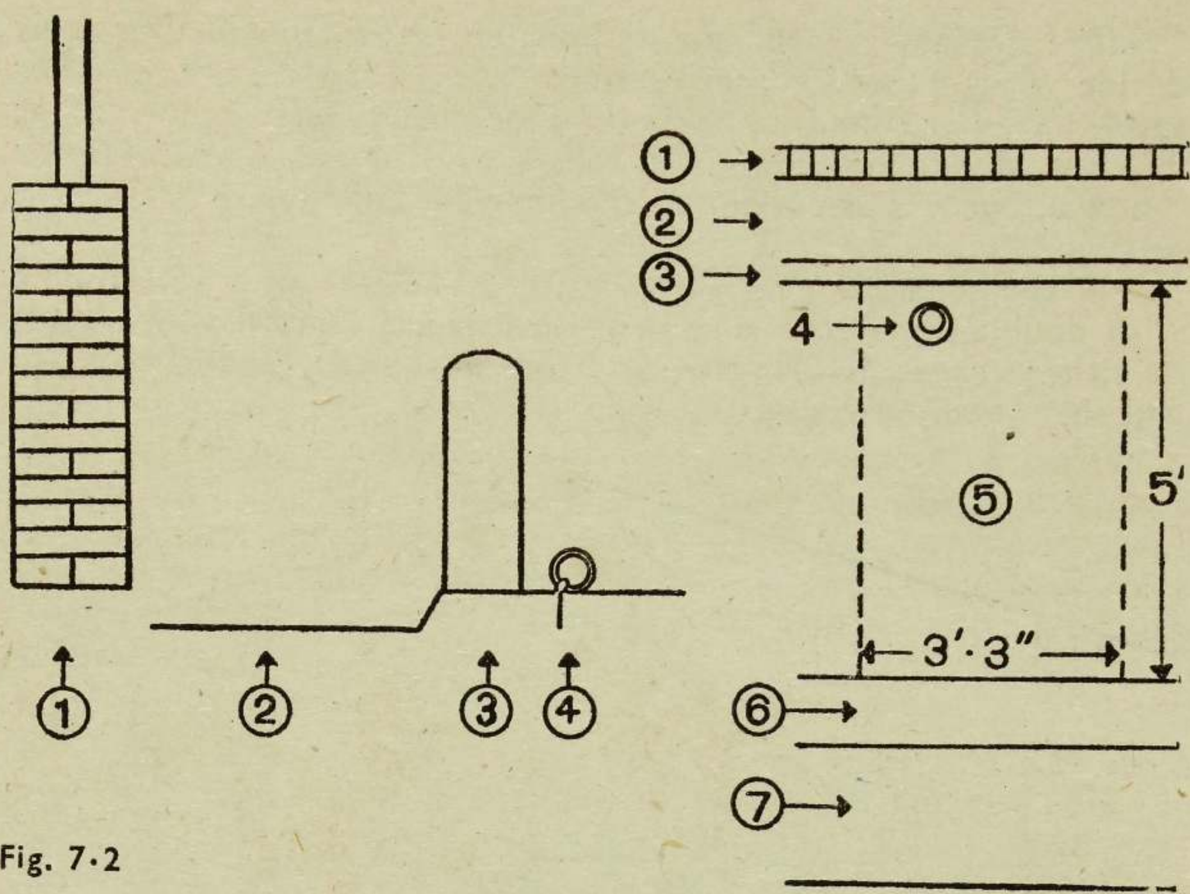


Fig. 7·2

Enlarged section of Trough, Walls and Tie-ring (Left) and Enlarged Ground Plan showing stall space for one medium-sized Cow (650—850 lb.)

(1) Outer wall (2) Feeding Trough (3) Inside wall (4) Tie-ring (5) Stall (6) Drain

with a floor space of 36 sq. ft. each, inclusive of stall, feeding trough, drain and alley i.e. 576 sq. ft. In addition the three calves will require 60 sq. ft. If you add to this a further 60 sq. ft. for a small milk room you have a total floor space of 696 sq. ft.

TYPE OF ANIMAL REQUIRED: Productive stock is a *sine qua non* of successful dairying. Unfortunately, 90 per cent of the cattle population in this country (excluding buffaloes) is comprised of small undersized animals weighing about 160 kg (350 lb). The average annual milk yield is 450 litres (100 gallons). This is not a very encouraging outlook, particularly when we are told that it will take 200 years to raise the milk yield of the Sinhala cow (i.e. the local breed) to the same level as an imported Jersey.

Now this would certainly be the position if we attempt to upgrade our scrub animals by selective breeding. Fortunately there is a very much quicker method where it is possible to exploit the genetic factoi of hybrid vigour, by crossing our indigenous stock with superior temperate breeds like the Friesian, Ayreshire, Jersey and Ilawara Shorthorn. Such a breeding programme if vigorously pursued should produce improved dual-purpose types with an average annual milk yield of 1,100 - 1,600 litres (250 - 350 gallons) and liveweights of 500 - 600 lb per animal, dressing out at 250 - 350 lb. These figures are 2½ - 3½ times the present milk yield and double the present body weight of local stock.

Of crucial importance to the success of such a breeding programme, however, is the availability of superior breeding stock. Very few pure bred or grade animals are available for this purpose. An attempt to meet this deficiency by the importation of several thousands of improved stock from abroad has not been a success because the private sector has been reluctant to purchase these animals at the high prices that they are offered. In the circumstances, almost complete reliance has now been placed on artificial insemination as the most economic and the most convenient means of upgrading local stock.

Artificial insemination permits a wider use of superior bulls than natural service and also a wider choice of bull semen. This is very important because the latest thinking on the subject of crossbreeding favours rotational breeding, or the use of three or more breeds to retain the hybrid vigour of the initial cross. If this is not done and instead the first generation crossbred heifers (Fl) are crossed with the same parent or allowed to breed *inter se*, then there is an appreciable reduction in the milk yield because of the loss of hybrid vigour. This is shown up clearly in experiments conducted by the Department of Agriculture from 1956 - 1973 at Karagoda-Uyangoda.

		Milk Yield 1956-66 (Kg)	*Milk Yield 1968-73* (Kg)
Friesian × Sinhala	Fl	1,573	1,482
	F2	987	981
	F3	—	957
Jersey × Sinhala	Fl	1,215	1,076
	F2	809	—
	Bl	—	948
Sinhala		570	234

Fl = First generation crossbreds
F2 = Second generation crossbred bred *inter se*
F3 = Third generation crossbreds bred *inter se*
Bl = First generation crossbred heifers back crossed to same parents

Source: Department of Agriculture.

ROTATIONAL BREEDING SCHEMES FOR THE WET ZONE: Rotational breeding is essential to retain the productive gains achieved by crossing local cattle with temperate breeds. Based on this principle here are some suggestions that may be practical in the wet zone.

Let us take the cool up-country first. Assuming a foundation stock of Sinhala cows, the suggested breeding programme is spread over three phases. In phase I the Sinhala cows are inseminated with Jersey semen. The Jersey is selected as a first cross parent because of its small body size which is nearest the local cow. The cross-bred calves are allowed to suckle the cows until they are completely weaned. Then the cows are sold, and the crossbred heifers when they come into heat are inseminated with Ayreshire semen. The Ayreshire is a medium-size animal. This is phase II of the programme. In phase III the crossbred Ayreshire cows and their progeny in turn when they come into heat are inseminated with Friesian semen. The Friesian is a big animal and the most productive milker in the country. From this cross can be expected excellent dual-purpose animals both for milk and meat.

If the dairy farmer already has a Cape cow (Hatton Cow) or a Jersey cow—as is frequently the case above 3,000 ft—then he is advised to have the cow inseminated with Ayreshire and Friesian semen in succession to get the full benefit of hybrid vigour. The increase in milk yield in this instance, however, will not be as marked as it is when widely dissimilar types like the local Zebu and European breeds are crossed.

A three-phase programme of breeding is also recommended for the hot low-country. The first cross again could be Sinhala × Jersey, the Jersey being selected for its small size and in this instance for its heat tolerance too. In the second phase, the crossbred calves are inseminated with semen from the Ilawara Shorthorn—this animal is of medium size and is also adapted to hot and humid conditions. In the third and final phase the cows and calves of the second phase are inseminated with Friesian semen.

Rotational breeding as suggested here is the only rational way to breed for both milk and meat. Nowhere in the world today, except perhaps in the U.S.A. and the Argentine where extensive ranch conditions exist, is breeding undertaken separately for beef. In most countries the greater part of the beef is produced from the dairy herd. In Britain, for instance, 70 per cent of the beef consumed is dairy beef. This will have to be our policy too.

A BREEDING SCHEME FOR THE DRY ZONE: Owing to the harsh climate and prevailing poor standards of nutrition and management obtaining in the dry zone, the immediate infusion of European blood may not be advisable although the Jersey has distinct advantages because of environmental and managerial conditions. Available experimental evidence suggests that a two-stage crossbreeding programme would pay greater dividends in the long run.

In such a crossbreeding programme the indigenous Sinhala female stock is first crossed with bulls of Indian breeds like the Sahiwal or Sindhi to produce an improved Zebu foundation stock, and this is followed by an introduction of European blood, since further upgrading to the Indian breeds is not economic. This has already been demonstrated in another experiment conducted at the Department of Agriculture Livestock Farm at Weerawila from 1961 to 1973:

	Milk Yield 1961-69 (Kg)	*Milk Yield 1970-73* (Kg)
Sindhi × Sinhala		
F1	770	—
B1	760	—
Sindhi	908	882
Jersey × F1 (above)	—	1,209
Shorthorn × F1 (above)	—	1,320

Source: Department of Agriculture.

You will notice that when the first generation crossbreds are back-crossed again to the Sindhi parent there is no improvement in the milk yield, but when they are crossed to a Jersey or Shorthorn there is an increase in milk yields by 60 - 70 per cent. Both Jersey and Shorthorn are therefore suitable crossing breeds for the dry zone, but where milk is the prime consideration the Jersey would be the more desirable parent, but where milk and meat are both important the Shorthorn is preferable because of its larger size.

TIME OF BREEDING: The time of breeding is important if a cow is to achieve maximum productivity and also produce a calf regularly every year. A calf every 12 months is generally considered to be the desired frequency for economic dairy farming. Wellington *et al* (1970) have suggested that the milk yield per day of the calving interval is a useful measure of productivity. For instance, suppose that two cows A and B both give 4,000 lb of milk in a single lactation, but that Cow A has a calving interval of 370 days and Cow B 420 days. Then, in the case of Cow A the milk yield per day of calving interval would be $\frac{4,000}{370}$ = 10.8 lb and the milk yield per day of Cow B $\frac{4,000}{420}$ = 9.5 lb. Assuming a selling price of Re. 1/- per lb this means that Cow A is more profitable than Cow B by Rs. 1/30 a day or Rs. 475/- a year. In a five-cow herd this works out to Rs. 2,375/-.

It is obvious from this example that the closer a farmer can approach to annual calf-production the more efficient will be his dairying. But in order to do this—i.e. to ensure that a calf is born regularly every year—he must have the cow successfully inseminated by the 85th day after calving. This means that the cow must be first inseminated 40 - 60 days after calving to allow for one or two infertile inseminations that might occur. If the cow is successfully inseminated by the 85th day, then she should calve 280 days later to achieve the ideal calving interval.

ARTIFICIAL INSEMINATION: The least expensive method of up-grading dairy animals is artificial insemination (AI). Many people are still suspicious of this method. They think that AI is not as effective as natural service and the calves produced by AI are weak or predominantly male. Farm records and field data however, indicate quite definitely that the sex ratio of both AI and NS (Natural Service) calves is in the ratio of 1:1, that the birth weight of AI and NS calves is the same (around 40 lb in the case of Jersey calves born in up-country government farms) and also that there is no difference in the rate of calving which is around 43% in the case of both AI and NS calves.

Except in definite cases of sterility the failure to conceive after AI is usually due to late insemination after the effective "heat" period is over. This happens because the dairyman is not alert to distinguish the signs of heat in time or the inseminator is unable to get to the animal in time.

A cow comes into heat every 18 - 21 days. The signs are unmistakable: bellowing and mounting other cows, restlessness, a redenning of the vulva and a vaginal discharge. A tentative schedule showing when a cow showing these symptoms should be inseminated is given below:

	Signs of Heat	*Time of Insemination*
(i)	Noticed before 9.00 a.m.	In the afternoon of same day
(ii)	Noticed between 9.00 a.m. and 12 noon	In the evening of same day or early next day
(iii)	Noticed between 12 noon and 6.00 p.m.	Next morning

Also ensure that cows that are inseminated are healthy and well nourished. Undernourished cows, especially cows that lack mineral sources, are often infertile. They also do not show distinctive sings of 'heat'.

CALVING: If the cow does not come into 'heat' and a subsequent "pregnancy diagnosis" confirms that she has conceived, then the calf's birth date can be calculated for 280 - 285 days after the day of successful service. Calving is a normal natural process. In the great majority of cases the cow requires no assistance from the stockman to produce her calf but good husbandry demands careful observation of the cow at that time.

The first positive sign is the appearance at the vulva of a bag of fluid which will rupture at or slightly before the birth of the calf. The calf is most commonly presented in the birth canal forefeet first with the head resting over the legs and the nose forward. An uncomplicated calving in this position may take only a few minutes, but in heifers calving for the first time it takes much longer. By far the most common cause of failure to calve without assistance is a deviation from the foetal position described above.

In a normal birth the cow will begin to lick the calf dry immediately it is delivered. This is necessary to stimulate respiration and improve circulation. If the cow does not do this, the stockman must do so with a clean dry piece of gunny or some straw. The stockman should also disinfect the calf's navel cord with tincture of iodine. It may be necessary to apply a little margosa oil over the next few days to keep the flies away. A vigorous calf will attempt to rise in about 15 minutes and to suckle in about half an hour. If the calf is unable to nurse by its own efforts it should be helped by holding its head to the dam's udder.

CALF-FEEDING: The most important single safeguard is to see that the calf drinks an adequate quantity of colostrum within the first few hours of its life. Colostrum is the first milk secreted by the dam at the birth of the calf. It is laxative, but more important it is highly nutritious and carries a number of essential substances including antibodies which are necessary to build up a resistance to disease in the calf. The gut is permeable to antibodies only for a relatively short time. Six hours after birth permeability begins to be lost; after 36 hours it no longer exists. For this reason new born calves must have their dam's colostrum in the very first few hours of life. The vitamin content of colostrum, particularly vitamins A and D is several times higher than that of normal milk. Since these vitamins are not particularly well stored and calves are born with low reserves, the colostral source is most important at least for three full days.

On the fourth day the calf is weaned and housed separately. Individual pens are best as this does not allow them to lick each other and collect balls of hair in their stomach. The floor space of each pen will vary from 16 sq. ft. after birth to 20 sq. ft. at the age of 6 months. Keep the pens clean, disinfecting them every few days with Jeyes fluid or Tropical Chloride of Lime. If the floor of the pen can be raised a few inches on a slatted wooden platform so that the dung falls below and out of reach of the animals, *E. Coli* and Salmonella infections (causing white diarrhoea) will be prevented to a great extent. But give the calves a few hours of exercise in the sun every day.

The quantity of milk to be given everyday up to the end of 8 weeks is shown below. This quantity should be divided into two equal feeds and given in the morning and evening. These quantities have been calculated on the assumption that the calf is born of an improved medium sized animal, and that its weight is about 60 lb. The quantity may be increased or decreased for calves of greater or lesser weight respectively.

Age	*Whole Milk (pints per day)*	*Concentrates (lb/day)*	*Grass (lb/day)*
1 — 3 days	Colostrum	—	—
4 — 7 days	7	—	—
2 — 5 weeks	7	1/4	—
6 — 8 weeks	7	1/2 - 1	5 - 8
3 — 6 months	—	1	*ad. lib.*

In addition to milk, concentrates and grass must also be fed in increasing quantities. Concentrate feeding (coconut poonac and rice bran mixed in the proportion of 2:1) should begin about the 14th or 15th day—small quantities at first till the calves grow accustomed to it. Fresh grass is not fed till the calves are 6 weeks old. During the first few weeks of the calf's life the rumen or first stomach which deals with the digestion of grass is not fully developed and cannot cope with bulky feeds of fresh grass. Hay (sun-dried grass) however, can be fed to advantage during this period, starting from about the 10th day. Early hay feeding helps to develop the rumen into a large sac which is capable of dealing with large quantities of grass when the calf is older. When the calf begins to eat fresh grass from the sixth week onwards it is very selective at first, so be sure to provide grass that is not more than 4 weeks old.

In addition, the calves must be provided with mineral mixture i.e. calcium and phosphorus. Ready-mixed minerals are available as Pecutrin and Supermindef. You can also prepare your own mixture by mixing two parts of steamed bone meal with one part of common salt. A calf should be given half-ounce of mineral mixture everyday with the concentrate up to 3 months of age and one ounce from 3 - 6 months.

HEIFER FEEDING: At the end of six months a calf should average 200 lb. It is usual for dairymen at this stage to put the heifers on to grass feeding alone together with a little mineral mixture. But this is not a wise thing to do because this is the time of puberty and weight gains should be at their maximum. It is necessary, therefore, to continue the concentrate feeding till at least the animal is 9 months old. If this is not done permanent stunting could arise leading to late maturity.

Under good feeding and management with good breeds the heifer should be ready for breeding at 15 months of age. Age, however, is not necessarily the criterion. If the animal weighs between 470 and 500 lb it is mature enough to be bred to the bull.

Age (*months*)	*Concentrates* (*lb*)	*Mineral Mix.* (*oz*)	*Grass* (*lb*)
6 — 9	1	2	70 — 100
10 — 15	—	2	70 — 100
	(*Heifer is mated at this age*)		
15 — 22	—	2	70 — 100
22 — 24	8	2	70 — 100
	(*Cow calves at this age*)		

You will notice from the above table that the heifer is given a high level of concentrate feeding two months before calving. This is very important for two reasons: (i) it is necessary for the heifer to put on sufficient weight before it starts milking, or during the course of lactation it will be compelled to draw on its maintenance body resources with consequent ill effects on its health and future performance, (ii) during the last two months of pregnancy the calf grows rapidly gaining about two-thirds of its birth weight. For these two reasons the pregnant animal has to be "steamed-up" two months prior to calving.

MILCH-COW FEEDING: The recommended rations for a 800 lb medium-sized milch cow giving 15 - 20 pints of milk is shown below:

Age (*months*)	*Concentrates* (*lb*)	*Mineral Mix* (*oz*)	*Grass* (*lb*)
25 — 28	8	3 — 4	100 — 120
29 — 30	6	3 — 4	100 — 120
31 — 32	5	4	100 — 120
33 — 34	—	4	100 — 120
35 — 36	8	4	100 — 120

(*Cow calves again*)

You will notice that the period of high level concentrate feeding is always from 2 months before calving to 2 months after calving when milk production is at its highest. Thereafter, it is gradually reduced to zero in the 9th and 10th months. At this stage the cow is dried off for two months to enable it to recover the body weight lost during the previous lactation. The annual cycle is renewed so long as the cow is economically profitable. Clean drinking water must be provided at all times. A cow requires about 10 gallons or more a day for drinking alone. On the basis of washing the shed and the animals in addition to drinking water a cow requires 30 - 40 gallons a day.

MILKING INTERVAL: Once the cow has calved and starts producing milk, it is necessary to establish a regular milking interval so that the animal gets accustomed to letting its milk down easily. On the contrary, irregular milking causes the cow to "hold back" milk and this is both economically unrewarding and detrimental to the animal's health.

The ideal milk interval is 12 hours between morning and evening milkings. Alternative intervals are 11 hours and 13 hours or 10 hours and 14 hours. But the interval should never be less than 10 hours or more than 14 hours. It should be noted that during the shorter intervals less milk is produced but the fat content is higher. And in the longer interval more milk but less fat is produced.

The usual policy is to strip the udder so as to minimise the chances of bacterial infection. While this is all right with older cows, it should not be attempted with newly calved heifers to avoid damage to the milk-conducting vessels in the udder.

HERD REPLACEMENT: Commercial dairymen must also make provision to replace uneconomic milkers in the herd with young productive heifers. The rule of thumb is an annual replacement rate of 20 per cent. This means that in a 10 - cow milking herd, assuming a calving rate of 80 per cent, 8 calves will be produced in a year. And since the ratio of bull calves to heifer calves is generally 1:1 we can expect 4 bull calves and 4 heifer calves. Since the annual replacement rate is 20% this means that in a 10 - cow herd only 2 heifer calves need be retained—the other 2 heifer calves and 4 bull calves may be sold.

CLEAN MILKING PROCEDURE: Before you start milking see that the dung is removed and the cattle shed washed. Then wash the udder, flanks and belly of the cow with water first and disinfect the udder with a warm Condys solution just enough to give a faint pink colouration to the water. Finally clean the udder dry with a fresh cloth before milking.

Use clean pails. Pails specially designed for milking are constructed free of rivets and seams to facilitate washing and the exclusion of harmful bacteria. Once the animals have been milked take the pails immediately to the milk room to prevent contamination and the absorption of offensive odours. Strain the milk using a cotton-pad strainer or a clean cloth.

At the end of each session of milking wash the milk pails thoroughly first with warm water and then hot water containing a detergent like washing soda ($\frac{1}{2}$ lb in 1 gallon water) till all traces of milk and greasy residue are removed. Finally rinse with clean water and sterilize with boiling water.

Similarly see that all udder cloths are disinfected and thoroughly washed before they are used again.

HEALTH CARE: The following precautions should be taken to ensure good health:

Disease or Parasite	*Recommended Action*	*Remarks*
Pneumonia	Sub-cutaneous vaccination at birth and 10-14 days later	This precaution is very necessary in the cold up-country
Salmonella	Sub-cutaneous injection 2 weeks after birth	Germs are found in alimentary canal and cause diarrhoea

Disease or Parasite	*Recommended Action*	*Remarks*
Roundworms	Give anthelmentics orally e.g. Nilverm or Thiabendozole or Phenothiazene. First dose at 1 - 2 months followed by one dose every month up to 6 months.	When phenothiazine is given a reddish colour urine will be passed. During this time the calves should be kept indoors and not exposed to sunlight as they can develop a sort of "blindness".
Ticks	Apply anti-tick solution every 2 months	Ticks can be a problem where animals are not stall-fed but allowed to graze in low-country wet zone.
	e.g. Asuntol or Neguvon or Negusant	First bathe the calf, partially and then apply anti-tick solution with wet cloth to body, specially under legs, behind ears and under base or tail where ticks tend to hide.
Black Quarter	First vaccination at 4 months and re-vaccination every 6 - 8 months	Black Quarter and Foot and Mouth are prevalent mainly in the mid and up-country wet zone. At present Foot and Mouth vaccination is not available to public (it is used only in government farms)
Foot & Mouth	First vaccination at 6 months and re-vaccination every 6 months	
Haemorrhagic septicaemia	First vaccination at 4 months and re vaccination every 6 - 8 months	If there is an outbreak all animals from one month of age should be vaccinated. Prevalent in dry zone.
Anthrax	First vaccination at 4 months and re-vaccination every year.	Prevalent in dry zone

You should also guard against two other diseases viz., Brucellosis or Contagious Abortion and Mastitis.

BRUCELLOSIS: This disease is the most important single cause of abortion in cattle. Abortion is generally followed by temporary or permanent sterility. Therefore, if abortion occurs in a herd, Brucellosis must be suspected and immediate action taken to test the herd and also to dispose of the suspected infected material in a sanitary manner.

(i) Dispose of the aborted foetus, afterbirth, or like material by burying deep in the ground and covering with quicklime.

(ii) Since the disease is comunicable to man as Undulant Fever, be careful in handling the infected material. Hands and arms should be washed thoroughly using a suitable disinfectant.

(iii) Milk from an infected animal is potentially dangerous and must therefore be boiled or properly pasteurised before consumption.

Note: If the Brucellosis Test is positive the Government Veterinary Surgeon will advise you in respect of the retention or disposal of reactors. This Officer will also take action to vaccinate all calves in the herd (6-8 months in age) with strain 19 vaccine so that they develop an increased resistance to the disease.

MASTITIS: This is a common udder disease, but it is rarely noticed until it suddenly erupts in the acute form. Then the udder becomes hot, swollen and tender. The first strippings taken from the udder may show the milk to be watery, stringy and to contain flakes or blood clots.

When such a condition of the udder is noticed the following action should be taken:

(i) Separate the diseased animals from the healthy cows and milk them last after the healthy cows have been milked. This will prevent the spread of infection.

(ii) Since the mastitis germs are transmitted from one cow to another on the milker's hands, teat cups of the milking machine, dirty udder cloths or by flies feeding on infected milk fallen on the ground, it is imperative that you maintain the highest standard of cleanliness when milking.

This means washing the udder of each cow and the hands of the milker with a Condys solution prior to milking, and flushing the floor thoroughly underneath each cow after milking.

(iii) Diseased animals should be given relief by hot fomentations of the udder. The udder surface should be kept well lubricated with a suitable ointment to assist in relieving the congestion and help in massaging the swollen gland.

(iv) For internal medication of the udder consult the local Veterinary Surgeon.

SIGNS OF SICKNESS: If your cows at anytime should show a sudden drop in their appetites, or their daily milk production; if they should stop rumination (chewing the cud) and if you notice that their coats are not sleek and glossy as usual but dull with the hairs standing up, then you should suspect some sickness and seek the advice of a Veterinary Surgeon.

BUDGET FOR A MODEL FIVE-COW DAIRY UNIT.

Here is a model investment projection, sales and operating expenses projection and a financial projection for a five-cow dairy farm in the mid-country on a stall fed system of management on 4 acres of land.

The total investment required is Rs. 17,600/- spread over two years. Out of Rs. 13,600/- required for investment in the first year, Rs. 2,000/- comes as a subsidy for pasture establishment on 4 acres at Rs. 500/- per acre. The farmer contributes Rs. 2,000/- to finance the cost of equipment and water service. The balance Rs. 9,600/- (Rs. 6,000/- for cows, Rs. 2,800/- for the building and Rs. 800/- to cover part of the forage development cost) has to be obtained as a long term loan from a bank in the first year.

In the second year another long term loan of Rs. 4,000/- is required to purchase two additional cows. The total bank loan is Rs. 13,600/- for both years.

In computing the returns from milk sales, an average production of 3,000 pints per cow has been assumed and the milk has been valued at -/90 cents per pint.

No costs have been included for labour as this unit is assumed to be managed by a family.

All other assumptions have been stated as footnotes on the different projection sheets.

It will be seen from the cash flow projections that from the third year the farmer is able to earn an income of Rs. 550/- per month. With improvement in soil fertility and more efficient forage management this farm could carry 8 cows and followers in which case the income will reach Rs. 850/- per month. On this basis the return to capital and labour in Rs. 2,500/- per acre per year.

(*Source:* Department of Agriculture)

MODEL FIVE-COW DAIRY FARM (STALL FEEDING SYSTEM) MODEL INVESTMENT PROJECTION

	Unit	*Cost*	*Year 1*		*Year 2*		*Total*
Forage Development (1)	Ac	700	4	2800	-	—	2800
Buildings (2)	Au	400	7	2800	-	—	2800
Cows (3)	Au	2000	3	6000	2	4000	10000
Water service (4)	Farm	1500	1	1500	-	—	1500
Equipment (5)	Farm	500	-	500	-	—	500
				13,600		4000	17,600

1. Forage development

Land clearing	200
Planting etc.	100
Fertilizer	400
	700

Ac=acre

Au=animal unit

2. Rs. 400/- per Au.
3. At Rs. 2,000/- each.
4. Water Service—Cost of pipes & reservoirs only. (gravity flow)
5. Equipment—buckets, pails, etc.

MODEL SALES & OPERATING EXPENSES PROJECTION

Year	*1*	*2*	*3*	*4*	*5*	*6—20*
Sales						
Milk sales (1)	4860	8640	10800	10800	10800	10800
Calf sales (2)	100	200	200	200	200	200
Cull cows (3)	—	—	—	1000	—	1000
Surplus heifers (4)	—	—	1000	—	1000	—
Total	4960	8840	12000	12000	12000	12000
Operating Expenses						
Labour (5)	—	—	—	—	—	—
Concentrates (6)	1200	2400	3000	3000	3000	3000
Forage maintenance (7)	—	1600	1600	1600	1600	1600
Maintenance of structures (8)	250	250	250	250	250	250
Disease control & A. I. (9)	100	250	250	250	250	250
Insurance	100	300	300	300	300	300
Total	1650	4800	5400	5400	5400	5400

1. At -/90 cents per pint
2. At Rs. 100/- per bull calf
3. At Rs. 1000/- each
4. At Rs. 1000/- each
5. Family labour only
6. At Rs. 600/- per ton
7. At Rs. 400/- per acre
8. 5% on building 20% on equipment
9. At Rs. 50/- per cow

MODEL FINANCIAL PROJECTIONS

Year	*1*	*2*	*3*	*4*	*5*	*6—20*
Cash inflow						
Sales	4960	8840	12000	12000	12000	12000
Subsidy	2000	—	—	—	—	—
Long term loan	9600	4000	—	—	—	—
Farmers contribution	2000	—	—	—	—	—
Total	18560	12840	12000	12000	12000	12000
Cash outflow						
Operating Expenditure	1650	4800	5400	5400	5400	5400
Investment	13600	4000	—	—	—	—
Total	15250	8800	5400	5400	5400	5400
Annual Cash balance before debt service	3310	4040	6600	6600	6600	6600

BUFFALOES

Although buffaloes represent only one-third of the cattle population of India, they account for more than half the milk produced. The reason for this is often attributed to the fact that the cow is venerated by the Hindus and is used mainly for mothering cattle for draft and not for dairy purposes.

But there are other more significant reasons. The Indian buffalo is as good as a milker as the Sindhi, Sahiwal, Gir and Tharpakar-the best Indian milch cattle. Being a hardier animal which surpasses all other domestic animals in its ability to utilize coarse feeder it is also easier to raise and has a much longer economic life period.

Since the buffalo population in Sri Lanka is quite considerable (0.77 million in comparison to 1.7 million cattle) these reasons demand serious consideration both by Government and the private sector in any animal husbandry development plans that may be envisaged in the future, particularly in the dry zone where poor nutrition and harsh climate are deterrents to the dairy industry.

Of course, there is a prejudice about drinking buffalo milk because it has a harder curd and higher fat content than cow's milk. But there are other ways of taking buffalo milk—as curd, condensed milk, milk powder and toned milk. It is sheer folly, therefore, to hold such prejudice in these enlightened times when buffalo milk is known to be as good as cow's milk or goat's milk.

	Water	*Lac-tose*	*Pro-tein*	*Fat*	*Cal.*	*Phos.*	*Ash*	*Cal/litre*
Buffalo	82.2	4.8	4.3	7.5	—	—	0.8	1030
Cow	87.1	4.8	3.4	3.7	1.6	0.2	0.7	680
Goat	87.0	4.8	3.3	4.2	0.21	0.3	0.8	700

Figures refer to percentages

(*Source:* Department of Medicine, Medical School, Peradeniya)

BREEDING: As a result of nondescript breeding and poor feeding and management over the ages, the local buffalo like the local cow has deteriorated to a stage where 75 gallons of milk per year is about all you can expect. And since it is most likely that straight selection within the breed in combination with a better feeding standard can bring about a significant improvement in the milk yield, the potential investor in a buffalo project must look to recognised Indian milch breeds and their crossbreds as nucleus breeding material.

Jaffarabadi, Mehsana, Murrah, Surti, Nili and Ravi are the best of the milch buffaloes of Indian and Pakistani origin, producing 300 - 375 gallons of milk per lactation. The Murrah and the Surti are the most popular in this country. They produce 350 gallons of milk per year, and their crossbreds 225 - 250 gallons. Milk yields are highest at the fourth or fifth lactation, and in each lactation peak yields are obtained about 6 - 8 weeks after calving.

OESTRUS ("HEAT"): A baffling problem in respect of the reproductive behaviour of the buffalo is the seasonality and weakness of the "heat" period. Oestrus activity has a direct relationship with the nutritional level. When nutrition is good oestrus activity is pronounced and *vice versa*. This is clearly demonstrated at the two Department of Agriculture buffalo stations at Tamankaduwa and Ridiyagama.

In Ridiyagama the "flush" period is during November to March in the season of the *maha* rains. During this period, therefore, oestrus activity is very high, and it is at this time that the cows should be served for best results. On the other hand, at Tamankaduwa during the *maha* season from October to January the normal grazing grounds of the buffalo in the fertile Mahaveli ganga basin are flooded. During this period the buffaloes have to "make do" by grazing on the poor scrub in the highlands. They are only able to return to the fertile grazing grounds in the lowland from April to about June. This, then, is the best time to serve the buffaloes in this region. Calving should take place 10 months later i.e., from February to April in contrast to the calving period in Ridiyagama which is September to November.

Detection of "heat" however, is rather difficult since its intensity is weak unlike in milch cows. Or, in other words, the symptoms are not so noticeable: the flow of vaginal mucous is less marked, bellowing is characterised by a baring of the teeth rather than a loud sound, homosexuality or the desire to mount other cows in the herd is virtually non-existent. In the circumstances, buffalo "heat" is said to be "silent heat" and for this reason it is likely to pass unnoticed and this is a problem so far as artificial insemination is concerend. In fact it is one of the main factors responsible for the adoption of natural breeding by farmers.

Buffaloes calve slightly later than four years (50 months). The average gestation period is 310 days. A calf weighs about 30 kg (66 lb) at birth. It could weigh about 200 kg (440 lb) at one year. Under a high level of nutrition and management a weight of 350 kg (770 lb) is possible at 2 - 2½ years. At this stage of body development the buffalo heifer is ready for breeding as it is two-thirds of its mature weight i.e. 500 kg (1100 lb). Accordingly, the mean age of first calving can be brought down from 50 months to 42 months.

FEEDING: Indian breeds and their crosses can be successfully weaned like dairy calves on the 4th day. The general practice, however, is to allow the calf to suck one teat only till it is 6 - 8 weeks old. Then the milk allowance is gradually reduced and discontinued at 3 - 3½ months.

Milch buffaloes should be able to obtain the requisite amount of nourishment from grass and fodder alone provided it is succulent and 50 per cent leguminous. Where fodder is deficient however, and crop residues like paddy straw have to be substituted, it is necessary to feed a concentrate—the same fed to dairy cattle—at 50% of the milk yield. If the daily milk yield is one gallon (10 lb or 4.5 kg) the buffalo cow should be given 2.25 kg (5 lb) of concentrates per day.

POTENTIAL FOR BEEF: While some attempt has been made to upgrade the milk yield of the local buffalo, there has been no policy in regard to beef production, mainly because there is a ban on the slaughter of this animal at present. Anyway, an experiment carried out at the Polonnaruwa Livestock Centre by Matsukawa *et al* 1974 showed that on a weight basis the buffalo gave much higher yields than cattle.

The animals were allowed to graze on *Brachiaria brizantha* pasture mixed with weeds at a stocking rate of 1.5 per acre. The results of the 48 week experiment are shown below. The mean age of the animals at the start of the experiment was 8 months and at the end of the experiment 19 months.

	Mean Weight at 8 months	*Mean Weight at 19 months*	*Mean Carcass Weight*
Murrah	104 kg	204 kg	101 kg
Sindhi	80 kg	160 kg	86 kg
Sinhala	69 kg	155 kg	83 kg
Friesian	122 kg	148 kg	71 kg
1 kg=2.2 lb			

(*Source:* Department of Agriculture)

With selection for weight gain and carcass weight, and with further improvement in nutrition and management superior carcass weights could be expected.

Contrary to popular opinion which associates buffalo meat with a less palatable, coarse, tough quality, a comparative study of tenderness conducted at Polonnaruwa indicated no difference between buffalo and cattle meat. This experiment was carried out with the Shear Metre—an instrument used to measure tenderness and an 18-member consumer panel. In fact the majority of the members of the panel could not differentiate between the two types of meat by colour, taste or flavour, and most of them opted for buffalo meat from the point of view of palatability. The buffalo, thus, has a good potential for beef production in this country.

MUTTON GOATS

Today there is marked shortage of meat largely because the existing stocks of meat cattle are unable to keep pace with the rapid rate of increase in our population.

Any solution to the beef problem must necessarily be a long term one because the improvement of local meat cattle is limited by lack of good breeding stock and pasture, and the relatively long time that must be taken to effect any improvement when compared to other livestock.

One can well understand, therefore, why there has been a reluctance on the part of private enterprise to move into this field of animal husbandry development. But one wonders why there has been a similar lethargy towards the development of other forms of meat animals, particularly the raising of mutton goats.

Of all types of livestock development goat rearing holds the greatest possibility of developing into a lucrative business in this country because it involves the least expenditure, needs very little expertise and unlike beef and pork there is very little prejudice against the consumption of mutton.

SUITABLE AREAS: Most parts of the dry zone are suitable for rearing mutton goats, particularly the semi-arid regions of Puttalam, Mannar, Trincomalee, Batticaloa and Hambantota which are generally of no use for any other form of agriculture. The scrub jungle found in these areas provides the best fodder for goats.

The convenient size of herd which one man may handle is around 100 adult goats and followers. It is difficult to assess the exact extent of land required per goat, but considering the normal rate of jungle regrowth about one acre will be required per goat. If fodder trees such as horse tamarind, glyricidia and tulip are planted as fence lines and shade trees, it should be possible to have up to 5 goats per acre.

BREEDING: There is no shortage of stock. It is a fact that local animals are of poor stature, dressing out at a carcass weight of 9 - 11 kg (20 - 25 lb), but they could be improved by crossing with a large sturdy Indian breed which is available from the Department of Agriculture. Considering that goats are promiscuous breeders—the females kidding twice a year—it should not take too long to improve the herd. One stud is enough for 30 females. This animal should be at least one year old before it starts mating. The oestrus period or heat cycle is 17 - 21 days.

FEEDING: Mutton goats are generally raised entirely on pasture and tree fodder, but in the case of males that are used for breeding a small quantity of concentrate feed must also be given, made up of equal parts of rice bran and coconut poonac. About 1 - 2 lb per animal every day. About one ounce of mineral mixture should also be added to the mash every day.

HOUSING: Unlike in dairy farming and poultry-keeping elaborate houses are not necessary. The simplest shed is sufficient, provided it is dry and protected from draughts. Goats are particularly susceptible to pneumonia as a result of damp floors, bad ventilation and overcrowding. The minimum height of the building should be 10 feet at the ridge and 6 feet at the eaves. The floor space should be 6 - 8 sq. ft. per animal. The floor must be of rammed earth sloping from the middle to the sides to dispose of the droppings.

REAR GOATS SEPARATE FROM CATTLE: Although goat-rearing does not call for much skill, there are certain problems that must be taken into account. The first of these is the beginner's mistake of running goats and cattle together largely because there is a scarcity of grazing ground. This practice exposes the goats to a serious disease known as "goat paralysis".

Goat paralysis is caused by certain young worms that lodge in the brain and spinal cord. Consequently, there is a loss of motor power in the hind legs or in all four legs. The onset of the disease is sometimes dramatically sudden—a goat may be found on its side struggling to rise until it dies in a day or two, or more often the first sign is the unsteadiness of the limbs.

The adult stage of this worm is found in the abdominal cavity of cattle and is easily passed on to the goats with disastrous results although no harm is caused to the cattle. There is no treatment for paralysis. For this reason goat-breeding is best undertaken in areas which are unsuitable for cattle. Such areas, as stated earlier, exist in the Puttalam, Mannar, Trincomalee, Batticaloa and Hambantota Districts.

WET-SEASON CARE: Goats thrive best under arid or semi-arid conditions, so that the wet season is always a dangerous time for them from the point of view of two troublesome diseases viz., gastroenteritis caused by worms and foot-rot which is caused by bacteria.

All goats have worms. They live in the intestines and when mature lay eggs which are passed with the faeces. If the ground is dry and the weather is sunny the eggs are dried out and killed—very few survive to reinfest the goats. But in the rainy season when the ground is wet and there is plenty of grass to shade the eggs, they survive in large numbers and reinfest the goats four days from the time that they are deposited. This is why goats that have bean quite healthy during the dry season, specially the kids, suddenly become emaciated in the wet season despite the fact that plenty of pasture is available for feeding.

Control measures, therefore, should be effected as a routine drill during the wet season instead of waiting for the animals to fall sick before doing anything about it. (See section on "Sheep" for details of control programme).

Provided plenty of grazing land is available you should also move the goats to a new area every 3 or 4 days before the eggs have a chance to hatch out and reinfest them. If you ensure that goats feed on new ground every four days and do not come back to the ground for at least one month, you should have strong healthy animals all the year round.

In as much as healthy animals suddenly become sick and emaciated in the wet season because of worms, they may also go lame owing to bacterial infection of the hooves. During the dry season the hooves are hard and dry and bacteria cannot get in easily. In the wet season, however, the hoof is soft and easily damaged and this facilitates the entry of bacteria. Pus is formed and the disease progresses by creeping in under the hoof causing large sores which make it very painful for goats to move around and forage. Consequently they grow weak and emaciated.

"Foot-rot" can spread rapidly through a herd especially in muddy areas. Be sure, therefore, to use a disease repellent like a 10 per cent solution of bluestone (copper sulphate) in the form of a foot bath at the entrance to the house. Animals that show signs of limping should be segregated and their feet washed or bathed regularly in a solution of bluestone or 0.5% formalin.

TICKS AND MANGE: Ticks and mange are problems of the dry season. Regular spraying with "Asuntol" however, should keep the ticks under control. Mange is not easy to control once it gets a hold on the goat: so examine your herd regularly for the first signs which appear as hard scabs at the tips of the ears and under the neck. Diseased animals should be segregated and treated with "Neguvon."

MILCH GOATS

Goat-rearing for milch purposes has many advantages when conducted on a small scale. When compared with a dairy cow a goat needs only a small capital investment—say Rs. 175/- to Rs. 200/- compared to Rs. 2,000/- in the case of an improved cow. Its nutritional requirements too are much less—you can feed seven goats on the food required for one cow. Goats also multiply much faster than cattle and they have longer lives. Taking all these advantages into consideration one wonders why milch goat-raising is still not very popular.

There could be several reasons — a lack of tradition in this aspect of animal husbandry or a lack of promotional activity by the authorities — but by and large the main reason is perhaps the popular prejudice against the consumption of goat's milk. Just as much as duck eggs are reputed to have a fishy flavour, so goat's milk is supposed to have a peculiar flavour. But it is important to make a distinction. Unlike duck eggs where the flavour is there always, in the case of goat's milk it is there only when the buck or male goat is in 'musk'. At certain times of the year 'musk' glands develop at the base of the horns. When the male goat butts the female this 'musky' objectionable smell rubs off on the body of the female and taints the milk. It is easy enough however to prevent this happening by keeping the buck separate from the doe until breeding time.

GOAT'S MILK: Goat's milk is just as good as cow's milk. When compared with the milk of other animals it approaches nearest to human milk in its fat percentage. Its fat globules, however, are very much smaller than in cow's milk and they form a soft light curd which is easily digestible. This is what makes goat's milk such a popular infant food in many Asian countries, and even in European countries like Greece and Switzerland. In Switzerland the goat is referred to as the baby's "foster mother".

Goat's milk also has certain medicinal properties. Unlike cow's milk which is acidic in reaction, goat's milk is alkaline and its use is therefore recommended for people suffering from hyperacidity. It also has an anti-allergic property. As such it is of medicinal value for eczema, asthma and hay-fever.

Goat's milk also makes a fine firm curd like buffalo milk.

JAMUNAPARIS AND SAANENS: Of course, to obtain economic yields it is necessary to keep an improved breed, since our indigenous animals are very poor milkers giving half to one bottle a day. The Jamunapari or Saanen may be recommended, either in the pure form or crossbred with the local animal. The crossbreds are capable of giving three bottles of milk a day, and with proper care and attention the lactation period can be extended to 9 - 10 months. Two goats bred to freshen at different times will produce a regular supply of milk throughont the year.

FEEDING: Assuming that you are going to stall-feed your goat, the main thing to bear in mind is that this animal thrives best on a variety of vegetation. The home garden should be able to provide a good part of the green feed. Vegetable tops, radish and sweet potato, young jak fruit and bread fruit are always available. There is also an abundance of grass and other vegetation. In addition fresh loppings should be given regularly from trees like horse tamarind, jak, gliricidia, dadap and margosa.

Remember that a goat is finicky about what it eats. It will not eat fodder that has been trampled underfoot or that is too wet. So be sure to dry the moisture on the green feed first and to hang it up in the stall in such a manner as to permit the goat to browse comfortably. Greenfeed, however, is not enough. A little coconut poonac or a mixture of poonac and rice bran in the ratio of 50% to 50% or 25% to 75% is also necessary. Half to three-quarter pound should be given a day plus at least one ounce of mineral mixture. Plenty of clean water for drinking should be provided at all times.

BREEDING: Time of breeding is imporatnt. All goats mature early, but they must not be allowed to mate until the female is at least 15 months old and the male about one year. If they are bred earlier then the resulting offspring tend to be weak and become poor milkers. For this reason the male and female animals should be separated from the time they are 2 - 3 months old and brought together again only when they have reached the correct age for breeding. In 5 months the goat should have a kid—usually one kid and very rarely two.

Not only the time of breeding but also the frequency of breeding is important. A goat usually comes into season 6 - 8 weeks after the birth of the kid, but this does not mean that she should be mated immediately. Because a goat's gestation period is only 5 months, local goat breeders try to get two kiddings in one year. But this practice cannot be recommended under the generally poor feeding conditions prevailing in the country. If you try to cram in two kiddings what generally happens is that the lactation period is shortened—the goat going dry in the middle of pregnancy. The kids produced are also likely to be poor in health and vigour. It is much better therefore to have only one kidding in a year. This way you can ensure a long lactation period and healthy kids. This means giving the goat a rest period of 2 - 3 months after kidding before she is mated again.

THE KID: The kid is on its feet a few minutes after birth. In European countries it is weaned in a couple of days and fed on milk from a bottle. But in the east the practice has been to keep the kid with the mother for 3 - 4 months before weaning. Male kids not required for breeding may be sold after weaning. They should preferably be castrated when 2½ - 3 months old because this enables them to put on weight quickly. Castrated males also do not develop an objectionable odour.

HINTS ON BUYING A MILCH GOAT: Wherever possible look for a goat that has kidded because she will give you the quickest return on the purchase price. A goat in kid is also a good buy as she has plenty of time to learn your ways and settle down before she begins to milk.

A good goat should look lively and alert. Her feet should be sound with hooves not overgrown. The skin when grasped in the hand should be loose and supple. Avoid buying a goat which looks listless and has a "staring" coat i.e. hair standing away from the body. Or a goat whose skin is tightly stretched over its ribs and hard to grasp. Such an animal, if not congenitally unthrifty, is in poor condition.

The udder of a milking animal should be spherical and attached to the body over a large area. An udder that hangs from a narrow neck and swings from side to side is liable to be damaged. When the goat is milked-out feel her udder. The skin should be fine and silky, not coarse and leathery. You must expect a certain amount of hard flesh within the udder but beware of pronounced lumps like small balls for they probably indicate a history of mastitis.

A goat that is milking well should not carry much surplus flesh. It should be between 100 and 120 lb and have a capacious rib frame, indicating a good capacity for forage consumption. A goat not yet kidded, however, should be well paddled or she will go to pieces when she begins to milk.

SHEEP

Sheep-rearing is not a new thing in this country. Farmers up north have always kept flocks, but they have done this mainly with the purpose of collecting valuable organic manure for their intensively cultivated market gardens. But sheep-farming on a scientific basis with a view to producing mutton for the local market came into existence only in the mid sixties, when certain enterprising coconut planters tried their hands at it in the Intermediate Zone where the rainfall is 60 - 75 inches a year.

There are about 120,000 acres of coconut in the Intermediate Zone and it is estimated that about 500,000 sheep can be maintained in this area to produce around 14 - 15 million pounds of mutton a year. And this, according to the Consumer Finance Survey conducted in 1968, is our minimum annual requirement for this form of meat. That we have a market for mutton then there is no question at all. What we have to ascertain now is whether sheep can be raised successfully and profitably on grass under coconut. This is where experience gained by the members of the Sheep Breeders' Association and Specialist Officers in the Department of Agriculture is going to stand us in good stead.

IMPROVING BODY WEIGHT AND CARCASS VALUE: Taking everything into account it would appear that sheep-rearing can be developed into a profitable enterprise if certain problems are overcome. The first problem is the poor carcass value of the local animal and the dearth of local stock. The local animal which is commonly called the Jaffna Sheep weighs only 18 - 22.5 kg (40 - 50 lbs) as an adult. This weight is obviously no good for mutton production on a commercial basis. What is more, the Jaffna sheep is not present in large numbers like local cattle. There are not more than 250,000 animals in the country.

Two steps have been taken to overcome these deficiencies. An attempt has been made by the Department of Agriculture to increase the existing foundation stock by introducing sheep from India. These sheep are now being multiplied at Kottukachchiya and Weerawila. An attempt has also been made by the department and private producers to increase body weight by crossing the local sheep with more productive animals from temperate countries. Several exotic breeds have been tried—the Southdown, Wiltshire, Dorset and Finn among others, but of all these it would appear that the Dorset has given the best results, producing a crossbred animal that weighs 70 - 80 lb when one year old. The lambing percentage of these crossbred animals is 70-80, which is a definite improvement on the lambing percentage of the local sheep which is around 60.

All in all then the initial problem of making the local animal a more profitable meat producer has been solved by adopting an improved breeding policy. What you got to do is to purchase your foundation stock from the indigenous animals that are found in the Jaffna, Batticaloa, Mannar and Puttalam Districts. 25 - 30 ewes should do for a start. You will doubtless be horrified at the appearance of these local sheep, but do not let this worry you—these ewes will produce surprisingly good offspring if you put them to a good ram.

The next question, therefore, is where to get a good ram? Your chances here are fairly limited because there is great dearth of good breeding stock. However, the Department of Agriculture and certain private producers have surplus rams to sell from time to time and your requirements could be obtained from these animals.

You will need one ram for every 30 ewes. The ram must be over 2 years and not older than 6 years, while the ewes must be at least 1½ years old when bred if a strong vigorous flock is to be built up over the years. The oestrus or heat cycle is 17 - 21 days.

MATCHING FLUSH PERIODS WITH CRITICAL NUTRITIONAL PERIODS: Now, where the first problem was one of breeding, the second problem is associated with nutrition, or the provision of enough grass to the sheep throughout the year. In the Intermediate Zone which has been recommended for sheep farming, there is a bimodal rainfall pattern, or two distinct periods of rain—the heaviest rainfall being experienced from October to January and lighter showers from April to June. It is during these two peak periods of rainfall that the production of grass will be at its highest, so in any programme of management the times of high nutritional requirements of sheep must be matched with these two peak periods of rainfall and grazing if the maximum benefits are to be derived from the pasture.

There are three critical stages is the life of a sheep during which a high plane of nutrition is required. The first is when the ewe is pregnant. The second is when the ewe has given birth to a lamb and is feeding it with milk. And the third is during the growing period of the lamb. These three periods must be made to coincide with the peak periods of rainfall from October to January and April to June.

To achieve this you must adjust your breeding programme so that the rams are introduced to the ewes in July and allowed to run with them till mid-September when they are removed and separated. The ewes enter their pregnancy period and start lambing about mid-December. During this period which is usually served by the *maha* rains there should be ample grazing for the pregnant and lactating ewes. This is followed by the second rainy season—the *yala* rains which usually occur in April and go on till June. It is during this period that the growing young lambs get their "fill" of grass. This permits quick growth and fattening before they are sent to market. The ewes who are now in an emaciated state after a long period of nursing are also able to take advantage of this abundant grass flush to get into condition again before the next breeding cycle commences in July. So you see, a management programme planned on these lines allows for the maximum utilization of pasture in the nutrition of sheep.

CONTROLLING ROUND WORM INFESTATION: Now, where the first problem was a breeding problem, and the second a nutritional problem, the third is a health problem. Round worms are a serious health hazard with sheep. They live and feed in the entrails of these animals causing "gastroenteritis" which is a serious wasting disease. The eggs which are passed out in the faeces and deposited on blades of grass are eaten again by the sheep.

The highest rates of infestation seem to occur about 6 weeks and 12 weeks after lambing. Effective control, therefore, can be achieved if the ewes are wormed one week after lambing and again one month later. This eliminates the two peak periods of infestation. Another worming may be done after the lambs have been weaned and just before the ewes are brought into condition for a second round of breeding. Because at this stage the animals are very weak and can easily succumb to infestation unless suitable control action is taken.

But do not forget that it is the lambs that are most susceptible. The critical period is between 2 and 4 months after birth. The highest percentage of deaths due to worms has been recorded at this stage. This is the time the lambs are just let out to grass with their mothers and are easily affected. It is very important, therefore, to see that during this period the lambs are not exposed to wet conditions which increase the hazard of worm infestation. This has been taken into account in the management cycle suggested above. When lambing is planned to occur in mid-December, this means that the lambs will be 2 - 4 months of age during February and March which are usually dry months. Anyway, as a precaution against infestation in the following rainy season, the lambs must be wormed at intervals of 5 weeks from the time they are 2 - 2½ months old till they are disposed of at 5 - 6 months.

So there you are! Sheep farming can be a practical preposition if it is carried out on grass under coconut areas where the rainfall averages 60 - 75 inches a year. Local grasses are alright to start with but better results are obtained with introduced grasses like *Brachiaria miliformis* and *Brachiaria brizantha*—the same grasses

BREEDING AND MANAGEMENT CYCLE

<table>
<tr><th>CALENDAR</th><th>RAIN</th><th>BREEDING</th><th>NUTRITION</th><th>WORMING</th></tr>
<tr><td>JULY</td><td></td><td>Introduce rams</td><td></td><td></td></tr>
<tr><td>AUG.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>SEPT.</td><td></td><td>Remove rams</td><td></td><td></td></tr>
<tr><td>OCT.</td><td></td><td></td><td rowspan="4">Good flush during pregnancy and lactation</td><td rowspan="2">First worming of ewes</td></tr>
<tr><td>NOV.</td><td></td><td></td></tr>
<tr><td>DEC.</td><td></td><td>Lambing starts</td><td></td></tr>
<tr><td>JAN.</td><td></td><td></td><td rowspan="2">Second worming of ewes</td></tr>
<tr><td>FEB.</td><td></td><td></td><td></td></tr>
<tr><td>MAR.</td><td></td><td></td><td></td><td>Worming lambs</td></tr>
<tr><td>APR.</td><td></td><td></td><td rowspan="3">Good flush for lambs and emaciated ewes</td><td></td></tr>
<tr><td>MAY</td><td></td><td rowspan="2">Lambs sold</td><td></td></tr>
<tr><td>JUNE</td><td></td><td>Third worming of ewes</td></tr>
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that are recommended for milch cattle. 150 sheep may be maintained on an improved grass pasture on 50 acres of coconut.

RECOMMENDED ANTHELMENTICS: Nilverm and Thiabendazole are most effective against troublesome roundworms giving a hundred per cent kill. Phenothiazene is cheaper than the other two anthelmentics but it is not as effective as it kills only the adult worms and permits the young ones to escape. This means double dosing each time in contrast to the other two anthelmentics which need to be used only once.

Mansanil is the recommended anthelmentic against tapeworms. After it is given the sheep are kept indoors for 2 days so that the infested droppings can be collected and disposed of safely so as not to cause reinfestation. The sheep may be allowed out to pasture again on the third day. Young animals should be dosed every 45 days from the age of 2 - 2½ months to one year. Adults are not so susceptible to tapeworms.

The anthelmentics stated above are recommended for goats as well.

BOT FLY: This fly (*Oestrus ovis*) which is a little bigger than the common house fly is viviparous by nature and deposits its larvae directly into the nostrils of the sheep. The larvae feed on the nasal discharges and make their way right into the sinuses. When this happens the sheep start sneezing and digging their noses into the the backs of other sheep to gain some relief. The nasal discharge thickens and the animal finally goes off its feed. Emaciation is followed by death. The adult larvae drop off into the soil where they pupate and become flies again in 3 weeks, starting the whole cycle of reinfestation again. Larvae infestation is heaviest in the rainy periods from May to July and November to January. Preventive action may be taken via the use of oral "Neguvon" once a month.

HOUSING: Sheep may be housed in the same manner as goats with the same spacing of 6 - 8 sq. ft. per animal. Raised houses and slatted floors to allow the droppings to fall through are preferable. The slats should be far enough apart to allow the droppings to fall through while ensuring that the feet of the sheep, particularly the lambs, cannot go through. Make provision for the feed trough to be on the outside of the shed so that you can conveniently stall-fed your stock in very wet weather. Keep containers for mineral mixture and water outside the shed but in such a manner that the sheep can reach through but cannot soil the contents with dung and urine. Place some absorbent material like saw dust or paddy husk under the floor of the house and you will have a fine source of organic manure. Construct a drain around the periphery of the shed to prevent water getting underneath the shed and making a mess of the droppings.

PIGS

The pig is the most economical meat-producing animal. It surpasses all other animals in the efficiency and rapidity of converting feed into edible meat—requiring about 4 lb of feed per day to gain one pound in liveweight. The pig also has a very high dressed carcass weight of about 70 per cent the liveweight, which is nearly $1\frac{1}{2}$ - 2 times the dressed weight of any other animal.

BREEDS AND BREEDING: Large White, Large Black, Landrace and their crosses are the popular breeds. For bacon (180 - 200 lb in 8 months) Large White, Landrace, Large White × Landrace and Large White × Large Black crosses are suitable. For pork (150 lb in 6 months) Large White, Large Black or Large White × Large Black crosses are best.

A young sow is usually mature in 3 - 5 months. But she should not be mated so early because the results could be disappointing. For one thing early-mated gilts do not produce the full complement of 10 piglings. The piglings are also undersized. Breeding therefore, must be delayed until the gilt is at least 8 months old to allow for full growth and development. The gilt must also have 10 - 12 well developed and regularly spaced teats to enable each sucking pig to have its own teat.

Stud boars may be used for service when 9 months old if they are well grown and vigorous. They are at their best however when 2 - 4 years old and they remain productive for long periods if kept apart from the sows when not used for service.

Except when pregnant or nursing the females come into heat at intervals of 3 weeks throughout the year, so that it is possible to arrange for litters any time that is convenient. Swelling and redenning of the vulva denotes the first sign of heat, which lasts for two or three days. Since ovulation occurs 18 - 36 hours after onset of heat in the Large White and Landrace and 35 - 54 hours in the Large Black, serving should be arranged on the second and third days of the heat period respectively. A single mature bore can serve 25 - 30 gilts. The gestation period is 114 - 116 days. The economic life period of a breeding sow is usually 5 years. But if there is an adequate supply of gilts, unthrifty sows should be replaced after a period of two years.

After she has produced her first litter and the piglings are weaned at 8 weeks, the sow must be mated again as soon as 'heat' is observed. This should happen 3 - 4 days after weaning. Prompt remating is essential to ensure that the sow has two litters a year. For it is only when the sow has two litters a year that she can produce a maximum of about 3/4 ton of pork on the hoof.

For example, say the sow produces her first litter in January and the piglings are weaned in March. Re-mated immediately she will produce her second litter in June, so that you can have a second batch of pigs ready for the market before the end of the year.

A sow generally farrows-down 114 - 116 days after successful service, and since any sudden alteration in her quarters immediately before farrowing is apt to upset her, it is always advisable to have the sow transferred to a special farrowing pen at least one week before the expected date of farrowing. Since the piglings remain in the pen with the mother until weaning it is a wise precaution to equip the pen with farrowing rails. These rails which are made of iron piping or stout wood strong enough to resist the weight of the sow should be fixed 10 inches high and 8 inches away from the two side walls and rear of the pen. The space between the rails affords the piglings an escape from the blundering movements of the mother.

See that the sow is not nervous or irritable when farrowing as she is likely to kill a large number of her litter by blundering about. An irritable or restless sow can be quietened by rubbing her belly. The attendant's main function during this critical time is to calm a restive sow and induce her to lie down without crushing her young. Beyond this all he is expected to do is to remove the after-birth when it is discharged to prevent the sow from eating it and becoming sick.

FEEDING: The weight of pig at weaning bears a distinct relationship to subsequent live-weight increase. Investigations have revealed that the live-weight at 4 months is usually 2½ times the weaning weight at 2 months. The importance of this finding is seen if we compare a 25 lb weaner with a 40 lb weaner. A 25 lb weaner will be about 67 lb at 4 months of age while a 4 lb weaner will be 100 lb. Thus, a 40 lb weaner will reach market weight much earlier than a 25 lb weaner. The economic consequences are obvious. The objective of every producer therefore should be to produce an average weaner weight of 40 lb i.e. the total weight of 8 piglings reared to 8 weeks divided by 8 should be 40 lb.

The only way to achieve this goal is to feed the developing piglings a high protein concentrate feed during this period in addition to the milk they get from the mother. Concentrate feeding should start about the 3rd week because at this time the mother's milk supply begins to be significantly reduced. Start with about quarter-pound a day for each pigling and increase to one-pound at weaning. The concentrate feed, of course, must be fed wet. At first the piglings will consume only a mouthful at a time and continue to do so several times a day till about the fourth or fifth day when they begin to take an appreciable quantity. To prevent the mother sow from getting at the feed provided for her young, see that it is served in a separated boarded-off portion of the pen known as the "creep" because it permits only the young pigs to creep in and out.

Here are two alternative concentrate feeds containing 20 per cent protein:

Ingredient	Feed (I) (lb)	Feed (II) (lb)
Coconut Poonac	77	67
Rice Bran or Polish (Grade I)	10	10
Fish Meal	10	—
Milk Powder	—	20
Mineral Mixture	03	03
Vitamin Supplement	*	*
	100	100

* Vitastress or Zoodry, for instance, which should be given at manufacturer's instructions.

MINERAL MIXTURE: Use proprietary products like Pecutrin or Supermindef. Instead of rice bran you may use flour sweepings and broken sorghum.

Since sow's milk is deficient in iron, this mineral too has to be supplied to prevent the piglings developing anaemia. This has to be done early—about one week after birth. Iron is supplied in the form of Ferrous Sulphate. It is either injected by a Veterinary Surgeon, or mixed with soil, which is provided in the pig pen after the first week and up to weaning. The little pigs will "root" about in the treated soil and get all their requirements of iron this way. One pound of Ferrous Sulphate has to be mixed with 100 lb of soil.

After weaning the growing pigs have to be given a ration containing less protein. This same ration may be fed to the sows and boars as well. Here are two concentrate feeds containing 17% protein:

Ingredient	Feed (I) (lb)	Feed (II) (lb)
Coconut Poonac	82	77
Rice Bran and Polish (Grade I)	10	10
Fish Meal	05	—
Milk Powder	—	10
Mineral Mixture	03	03
Vitastress or Zoodry	(Manufacturer's Instructions)	
	100	100

The concentrate feed should be fed as follows:

Growing Pigs	*Daily Ration (lb)*
3rd and 4th months	02½
5th month	03
6th month	04
7th month	05
8th month	05
Pregnant Sows	
1st month	05
2nd month	07
3rd month	09
4th month*	10

* During the 4th month in the last week before farrowing reduce the feed from 10 lb to 5 lb to facilitate the birth process. Over-fed pigs find it difficult to farrow.

Nursing Sows	
(with 8 - 10 piglings)	10
Boar	06

The daily ration shown above is divided into two equal quantities and fed twice a day mixed with water.

It requires careful observation and a certain amount of experience to acquire skill in the adjustment of the daily ration during the first month after weaning. If the quantity of food is built up too quickly indigestion results. On the other hand, if it is not built up quickly enough the ill-effects of the post weaning "check" may be intensified. When the pigs clear up the food given them at each meal in half an hour it is an indication that they are receiving enough food. But if they clear up the food well in advance it means that they are not getting enough for their needs. In such a case it will be necessary to increase the allowance by half-pound of concentrate per batch of pigs or litter till the desired level is found.

SWILL: If the discarded remnants of human food (swill) can be obtained such feed will materially reduce the quantity of concentrates to be purchased. Weaned pigs can be fattened entirely on swill fed *ad lib*, but to get the best results it is necessary to give them about 2 - 3 lb of the concentrate mixture also daily up to the time they are 5 months old. Swill should be collected at least twice a week to prevent spoilage. It should be boiled or steamed for at least one hour before use to counteract disease germs.

WATER: Plenty of clean drinking water should be made available at all times in separate drinking vessels. But these vessels must be so designed as to prevent the pigs from wallowing in them. Lorry or bus tyres cut in half make excellent drinking vessels.

HOUSING: In the intensive system of pig-keeping described above, pigs are reared indoors on concrete floors all their life. The concrete floors have to be washed down daily and in this way the danger of worm infestation is obviated. A pen of 100 sq. ft. is adequate to house a single sow and its litter, or 3 breeding sows, or 12 pigs being fattened for pork, or 8 pigs being raised for bacon.

Sometimes only half the pen is covered with a lean-to roof: this protects the pigs from sun and rain and yet provides sufficient sunlight and ventilation. To cut down labour costs and cleaning difficulties it is a good idea to keep the open ground in the front half of the pen constantly wet with moist gunny bags or soaked straw. This will induce the pigs to dirty outside and keep the bed section of the pen clean.

Another way of cutting down on building costs is to raise only the fattening pigs and sows with litters in the building. Pregnant sows, gilts and boars may be reared outside on a grass paddock. Up to 25 sows and gilts can be reared in a paddock of one acre. Adequate shade and "wallows" should be provided to keep the pigs comfortable. And the paddocks should be fenced to prevent the animals from straying. A strict rotation of animals within the paddock and a routine programme of worming are necessary to keep the animals healthy.

HEALTH CARE: It is a mistake for a pig-keeper to attempt to be a Veterinarian, but he should be able to treat minor ailments. Fortunately there are no serious diseases. But this does not mean that you can afford to be careless in management. It is always a wise policy to segregate a newly purchased pig before allowing it to mix with the rest of the herd. During the period of confinement it should be closely observed for signs of illness. An abnormal thirst frequently accompanies a ferverish condition. Panting, or the heaving of the sides, generally indicates that the animal is suffering from an acute inflammation. If you suspect a disease summon a Veterinarian.

Minor ailments are comparatively common among pigs, but they generally yield to simple treatment if it is applied in time. An efficient pig-keeper, therefore, should be constantly on the alert for symptoms of ill-health and be prepared to take reasonable preventive measures.

A healthy pig has a good "bloom" to its coat which is lost if the animal falls off in condition, but the pig's appetite is perhaps the most useful indicator of its state of health. Normally pigs are voracious feeders and if any one of them loses its appetite it is an almost infallible sign of ill-health.

Apart from loss of appetite a sick pig is likely to be listless and frequently has an inclination to lie down and sleep away from the rest of the herd.

DIARRHOEA OR CONSTIPATION: These are sure signs of minor digestive troubles caused either by the use of unsuitable food or overfeeding. If the trouble is due to unsuitable food it will quickly disappear with a suitable change of diet. In the case of overfeeding it will be necessary to omit a feed, or to feed half rations consecutively for two meals before gradually getting back to the normal diet.

Constipation commonly occurs when pigs do not receive sufficient green food. It can be rectified by the simple procedure of turning the animals out to graze for two or three hours a day for several days in succession. If this is not possible it will be necessary to include more green food in the daily stall-fed diet. Be sure to see that the greens are succulent since fibrous material can increase constipation.

In case of severe constipation there is nothing better than dosing with Epsom Salts, which may be used at the rate of quarter-ounce per pig per day for pigs under 3 months of age and half to one ounce each for older pigs.

In the case of persistent diarrhoea there are a number of sulpha drugs which may be used with equal efficiency.

Pigs are also troubled by parasites. *Sarcoptic mange*, for instance, is caused by a parasite that burrows under the skin of the pig causing the affected animal to continuously rub its body against the sides of the sty till the skin gets red and scurfy.

Treating the affected parts of the skin with a mixture of 8 parts of coconut oil and 1 part of sulphur will relieve the irritation and check further development of the parasite. Diseased animals may also be treated with "Neguvon." But since mange is contagious and likely to spread rapidly it is necessary to scrape thoroughly and paint with hot tar the walls, posts and other parts of the sty against which the pig has rubbed its body.

SUNBURN: Sunburn is not uncommon in white-skinned pigs kept in sties which are inadequately shaded. This condition should not be confused with mange. In this case although the skin reddens and cracks the animal will not scratch its body. Gentle application with a bland oil such as coconut or gingelly will give the afflicted animal considerable relief.

WORMS: These parasites are most troublesome when the piglings are young. If indoor sties are thoroughly cleaned out and the young pigs are kept off land that has been soiled by other pigs there is a reasonable chance of avoiding serious infestation. But should a heavy infestation occur in spite of these precautions the pigs should be given a vermifuge.

Oil of chenopodium in castor oil and phenothiazine were commonly used before, but there are better vermifuges in the market today. But no matter what the vermifuge, it should not be given too close to weaning since it can cause a shock, which coming on top of the shock of weaning will result in a serious setback to growth. If the pigs are weaned at 8 weeks they should not be wormed till they are at least 11 to 12 weeks old.

SORE TEATS: This is a common ailment of nursing sows. It is caused by the teeth of the piglings growing excessively. If the teeth of offending piglings are broken off and the sore teats dressed with zinc ointment there should be no further trouble.

An *abscess* should be allowed to soften before it is lanced with a sharp knife and the pus ejected by gentle pressure. The cavity should be washed with a weak solution of Lysol (one teaspoonful in a pint of water). Shallow cuts may be washed and treated with tincture of iodine.

CASTRATION: Males that are not required for breeding should be castrated before weaning. If this is not done a noticeable check to the animal's subsequent growth rate results. There is no definite evidence regarding the comparative merits of various ages for castration, but the generally accepted view is that the earlier the operation is performed the less the shock to the pig. The best time to castrate is between four and six weeks of age. The pen should be thoroughly cleaned and well littered with straw prior to castration, and after the operation is performed the animals should not be unnecessarily disturbed for 24 hours.

BUDGET: The following budget may be used as guide. It is for a 10-sow project on the intensive indoor system. It is assumed that the 10 sows will produce eight weaned piglings at each litter and that they will have two litters a year. It is assumed that 100 of the 160 litter will be marketed at the end of each year along with 3 sows who will be replaced by 3 gilts. This means that the original stock will be completely replaced every 3 years.

The cost of concentrate feed is variable, depending mainly on the cost of coconut poonac. In this instance the cost of a ton of concentrate is taken as Rs. 750/-.

Capital Costs:

(1) Buildings — 100 sq. ft. each for 10 sows and one boar is 1,100 sq. ft. At Rs. 10/- per sq. ft. total cost is Rs. 11,000/-.

(2) Stock— 10 sows and one boar at Rs. 750/- each is Rs. 8,250/-.

Annual Expenditure:

(1)	Buildings @ 10% depreciation:		Rs. 1,100/-
(2)	Stock at one-third replaceable annually		Rs. 2,750/-
(3)	Labour (1 man @ Rs. 300/- per month)		Rs. 3,600/-
(4)	Feed: 10 sows at 1 ton	= 10 tons	
	3 gilts	= 01 ton	
	1 boar at 1 ton	= 01 ton	
	Others	= 38 tons	
	Total	= 50 tons	
	50 tons @ Rs. 750/-		Rs. 37,500/-
	Total Expenditure		Rs.44,950/-

Annual Income:

(1)	100 pigs (100×200 lb) @ Rs. 3/- per lb	Rs. 54,000/-
(2)	Three sows (1000 lb) @ Rs. 3/- per lb	Rs. 3,000/-
(3)	800 used feed gunny bags @ Rs. 2/-	Rs. 1,600/-
	Total Income	Rs. 58,600/-
	Total Profit	Rs. 13,650/-

WEIGHING WITHOUT SCALES: The only accurate way of obtaining a pig's weight is by using a weighing machine. But you can obtain an approximate idea by measuring its girth immediately behind the shoulders, and then reading off the live-weight (within three percent accuracy) from the following scales:

Girth (inches)	*Live-weight (lb)*
25	89
26	95
27	101
28	107
29	113
30	119
31	125

This will help you to sell your young pigs to the pork trade.

In developed countries where nutritious feeds are freely available pigs can be made to reach a bacon weight cf 200 lb in 6 months as per table below. The conversion rate is about 3.5 lb per 1 lb live-weight:

Age in weeks	*Live-weight in lb*
08	40
10	55
12	70
14	90
16	110
18	130
20	155
22	180
24	205

But in Sri Lanka at the present time where nutritious concentrate feeds are expensive and in short supply it is rarely that these weights can be achieved. On the contrary, 200 lb in 8 months should be considered a good achievement under local conditions.

RABBITS

Recognised meat breeders are the New Zealand White, New Zealand Red, American Blue, Beveren, Champagne D'Argent and Chinchilla American. The Flemish Giant, which is also used for meat, is really a show breed. The most popular are the New Zealand White and the New Zealand Red. The name has nothing to do with the breed's origin. This breed is entirely an American creation.

Ideal mature weight of these breeds (except the Flemish Giant which is heavier) are 9 - 10 lb. But for breeding purposes select only medium - sized animals about 6 - 8 lb in weight. The age at this weight should be 6 - 8 months. A doe can be bred commercially from this age up to 3 years. Most rabbitries keep one buck to 10 does.

The period of gestation is 30 - 32 days i.e. the time between breeding and kindling. About four litters a year is a good average for commercial production. This means that rebreeding has to be done about 8 weeks after kindling.

BREEDING: When a doe is old enough to breed watch for signs. She will become restless, rubbing the feed containers with her chin, and will display a swelling and reddish appearance of her sex organs. A good way to check a doe for readiness to breed is to run your hand over her back from tail to head. If she is ready she will stretch her body and raise her tail slightly.

Each breeding doe should have a hutch for herself and her young. Bucks too should be kept in individual cages. At mating time the doe should be taken to the buck's cage. Pick her up by grasping over the shoulder (never the ears) and place your other hand under the hind quarters to take the weight off its skin. If you have to carry the rabbit any distance, place it under your arm close to the side of your body. This way the animal does not get excited or hurt in any way.

After breeding takes place the buck will usually fall over backward or on its side. The doe should be removed immediately to her own pen. To ensure that she has conceived take her back to the buck for test-mating on the 18th day. Refusal to mate by the buck, whining and attempts to escape by the doe should confirm that the previous mating was successful.

Palpation is another way of determing pregnancy. About 14 - 16 days after mating, if you are experienced, run your fingers and thumb on the under body of the doe. If you feel a series of nodules or lumps in the lower abdomen this is a sign that pregnancy has occurred.

NESTING BOX: Since the young rabbits are born blind and hairless they must be provided with a nesting box during the first few weeks of their life. The box should be big enough to take the doe along with her young. It is common to have litters of 10 - 12, but only 8 young should be raised per doe: the 'runts' are culled.

Whether the young rabbits live and make money for you or die at your expense, depends to a great deal on the type of nesting box and nesting material that you provide. A good nest box will keep the young warm, allow ventilation and drainage of moisture and keep them in the box until they are big enough to come and go by themselves. A box 16 - 20 inches long by 12 inches wide, open at the top with a 6 inch high guard in front is adequate (see diagram).

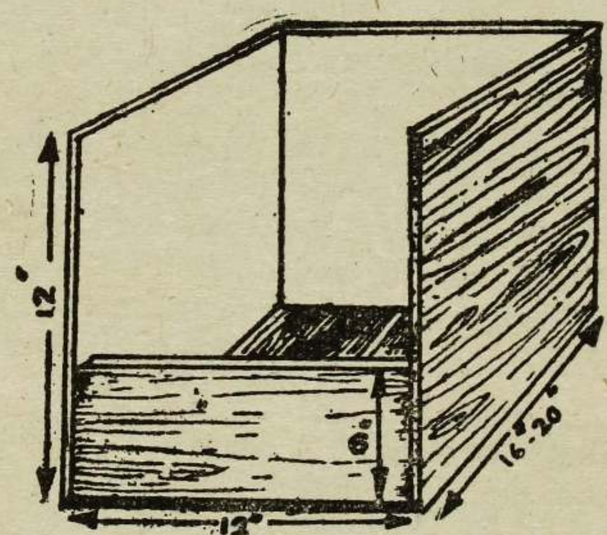


Fig. 7·3

Keep an accurate record of the date on which each doe is bred. On the 17th or 18th day after mating, clean the cage and place the nest box in the cage. Do not underestimate the importance of disinfecting the nest box, especially between litters when it must be completely scrubbed down. The bottom of the box should be filled with clean wood shavings and straw. The doe will make her own nest. If she eats a lot of straw, do not be alarmed, just add more straw.

The day after the young are born, check the nest box. Determine how many there are in the litter and promptly dispose of any dead members. For the first three weeks the young are completely dependent on the doe and her milk. After this they begin to come out of the nest box on their own. This is the time to remove the nest box. It is best to leave the young with the doe until they are 8 weeks old. At this stage they are marketed and should weigh about 4 lb each. Males and females that are not marketed around this time should be separated into pairs of the same sex, or individually caged for further growth and development.

FEEDING: Rabbits need a balanced ration containing 15 - 20% protein (the lower level for dry does and bucks and the higher level for nursing does), 3 - 5½% fat, not more than 20 - 25% fibre and plenty of salt. As there are no proprietary rabbit mashes on the local market, most rabbit breeders use poultry mashes—growers mash for bucks and dry does and chick mash for nursing does—about 4 to 6 oz per adult every day. Beware the use of mouldy or mildewed mashes however as they cause serious digestive troubles. If the feed provided is not cleaned up by next day reduce the quantity.

Fresh grass clippings, sweet potato leaves and *kankun* should also be provided. The more green food provided the less mash need be used.

An extra container of common salt and at least one gallon of clean drinking water a day is also necessary for a doe and her litter.

CAGES: A good cage or hutch is shown in the diagram below. It is 4 feet long by 2 feet wide, provided with a leak proof one-slope roof. The sides and floor may be of wire netting to provide good ventilation and drainage. The floor may be covered with straw which is replaced every day. A wooden floor may be better as rabbits tend to develop sore hocks when resting on wire. This size of cage is suitable for a doe of the medium sized breeds e.g. New Zealand Red or White and her litter. Larger breeds like the Flemish Giant need larger cages, at least 5 feet long. The hutch should be protected from direct drafts and exposed to sunlight for part of the day.

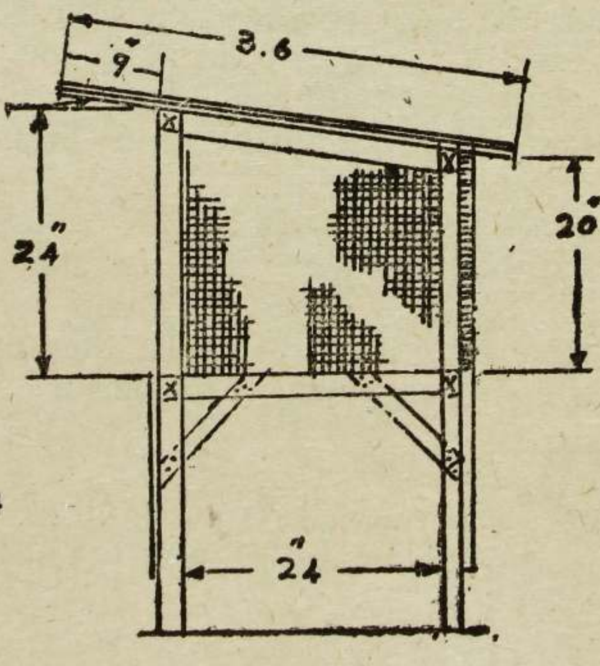


Fig. 7·4

SANITATION & DISEASE CONTROL: Good hygiene in the rabbitry is the best method of disease control. Preventing an outbreak of disease is much less costly than trying to get rid of it. Remove the droppings, soiled bedding and contaminated feed from the cages daily. Wash the watering equipment every week in hot, soapy water and rinse in clean water before refilling. Clean the feeders weekly with washing soda and hot water. When loose hair in cages and equipment becomes a problem it can be burned off. Then wash the cages with a solution of chlorine.

Strict sanitation as prescribed above will do much to control cocodiosis which is a serious problem in young rabbits. Should the disease occur however—the symptoms are loss of appetite, diarrhoea, rough coat and loss of weight—treat with sulfa. The drug is added to the drinking water at the rate of $1\frac{1}{2}$ oz per gallon and the treatment continued for 14 days. Then, after a break of 7 days it is continued for another 14 days.

Another common sickness is nasal catarrh or "snuffles". It starts with the symptoms of a bad cold—sneezing, coughing, watery eyes—nasal discharge and the animal rubs its nose with the front paws. If this condition passes off well and good. If it continues in the chronic form, then seek Veterinary aid because it can lead to emaciation and sterility.

Chickens (*Egg production*)

POULTRY HOUSE: It is an unfortunate fact that the average poultry keeper in this country shows a marked reluctance to invest in a suitable house for his laying flock, although he has sufficient business acumen to buy the best birds and the finest feeds in the market. The real reason for this neglect of proper housing is a combination of laziness and ignorance. While the poultry-keeper can readily obtain his stock and feed from franchise agents and forage merchants, the building of a house is something he has to do or superintend himself, and this requires a fundamental knowledge of design and building specifications which he often lacks.

The poultry house is not merely a place to keep the birds from straying or to protect them from polecats and other predatory animals. It is their home in which they will be confined for life under the deep litter system. And unless they are made as comfortable as possible during this time their performance must necessarily be poor.

A comfortable poultry house must be free from damp, well ventilated, reasonably cool and also provide the birds with sufficient space to feed and drink, lay their eggs and move about without getting in each other's feathers.

Dampness can be caused by rain coming in through the roof and sides of the house or seeping into the litter through the floor. Unless this is prevented the birds will suffer from colds and chills with consequent ill effects on production.

As a first precaution, therefore, the house must be provided with a roof of leak-proof material carrying an overhang of 3 feet on all sides to prevent spray beating in during heavy rains. The roof may be of rubberoid, asbestos, galvanized iron sheets or even cadjan. Cadjan has the advantage of keeping the house cool, although it is no protection against predators.

In wet areas the house should also have a cement floor and low wall of 2 - 3 feet in height to prevent ground draughts. A permanent wall of brick or wattle-and-daub, however, is unsatisfactory in hot wet areas because it impedes proper floor ventilation and makes it difficult to keep the litter dry.

It would be far more satisfactory if the walls were made of wooden planks, in such a way that they could be lifted like a flap on hinges and kept open during hot weather. When the weather is cold or rainy the flap may be lowered again.

Dampness can also be caused by poor ventilation. Owing to the high humidity of the air there is a tendency for excess moisture to collect in the poultry house and this is increased by the moisture exuded by the fowls. Several gallons of water are given off by the fowls daily through the process of respiration and excretion. Unless this moisture is eliminated by good ventilation the house will become damp to the discomfort of its tenants.

Wire netting on all four sides will permit efficient cross ventilation. Installing a ridge ventilator allows currents of air to be drawn out of the top of the house. This is a further safeguard against humidity. It also helps to keep the house cool.

Layers raised on deeplitter should have a minimum floor space of 2½ sq. ft. per bird. A greater stocking density should not be allowed because the quantity of excreta and urine passed by the birds will be in excess of the absorptive capacity of the litter.

The recommended materials used for litter are paddy husk, saw dust and wood shavings. About 50 - 60 gunny bags of paddy husk are required for a poultry house of 100 birds—the litter when spread should be about 6 inches high.

Comfort of feeding, drinking and laying must also be considered. The main object is to provide adequate space so that the weaker birds will not have to compete with socially superior birds in the "peck order".

A minimum of 8 inches of linear feeder space should be provided for each bird, assuming that all birds are feeding at the same time. This would mean using six 4 ft feeding troughs for 100 layers. In the alternative eight standard tube hoppers may be used.

For the deep litter system gutters are the best arrangement since they provide the least chance of the birds wetting the litter. Two gutters ($2\frac{1}{2} \times 3\frac{1}{2}$ inches) may be installed on the inside of the house with the ends projecting out. This permits the filling and emptying of the gutters to be done from outside without spilling water on the litter. Twelve inches of linear gutter space is required per 12 birds.

Individual nests (13 - 14 inches square) are preferred to community nesting boxes because they provide greater privacy and enable the hens to lay their eggs without bullying by socially superior companions. They should be placed at a height of 2 ft (and not more) from litter level along one wall in such a way that the eggs can be collected from the outside.

One nesting box should be provided for every 4 - 5 birds in the flock. If a community nesting box is used it should be constructed 12 ft $\times$ 2 ft for a 100 laying flock.

Specifications for a single - slope poultry house for 100 layers are: Length 21 ft. Width 12 ft. Eaves 3 ft. Front elevation 7 ft. Rear elevation 5 ft. Brick wall 2 ft. Two Egg Boxes 6 ft $\times$ 2 ft $\times$ 2 ft. The bill of quantities is as follows:

Timber 4 in $\times$ 2 in $\times$ 9 ft — 4 posts
Timber 4 in $\times$ 2 in $\times$ 8 ft — 4 posts
Timber 4 in $\times$ 2 in $\times$ 7 ft — 4 posts
Rafters 2 in $\times$ 2 in — 100 ft
Reepers 2 in $\times$ 1 in — 400 ft
Planks 12 ft $\times$ 6 in — 3 planks
Planks 2 ft $\times$ 6 in — 6 planks
Roofing cover for egg box — 4 yards
Wire netting 6 ft $\times$ 1 in — 20 yards
Wire nails $1\frac{1}{2}$ in — 2 lb

Wire nails $2\frac{1}{2}$ in — 2 lb
Panel pins 1 in — 1 lb
G.I. Sheets 6 ft × 3 ft — 26 sheets
Bricks — 500
Cement — 2 bags
Sand — 1/4 cart.

POULTRY HOUSE
(Single-slope roof)

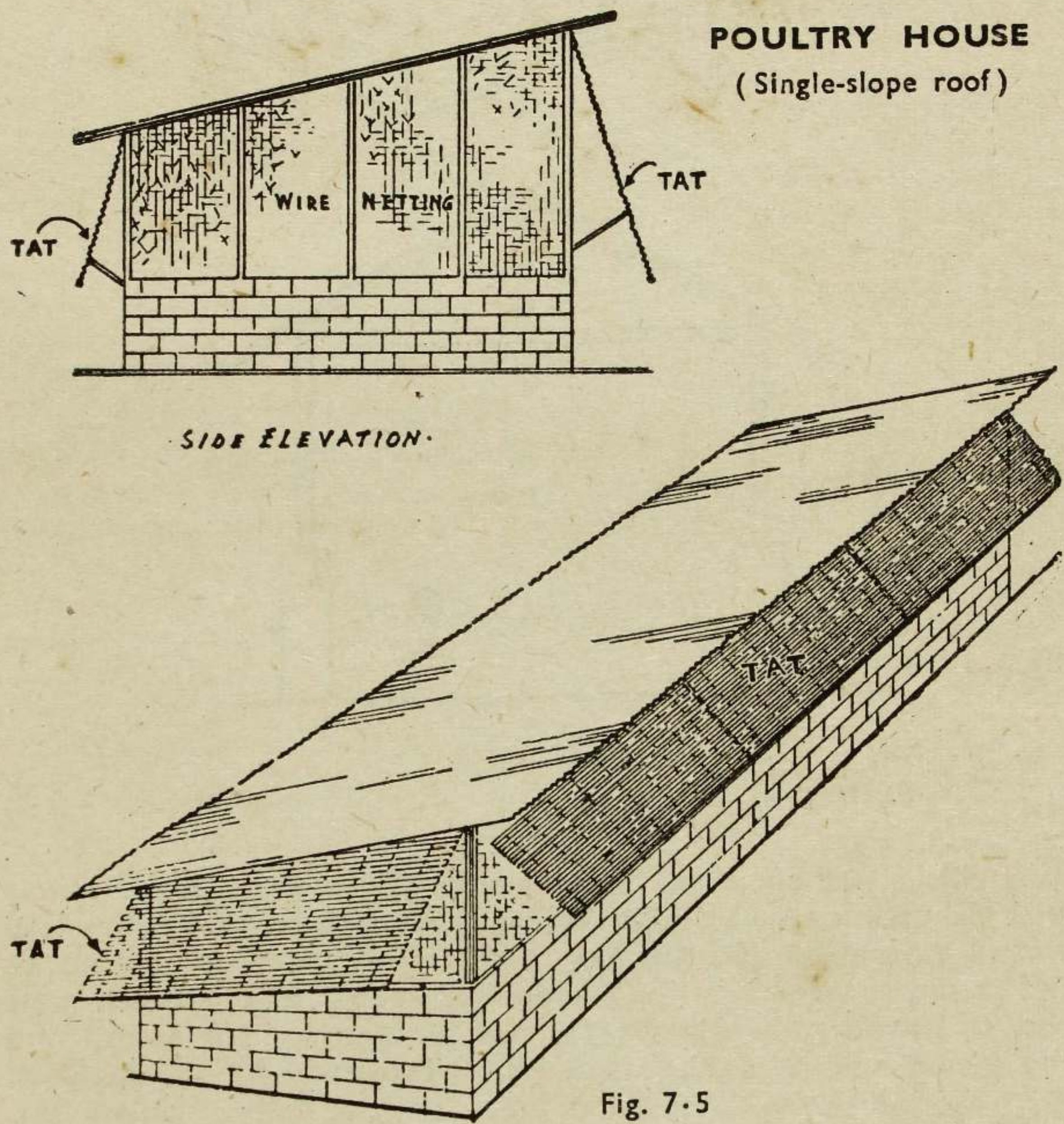


Fig. 7·5

CHICK-RAISING: Rearing day-old sexed chicks is the cheapest method of building up a laying flock. Day-old chicks can be purchased from the Department of Agriculture and private Franchise Agencies.

The brooding stage is the most critical in the life of the chick. "Brooding" is the term applied to a hen sitting on her eggs and providing the necessary warmth to hatch the eggs and raise the

POULTRY HOUSE (Double-slope roof)

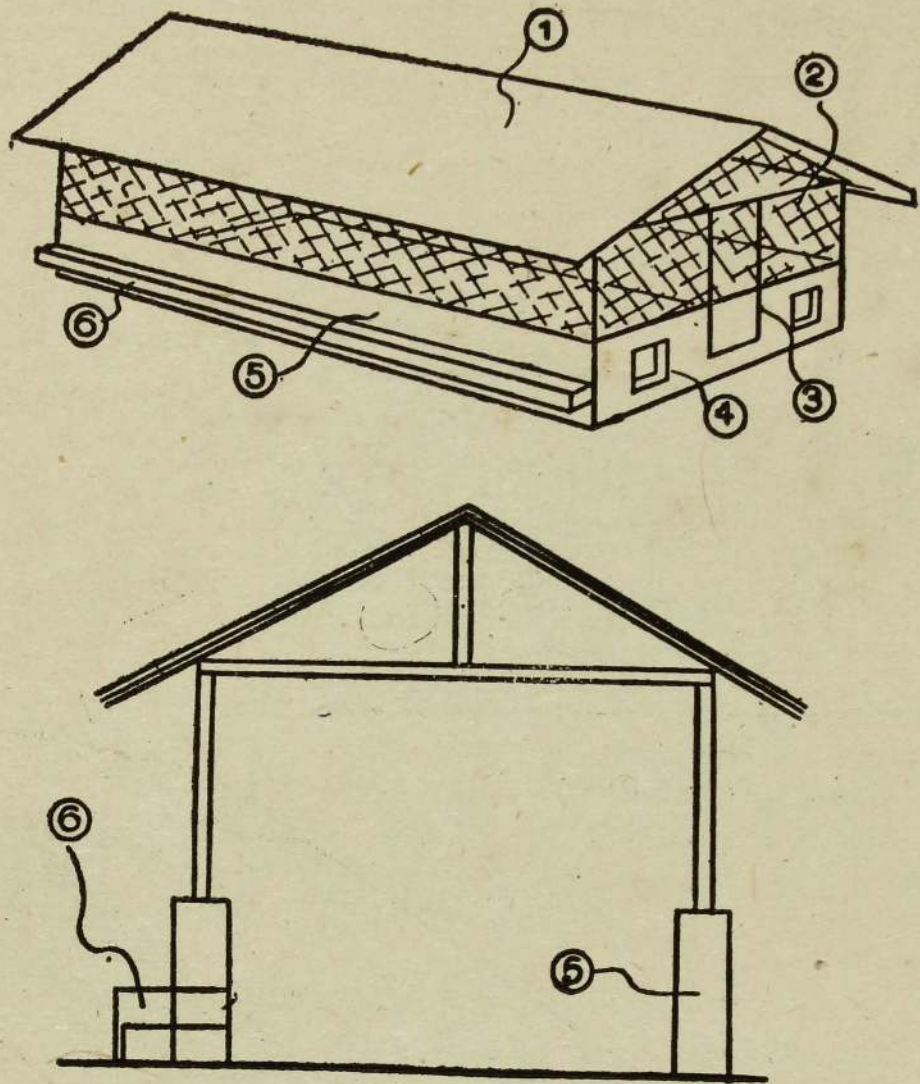


Fig. 7·6

1. Roof 2. Wire-netting 3. Door 4. Pop-holes
5. Half-wall 6. Nests 7. Entrance to nests

baby chicks without them catching cold. Since we have done away with the practice of natural brooding and replaced it with an artificial system where day-olds are purchased from commercial hatcheries and raised straightaway by the poultry-keeper, this warmth must now be provided by other means such as electric light bulbs, infra red lamps and hurricane lanterns. The two sources employed here are hurricane lamps and electric light bulbs. Unless this warmth is provided in the early life of the chick many deaths can be caused by chilling, and also there can be retarded growth as a result of delayed feathering. Once the growth of the chick is retarded at this stage there is nothing one can do to remedy the damage.

There are still too many poultry-keepers who are careless about the provision of artificial heat. They allow chicks to run around the compound in the day time and provide them with heat only at night. This attitude is born of a popular misconception that chicks do not require any artificial heat in tropical countries, when the sun is very hot. Some poultry - keepers argue that chickens are sent long distance by train without any heat and that they survive without any harmful effects. This is true, chicks can travel long distances when packed in well-designed boxes. The close confines of the box and their mass body heat keep them warm enough during the journey, but once they are taken out of the boxes and allowed to move about they are easily chilled unless artificially warmed.

It is universally accepted that chicks require a temperature of 90 - 95° F in their first week. This temperature can be provided for 50 chicks with a single kerosene-operated hurricane lantern or a 40 watt electric bulb. As soon as the chicks arrive therefore, see that they are placed in heated quarters. The source of heat should have been set alight or switched on at least 1 - 2 hours earlier.

It does not matter whether you have separate quarters for the chicks in a garage or outhouse or even in a room in the house, so long as the place is protected from draughts and is clean. But do not make the mistake of crowding the chicks. They require $\frac{1}{4}$ - $\frac{1}{2}$ sq. ft. each. This may be provided on the floor of the poultry house so long as there is a guard to prevent the chicks straying beyond the given space, or it may be given in a specially constructed brooder house.

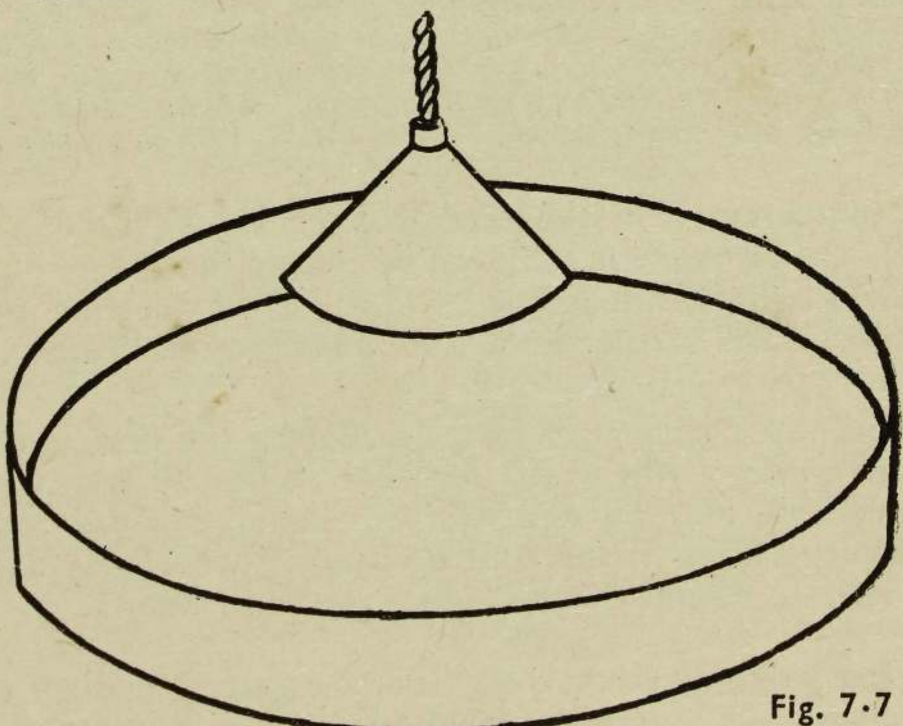


Fig. 7·7

Electric-light source of heat and 8-inch high cardboard guard to confine chicks. Feeders and drinkers should be placed at periphery to encourage birds to move about freely.

You will require two brooder houses, each 7 ft by 3 ft, capable of housing 50 chicks, two hurricane lanterns or two electric bulbs. See that the chicks are protected from burning themselves by using a wire netting guard around the lantern. Also see that they are not suffocated by smoke from the lantern. Prevent this happening by filling the container with oil to one-inch below capacity, by cleaning the air vents in the burner and the filler cap, and by trimming the wicks regularly.

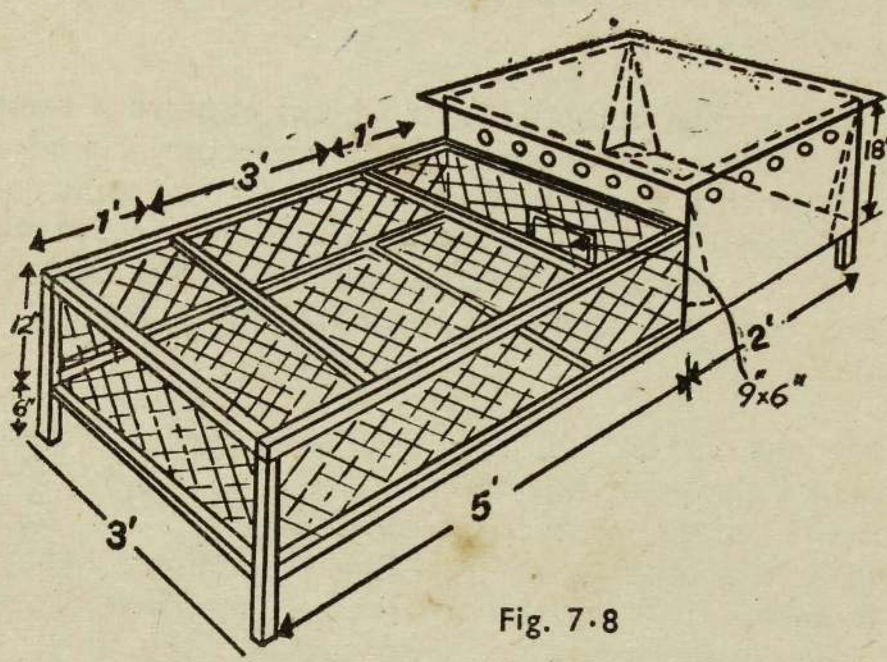


Fig. 7·8

SPECIALLY CONSTRUCTED BROODER

Heated section is made of closely fitted planks with a doorway 9" × 6" connecting it to the wire mesh run. Floor of heated section may be of wire netting (½ inch) to allow droppings to fall through. Heated section is 3 ft. wide, 2 ft. long by 18 in. high. Wire run is 5 ft. long by 3 ft. wide with a door on top. The brooder is built on six-inch legs.

The temperature in the second week should be 85 - 90° F. This lower temperature is achieved by raising the bulb or lowering the wick of the hurricane lantern. In the third week the temperature is lowered still further to 80 - 85° F in the same manner.

Day and night heat must be given during the first two weeks in the low country where the weather is usually warm. In the third week heat may be discontinued during the day and given only at night, except in the cold up-country where day and night heat will have to be maintained during the third week.

You can judge whether the chicks are getting enough warmth by their behaviour. If they crowd together, for instance, round the source of heat and keep up a constant high-pitched "cheeping", this means that they are still too cold to be comfortable. You must then raise the wick of the lamp or lower the electric light to make the necessary adjustment in temperature. If on the other hand, they scatter away from the source of heat and show signs of panting or gasping, then obviously they are too hot, and it will be necessary to lower the wick of the lantern or raise the light. All's well if they distribute themselves evenly over the whole area.

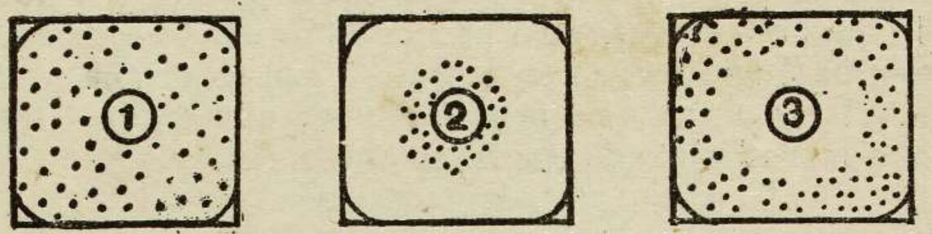


Fig. 7·9

CHICK BEHAVIOUR IN RELATION TO HEAT SUPPLY

1. Correct Heat — Chicks distribute themselves evenly over the area

2. Insufficient Heat — Chicks huddle together round source of heat.

3. Excess Heat — Chicks pant and move away from source of heat.

Usually chicks are not given anything to eat on the first day—this is the day they are packed in boxes and despatched to their destinations. Their beaks may be dipped in water at the end of the journey, or they may be given a little to drink to prevent dehydration. On the second and third days, however, fine grain should be allowed. This is usually given to the chicks spread on paper or cardboard placed on the floor. Thereafter, the chicks should be trained to eat dry mash. The "chick mash" should be made available in special chick feeders—four double-sided feeders for 100 chicks. Water which is given from the second day is made available in two 1 pint drinking fountains for 100 chicks. You should also feed the chicks chopped green leaves from the time they are four days old. Two to three times a week would do.

It is also a wise precaution to give the chicks an antibiotic in the drinking water during the first critical week. Half a teaspoonful of Terramycin mixed in one gallon of drinking water is enough to brace the chicks against colds and chills. Be sure to give them freshly prepared medicated water every day for the first week. After this there is no need to give terramycin regularly except occasionally when the chicks are vaccinated or during very wet and cold spells. During such periods of stress the strength of the dose may be doubled to one teaspoonful per gallon of drinking water.

GROWER MANAGEMENT: From the 9th to the 22nd week the birds pass through the grower stage. Most poultry-keepers assume that because the critical period is during the preceding chick stage that they can afford to relax in their management efforts at this stage. This is a serious error. The growers of today are the layers of tomorrow, and unless they are managed properly egg production could be disappointing.

The first point in the management of growers is housing. In the old days the chicks were brooded in a separate brooder house (as described) and moved to a grower house at the end of one month. They were kept in the grower house till 4 months old and then moved again to the layer house.

Today it is considered bad management to move growers from a grower house into a layer house as stated above because this is a critical period in the life of the bird when many metabolic and hormonal changes are taking place. Consequently, the birds are going through a natural period of stress and any added artificial stress that may be caused by moving them to new quarters at this stage can have detrimental effects on production.

The accepted practice today, therefore, is to move the chickens once and for all into the laying house at the end of one month and accustom them to the new conditions early so as to ensure a stress-free transmission from grower to layer.

Transferring the birds from brooder to the layer house is best done at dusk when the birds are quiet and handling them is easy. Avoid cold damp days when moving the birds. Also remember to keep them away from the corners of the house for a few days till such time as they become accustomed to their new habitat. Otherwise there is a tendency to crowd the corners and this leads to losses from smothering. After a week or so, the birds may be given the full adult requirement of $2\frac{1}{2}$ - 3 sq. ft. per bird.

They should also be provided with adult equipment—that is, one standard tubular feeder foi 12 birds and one galvanized drinking fountain of one gallon capacity for every 20 birds. If a water gutter is used one foot of gutter space must be provided for every 12 birds.

Feeders must be evenly spaced in the house. In the case of hanging feeders they must be placed on the ground at first and gradually raised off the ground as the birds grow and get used to feeding from them. The water gutter will have to be placed on supports 5 inches above the litter at first and gradually raised to 10 inches. A set of movable roosting stands should also be placed in the house. The laying boxes should be kept closed till the birds have completed 4 months.

The growing stage is intermediate between the quick-growing and feathering stage of the chickens and the productive stage of the layers. The birds ration has accordingly to be adjusted to one with a lower percentage of protein and a higher proportion of fibre that the rations given to chicks and layers.

This ration, which is known as the "grower mash", is introduced gradually at the 9th week and by the end of the 10th week the changeover from "chick mash" to "grower mash" should be complete. Subsequently at the 22nd week when the birds begin to lay the "layer mash" must be gradually substituted for the "grower mash".

LOOKING AFTER LAYERS: Assuming that the birds have been managed efficiently through the chicken and grower stages, what must the poultry-keeper do to ensure a full complement of eggs. One thing he must do is to satisfy himself that only the most vigorous pullets are selected for the laying flock. There is no point in carrying sickly birds or underdeveloped birds. Such birds should be culled at this stage. Many people may not like to do this for sentimental reasons, or because they hope for the birds to improve in time. But this is wishful thinking.

A first requirement of the laying flock is nests. Nests constructed of wood and placed flush with the walls are best. If it is a big poultry house where there is plenty of room along the walls, single nests may be provided in two tiers, each nest 12 inches wide by 12 inches deep with a circular hole of 8 inches diameter cut in the front face. One nest is required for every four birds in the flock.

But if wall space is restricted, community nesting boxes may be more convenient. A box 6 ft × 2 ft × 2 ft is ample for 50 birds. Like the individual nesting boxes it should have a wire-netting floor covered with straw to prevent breakage of eggs. The lid must be deeply sloped to prevent the birds roosting on it. It should also be hinged so that it could be raised for egg collection. Two eight-inch diameter holes, which serve as entrances to the nesting box, may be placed at the ends. If perches are placed immediately below the two entrances it will encourage the birds to use the nests instead of laying in the litter.

Nesting boxes should be made available sometime before the first egg is expected to allow the birds to accustom themselves to the new environment. If the nests are already in the house they should be opened up by the fourth month.

Good breeds start laying by the 20th - 22nd week. Fifty per cent production should take place by the 25th week and peak production of 70 - 80 per cent by about the 30th week. This means that in a flock of 100 layers you should get about 50 eggs a day by the 25th week and 70 - 80 eggs a day by the 30th week. After this egg production will decline by about 3 - 4 per cent a month till the flock is once again at 50 per cent production after 12 months of laying. Egg size at first is small. It increases gradually till the largest eggs are laid 4 - 6 months after the commencement of lay.

All good breeds are capable of giving over 200 eggs a year, but if the quality of the mash fed to them is poor to medium then egg lay can fall off below 200. It is possible, however, to offset this 'drop' in egg production by providing the birds with a longer day length from the peak period of production onwards. Light stimulates egg production.

Daylength in the tropics is usually 12 hours, sometimes less during the months of September to February. But if this peiiod of light can be increased to 14 - 15 hours by artificial lighting from the 30th week onwards, egg production can be significantly increased. To achieve this one would have to place 25 watt elecrtic bulbs at 10 foot intervals in the poultry house at a height of 4 - 5 feet above the heads of the birds, and the electric light will have to be turned on for a couple of hours before sunrise or after sunset.

Although the early morning period may be more inconvenient it is certainly the better time to provide artificial lighting, because this is the coolest time of the day during which the flock is most active. At this time the birds are ready and willing to eat large quantities of mash. The more mash they eat the more eggs they should lay. The majority of eggs are laid during the first part of the day. Of course, the poultry-keeper will have to determine for himself whether the income from the extra eggs covers the cost of extra electricity, leaving him a reasonable profit.

So much for nesting and supplementary lighting. Now let us get on to the daily drill of management, or the routine care of the laying flock. Every morning around 7 a.m. you should observe the birds without disturbing them. Those that look sick should be taken out and segregated. Lack of appetite, dull eyes, sniffling, huddling in corners and abnormal droppings are all signs of disease. If you are able to diagnose the disease you can treat the birds yourself: otherwise segregate them and seek expert opinion.

Next, check the mash in the feeders and top-up to the three-quarter level. Also fill the gutter with clean water.

Now, turn your attention to the litter. Collect any extra droppings that may be found around the roosts usually and dispose of it outside the house. After this, rake the litter lightly to mix the droppings evenly with it so as to hasten decomposition. If there are any patches of litter that appear abnormally wet or caked, remove these patches and replace with fresh litter. In the alternative you may use a drying agent like hydrated lime. Mix it with the litter at the rate of 1 lb for every 10 sq. ft.

About 10 a.m. collect the eggs. Take this opportunity to check the feeders and waterers again. Tube feeders may have to be shaken down as the mash very often tends to stick or "bridge" in the tube.

In the afternoon between 2 p.m. and 3 p.m. visit the birds again to give them their greens. At the same time make a second collection of eggs.

And finally about 6 p.m. in the evening, just before the birds begin to roost, make a final egg collection, stir the litter lightly again, arrange the movable roots for the night and pull down the jutehessian blinds in case there is rain or chilly weather during the night.

FEEDING & DRINKING: "Chick mash" is fed to the birds up to the end of 8 weeks. Four 1 foot long, double-sided feeders are required for 100 chicks, and the quantity of mash for 8 weeks is 200 lb. Drinking water during this period is provided in two 1 pint drinking fountains. In addition to mash, chicks must also be given green leaves at the rate of quarter-ounce each, two or three times a week. The green leaf (*Kathurumurunga*, *Mukunuwenna*, *Kankun etc.*) should be preferably chopped up and hung in small bundles just above the heads of the chicks so that they can jump up and pect at it. In addition, also provide a separate hopper or feeder of chick-size flint grit. Chickens, no matter whether they are young or old do not have teeth. Under natural conditions they pick up stones and grit from the garden, which are lodged in the gizzard to provide the necessary grinding action that is necessary for the digestion of food. If they do not have this natural aid to digestion, the gizzard can be eroded with detrimental effects on feeding and production.

Once the chickens are moved into the main poultry house at the end of 8 weeks they are given adult feeding and drinking equipment—12 tubular hoppers and 8½ feet of gutter for 100 birds. The feeders are first placed on the litter and gradually raised, as the birds grow, to hang at such a height that the rim of the hopper is on level with the top of the backs of the birds.

What a great many people do not realise is that a flock divides itself into social groups. If the majority of hoppers therefore are placed in the territory of one group, this group will jealously guard these hoppers and prevent birds from other groups eating their fill. Consequently, the health and production of these starved-out birds will suffer. It is essential, therefore, to see that the hoppers are evenly distributed in the house and that the birds do not have to go more than 10 feet to reach them from any point in the house.

As a rough guide you should ensure that one-hundred birds have at least 8 lb of "grower mash" daily when they are 8 - 9 weeks old, 20 lb at 15 weeks, 22 - 24 lb at 20 weeks and 24 - 28 lb of "layer mash" thereafter. In addition they should also be given flint grit in a separate hopper—4 to 8 ounces of medium sized grit from 12 to 20 weeks and 1½ - 2 ounces of adult sized flint thereafter. And in the case of laying birds do not fail to supply another extra hopper of shell grit to ensure strong egg shells.

It is the same thing with water! Water too should be adequately provided and easily accessible to the birds. To obtain the best results the feeders should be within easy access of the gutter—within 10 feet at least. This stimulates sustained feeding since the birds alternate between eating mash and washing the mash down with water. In a small house where the gutter is usually placed along a side wall, a distance of 10 feet between gutter and feeders can be maintained quite easily. But in a large poultry house this may not be possible unless the gutter is so placed as to run along the middle of the house.

In the chick stage the gutters are propped up 5 inches above litter level. They are then gradually raised to the level of the half wall—18 inches above the litter. Any lack of water, even for a few hours will lead to less egg production. And since nearly 70 percent of the egg consists of water any lack of water must necessarily lead to a reduction in egg weights too. So be sure to see that the gutter always has water in it—at least two inches of water, since the hen cannot suck up water but has to scoop it up with its beak.

One-hundred birds will require 4 gallons a day from 8 - 12 weeks, 4 - 5 gallons from 12 - 15 weeks and 6 - 7 gallons thereafter. The water must be changed every day to prevent it becoming unpalatable.

RECOMMENDED POULTRY MASH: As an alternative to the proprietary mashes available in the market, you can mix your own according to the following formulation:

Ingredient	*Chick (0-8 weeks)*	*Grower (9-20 weeks)*	*Layer (20 weeks on)*
Ground Maize	20	20	23
Ground Kurakkan	06	10	10
Rice Bran No. I	20	20	20
Coconut Poonac	35	35	30
Gingelly Poonac	05	05	07
Fish Meal	12	08	06
Shell grit	1.5	1.5	1.5
Bone Meal	0.5	0.5	1.0

(*Source:* Department of Agriculture)

In addition Chick Premix and a Coccidiostat must be added to the "chick mash" according to manufacturer's instructions; Chick Premix and a coccidiostat must also be added to the "Grower's Mash"; and a Layer's Premix only to the "Layers Mash". Premixes contain vital vitamins and minerals (these may be alternatively supplied from green feed fed 2 - 3 times a week to chicks at 1/4 oz per bird; 1/2 oz per bird fed daily to growers and 3/4 oz per bird fed daily to layers).

Coccidiostats are certain drugs that are added to the mash to give the birds a resistance to the coccidiosis disease. The common coccidiostats are (i) sulphonamides, (ii) nitrofurans, (iii) halogenated aronic acids, (iv) nicarbazin, (v) glycarbylamide, (vi) nitrophenide, (vii) zoalene,(viii) quarternary ammonium compounds, (ix) amprolium, (x) unistat and (xi) superstat. The most widely used are sulphaquinoxaline, amprolium and zoalene (zoamix).

Amprolium is recommended because the coccidia have still not built up a resistance to this drug.

READY RECKONER FOR 100–LAYING FLOCK

<table>
<tr><th rowspan="2">AGE (WEEKS)</th><th rowspan="2">FLOOR SPACE</th><th rowspan="2">FEEDERS</th><th rowspan="2">DRINKERS</th><th colspan="3">CONSUMPTION</th></tr>
<tr><th>MASH</th><th>GRIT (FLINT)</th><th>WATER</th></tr>
<tr><td>1</td><td rowspan="2">25 sq. ft.</td><td rowspan="3">4 double-sided chick feeders each 1 ft. long</td><td rowspan="4">2 pint-sized chick founts</td><td rowspan="4">200 lb. "chick mash" for 4 week</td><td rowspan="12">4 oz. chick-sized flint grit daily up to 12 weeks</td><td rowspan="12">2-4 gallons daily up to 12th week</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td rowspan="6">50 sq. ft.</td></tr>
<tr><td>4</td><td rowspan="5">7 double-sided chick feeders each 1 ft. long</td></tr>
<tr><td>5</td><td rowspan="8">3-4 pint-sized chick founts from 4-12 weeks</td><td rowspan="4">400 lb. "chick mash" for 4 weeks</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td><td rowspan="6">150 sq. ft.</td><td rowspan="4">4 tubular hoppers from 9-12 weeks</td><td rowspan="6">18 lb. "grower mash" daily from 9-14 weeks</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td><td rowspan="9">8 tubular hanging hoppers after 12th week</td><td rowspan="9">Gutter</td><td rowspan="8">4-8 oz. grower-sized flint grit from 13-20 weeks</td><td rowspan="8">4-5 gallons daily from 13-20 weeks</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td><td rowspan="7">250 sq. ft.</td><td rowspan="6">20-22 lb. "grower mash" daily from 15-20 weeks</td></tr>
<tr><td>16</td></tr>
<tr><td>17</td></tr>
<tr><td>18</td></tr>
<tr><td>19</td></tr>
<tr><td>20</td></tr>
<tr><td>After 20</td><td>24-28 lb. "layer mash" daily</td><td>$1\frac{1}{2}$-2 oz. adult-sized flint grit daily</td><td>6-7 gallons per day</td></tr>
</table>

DISEASE CONTROL: A major factor that determines the margin of profit is the presence or absence of disease. The most widespread infections are caused by viruses. These include Ranikhet, Fowl Pox and Marek's disease. There is no specific treatment. Control depends on vaccination and good hygiene.

Ranikhet vaccine is safely and conveniently dissolved and given in the drinking water. The first dose is given at 3 weeks. The vaccine is supplied in vials by Veterinary Surgeons of the Department of Agriculture. Two vials are necessary for 100 chicks. Dissolve the contents of the two vials in 2½ bottles (beer bottle size) of drinking water. The medicated water should be kept before the birds for 4 hours. To ensure that they drink it is necessary to make them very thirsty. This is done by removing all drinking vessels or stopping the water supply at about 3 p.m. on the previous day, and reintroducing the water—vaccine treated this time—early next morning.

The second dose is given in the same way at 3 months. On this occasion four vials of vaccine are dissolved in 12½ bottles of drinking water.

A warning! Do not clean or disinfect the gutter or drinking vessels with washing soda or any other proprietary disinfectant prior to introducing the vaccine water. If you do this it will have the effect of partially inactivating the vaccine.

Protection against *Fowl Pox* is given by vaccinating the birds at 4 weeks of age. This vaccine too is available in vials from Veterinary Surgeons in the Department of Agriculture. The actual vaccination which is done in the wing-web is a simple operation that can be handled by the poultry-keeper.

Recently *Marek's disease* has become quite a problem. Disease symptoms appear as a progressive paralysis of wings, neck and legs. One leg may be thrust out ahead of the other, a wing may droop and finally the bird dies. Birds between one month of age and point of lay are the most susceptible. The Department of Agriculture does not manufacture vaccine for this disease at present. Imported stocks, however, will be used to control this disease till such time as a suitable vaccine is processed locally.

Vaccination often causes stress. It is advantageous, therefore, to fortify the birds against the effects of such stress by special treatment. The use of antibiotics in the drinking water, the provision of green leaves and wet-mash-feeding for 4 - 5 days before and after vaccination are recommended practices. Give an antibiotic, like Terramycin, at the rate of one teaspoonful in one gallon of drinking water. Wet mash should be fed in a separate metal feed hopper about eleven o'clock in the morning. Five pounds of mash (for 100 birds) should be thoroughly moistened with water and fortified with two teaspoonsful of cod-liver oil. The feed trough should be immediately cleaned when empty and kept ready for the next day.

Among the bacterial infections the *Salmonelloses* are the most serious. These bacteria are responsible for causing a disease that is similar to pullorum and fowl typhoid. It usually appears in flocks that are less than one month old. Affected chicks huddle together with drooping wings, show loss of appetite and increased thirst. A white pasty diarrhoea is a characteristic symptom. Prevention is more important than treatment because coconut poonac—a major ingredient of local mashes—has been found to harbour the bacteria. Moreover, rats and flies are frequent carriers of these organisms. Furazolidone is the recommended drug. It is given at the rate of one ounce is 56 lb chick mash during the first three weeks of the chick's life.

POULTRY PARASITES: The most serious parasitic infection is *coccidiosis*. Fortunately it can be kept under control, by the use of coccidiostats in the mash which build up a natural immunity in the birds. Today most commercial feeds contain a specific coccidiostat. A serious outbreak of coccidiossis, which may be diagnosed by the presence of blood in the faeces, is controlled by treating the birds with a sulphonamide drug (e.g. Sulmet) dissolved in the drinking water. It may be given continuously for a period of 5 days on intermittently on the following schedule 3 - 2 - 3, where the drug is given for 3 days, withdrawn for 2 days, and given again for another 3 days.

Worms too are troublesome, specially the large round worms. These parasites must be controlled by strategic dosing of the flock with a piperazene-based vermifuge like Coopane or Verban. Dosage will depend on age of bird. In the case of Coopane half-ounce in each gallon of water is adequate for 100 twelve-week old pullets or one-ounce in a gallon for 100 adult birds. If Verban is used three-quarter ounce may be dissolved in each gallon for 100 twelve-week old pullets ; $1\frac{1}{2}$ oz for 100 adult birds.

A satisfactory vaccination and worming programme is shown below:

3 weeks — Ranikhet Vaccine (first dose)
6 weeks — Fowl Pox vaccination
11 weeks — Worming
12 weeks — Ranikhet vaccine (Booster dose)
20 weeks — Worming
21 weeks — Fowl Pox Vaccination
28 weeks — Worming—and thereafter every 2 to 3 months

NUTRITIONAL DISEASES: Chickens and growing birds very often peck at the juicy pin feathers at the base of the tail. When this habit develops it is called *cannibalism*. It was once thought that this disease was caused by boredom and by crowding in the poultry house. These may be incidental factors, but the latest opinion is that cannibalism is caused by the lack of an amino-acid known as argynine. The base of the tail feathers is rich in this amino-acid. Whenever the birds feel the need for this amino-acid therefore, and this is usually when they are 6 - 7 weeks old, they start feather-pecking. The answer to the problem is to supply the birds with extra fish meal — a protein feed that has a full complement of argynine and other essential amino-acids.

The other alternative is to de-beak the birds when they are10 - 14 weeks old. A third or fourth of the upper beak is removed by a little gadget known as a de-beaker. If the operation is done correctly food consumption is not impaired, and there are no ill-effects on the birds, except for a slight stress immediately after the operation.

Vitamin deficiencies are also responsible for certain chick diseases. In *crazy chick* disease, for instance, which is caused by vitamin E deficiency, the chicks fall down and make pathetic "bicycling" movements with their legs in their attempt to rise. On the other hand, if the chicks show a typical *curly-toe* paralysis, where the toes are retracted, then the disease is caused by vitamin B2 deficiency. Paralysis is also caused by vitamin B1 deficiency. In this instance, the chicks will be found sitting on their paralysed legs with their heads drawn back and up in a typical *star-gazing* position.

These vitamin-deficiency diseases can be corrected by the addition of the deficient vitamin to the mash. Rovimix E, for instance, a proprietary product contains vintamin E. Vitamin B1 can be supplied as rice polish and vitamin B2 as 4% Brewer's Yeast.

FLOCK SANITATION: Sound sanitation is one of the most important aspects of poultry management. Unfortunately it is also one of the most neglected. It is true that vaccination and inoculation done in time help to prevent the outbreak of certain diseases. It is also true that drugs when properly used control the damage that can be done by diseases. But it should be remembered that drugs and vaccines do not eliminate the sources of infection. Only a sound sanitation programme rigorously followed can do this.

It must be emphasized at the very beginning that a policy of "all-in-all-out" must be strictly adhered to in housing. By this it is meant that all the birds go into the poultry house at one time (when one month old) and should be taken out at the same time (18 months) when they have finished their economic life period.

At no stage should birds of different ages be housed together so that germs and pests from adult birds can be passed on to the more susceptible younger birds with disastrous results. Also see to it that no birds from outside are introduced to the flock, even if they are the same age, since these birds can be the carriers of pests and diseases.

As stated earlier the house must be washed, scrubbed and disinfected with a solution of washing soda before the birds are introduced at the one-month old stage. Besides washing soda there are many other chemicals (Germex for instance) which may be used to kill germs. And they can only, come in contact with the germs if the surfaces on which they are applied are not covered with layers of dirt, droppings or litter.

Hence the need to first scrub and clean these surfaces thoroughly, even to the extent of scraping to remove stubborn dirt, before applying the disinfectant. If wahsing soda is used, a solution is prepared by mixing two handsful in 2½ gallons of hot water. Washing, scrubbing and disinfection of the house should be done one week in advance of introducing the birds.

Once the birds are introduced thorough cleanliness in and around the poultry house must be maintained. A mat soaked in Jeyes fluid or Pynol should be placed in a shallow basin near the entrance and anyone entering or leaving the house should be asked to wipe his feet on it.

Thereafter the poultry house should be brushed and cleaned once a month, paying particular attention to the wire netting which can collect cobwebs and strands of dust and dirt. It will be a good thing to spray the pens also at this time with a solution of Germex—a quarternary ammonium compound or Jeyes fluid or Pynol.

In the process of keeping the litter in a working condition it will be necessary to remove old caked litter and replace it: this will be an insurance against the spread of litter-borne parasites and germs.

Drinking vessels and water gutters should be cleaned everyday before refilling them with fresh water. Feed hoppers must be thoroughly cleaned and scalded with boiling water at least once a month as a precaution against the build up of harmful bacteria.

As soon as the birds have finished their economic life period and are taken out of the house and sold for the table, it is necessary to give the house a thorough cleaning and disinfection as explained above before the next lot of chickens is introduced.

If there has been a high degree of over-crowding in the previous lot of chickens, or serious disease outbreaks, then it would be necessary to use a stronger disinfectant than Soda, Germex, Jeyes Fluid or Pynol.

Lysol (2%) is the strongest disinfectant yet known. It may be used in this instance with excellent results, although with caution and by responsible persons only, since it is a strong poison that can seriously harm the user if handled carelessly.

After disinfection with Lysol the house should be allowed to stand empty for three weeks at least before the next lot of chickens is introduced.

Broilers

With the possible exception of the pig no creatures are able to produce as abundantly and quickly as are poultry.

This is a fact that prospective investors in animal husbandry are accepting and wondering how to turn to good effect.

While it is true that there are shortages of certain feeding stuffs and the cost of feed is still too high, the fact remains that the production of table poultry can yet be put on a profitable basis.

Basic to the survival and the growth of the broiler industry is the production of a quality bird at the least possible cost of production, so that poultry meat can be taken out of the luxury class and put among the necessary things of life.

But how to achieve this? That is the 64,000-dollar question.

It is important first of all to select the right kind of stock. This means that the birds must be capable of producing plump, meaty breasts and thighs at the lowest possible consumption of feed.

Gone are the days when broiler or fryer production was a by-product of growing replacement chicks for egg production, that is, where the cockerels were separated from the pullets at 10-14 weeks of age and marketed as broilers. By modern standards such cockerels averaging $1\frac{3}{4}$ lb at ten weeks are unacceptable as table birds.

Today the broiler industry demands a fast growing chick capable of converting feed into meat with much greater efficiency. Modern broilers are generally crossbreds involving a special White Cornish male line and White Plymouth Rock (Barred Rock) female line.

There are a fair number of such commercial strains in the local market, and the prospective broiler grower is well advised to invest in one of them. The bird he should look for is one that will achieve an average liveweight of 3.3 - 3.5 lb in 9 - 10 weeks at a feed conversion rate of 2 - 2.5 lb of mash per one pound gain in liveweight.

Broilers are relished for their tenderness, but a general complaint is that the meat is not as flavoursome as the village bird or the dual purpose types like the RIR, which are reared for eggs and secondarily for their flesh when they have passed the economic egg lay period.

This is something that cannot be helped. Flavour comes with age and it is unfortunate that broilers become uneconomic when kept over 10 - 12 weeks. That is, feed efficiency suffers because after this age the greater part of the feed is used for body maintenance and not for new fleshing.

For meat production all stocks are started from day-old chicks. Birds are usually purchased as straight run chicks—about half pullets and half cockerels.

In this country broilers are raised in confinement on deep litter floors—starting with about two inches of litter and building up to 6 - 8 inches deep.

Provide a half square foot of floor space each until the chicks are two weeks old and one square foot between two and ten weeks.

Commercial growers usually raise four flocks of broiler per year with an interval of 4 weeks between batches.

Coccidiosis will almost certainly occur after the first or second batch. But this can be checked either by the continuous feeding of a coccidiostat in the mash, or by dosing with Sulmet or Embazene at the first sign of infestation.

Some poultrymen prefer to clean out the litter after each batch of chicks as a prevention against the possible build up of infection, but with good litter management and the use of a coccidiostat this is not really necessary till 3 or 4 batches have passed through the house. The recommended coccidiostat is amprolium.

No matter what system of litter management if practised an annual clean up of the house is essential and must be thorough. This includes washing the floor with a disinfectant, and for this reason a cement floor is best.

For each batch of 100 broilers provide the same amount and kind of equipment required for 100 pullets—that is, 8 tubular feeders of standard pattern and 5 one-gallon capacity drinking fountains or a gutter at the rate of one foot of drinking space for 12 birds. No nests or roosts, however, are needed.

Broiler chicks may be brooded on the floor of the deep litter house where they remain all their lives. At first they are confined to a small space by means of a circular cardboard barrier and the extent is gradually increased till at the end of one month they have the run of the whole deep litter house.

In the early brooding period be sure to have chick feeders and waterers arranged alternatively in the space provided. Make certain the feeders and drinkers are located in the light. After this the birds should be trained to eat from tubular feeders. These may be placed on the litter to start with and gradually raised, keeping their rims always on a level with the backs of the chick.

The object of rearing chickens for the table is to put the maximum weight on them in the minimum space of time. Therefore, broilers need a feed that contains 20 - 24 per cent. protein for the first six weeks. After 6 weeks they must be placed on a finishing mash that has a reduced protein content but an increased energy level.

Commercial broiler mashes are available in the local market, but should you want to mix your own, two efficient rations are shown below.

Prevention is the most satisfactory way to deal with poultry disease and parasites. Diseases caused by nutritional deficiencies seldom develop if chicken are fed balanced rations. Disease prevention and control measures are the same as stated in the previous section on "chickens".

RECOMMENDED BROILER MASH

Ingredients	*Day-old to 6 weeks (lb)*	*6 - 12 weeks (lb)*
Maize or other cereals like rice, kurakkan & sorghum	40	40
Coconut meal	20	20
Rice Bran	15	19
Fish Meal	18	14
Mineral Mix.	01	01
Shell Grit Powder	01	01
Beef Fat	05	05
	100	100

Include Chick Premix and a Coccidiostat in the mash.

Since fish meal is expensive, you might mix it with gingelly poonac, say 12 parts of fish meal and 5 parts of gingelly poonac for the starter ration up to 6 weeks and 10 parts of fish meal and 5 of gingelly poonac for the finished ration from 6 - 12 weeks.

Ducks

Ducks are hardy birds that are not susceptible to the various diseases that are the poultryman's bane. They lay about the same number of eggs a year, but the eggs are larger weighing half to three-quarter ounce more than a hen egg. The economic life span of the duck is also about six months longer than the hen.

Despite these advantages, duck-raising is not a widespread enterprise. One limitation of course is the so-called aversion of the consumer to a "fishy" egg. This is why duck eggs are used mostly for confectionery. But by far the greatest limitation is the tremendous appetite of the duck compared to the hen.

Raised in close confinement on deep litter the duck does just as well as the hen provided it is given a greater spacing of 5 sq. ft. per bird compared to 2½-3 sq. ft. per hen, and provided the feeding bowls and drinking vessels are placed on a raised central platform of wire with drainage conditions underneath to drain away the slopped water and feed. If this is not done it will not be possible to maintain the litter in a 'working' condition for one year. *The problem is that under these intensive conditions the duck eats 10 - 12 ounces of dry mash a day compared to the 4 - 5 ounces required by a light weight hen. Under the present conditions obtaining in this country where livestock feeds are dear it is therefore uneconomic to rear the duck under intensive conditions. But if plenty of free range is available, specially marshy land, where the duck can wander around and collect the greater part of its normal food requirement in the form of snails, slugs, insects, worms, water weeds and grass, then duck raising can be developed into a profitable enterprise, because the mash requirement can be cut by half.*

Under the open range system ducks need to be kept indoors only at night. For this purpose a rough lean-to shed 8 ft long by 4 ft broad and 4 ft high is ample to house 15 - 18 birds. The floor, which may be of brick or rammed earth, should be covered with a litter of dry straw. Perches are not necessary but shallow nest boxes 2 ft square and 3 inches deep should be placed inside the house, because ducks lay their eggs in the early morning. By 9 a.m. the ducks can be let out and the eggs collected.

BREEDS: The best egg breeds in this country today are the Veluwe and "Khaki Campbell". They are both prolific layers with a capacity of 200 - 225 eggs a year. The ducks come into lay in 5½ - 6½ months. Drakes of the "Khaki Campbell' breed reach a weight of 4 - 4½ lb in 10 - 12 weeks under good feeding, but both the drakes and the ducks of the "Veluwe" breed reach a weight of about 4½ - 5 lb in 13 weeks. The real table breeds, however, are the "Pekin", "Aylesbury" and "Muscovy". The "Aylesbury", in particular, is popular because of its rapid growth and white skin. Under good feeding at the age of 10 weeks the ducklings should weigh 5 lb. These table birds take about 8 months to start laying.

If day-old ducklings are available they should be purchased and brooded in the same way and under the same temperatures as chicks. But because of their rapid growth they require twice as much floor space.

Since the ducklings spill a great deal of water and slop their food about to make a mess of the brooder, it is advantageous to have one end of the brooder on wire, separated from the sleeping quarters by a planked wall or wire-netting partition with pop holes through which the ducklings come and go. Taking this precaution will save the ducklings from catching cold and dying of chills to which they are very susceptible till they grow their oily feathers in the 6th week.

As ducklings eat a lot of grass they should have access to a grass run from the time they are 3 days old. In addition they should be given 5 feeds of chick mash a day during the first week, reduced to 3 feeds during the 4th and 5th weeks. In the 6th week they can be transferred to the range shelter. Thereafter, they are given only 2 - 3 feeds a day depending on size of range. When plenty of range is available only two feeds are necessary—one in the morning as they are released from their shelter for the day, and the other in the evening before they are locked up again. If the range available is small a mid-day meal will also be necessary.

FEEDS: Ducks may be fed the same mashes as chicks, growers and laying hens—the chick mash up to 6 weeks, the grower mash from 7 weeks - 20 weeks and the layer mash thereafter. It is important to remember, however, that ducks require more protein than hens. For this reason they must be given 7 lb of extra fish meal for every 100 lb of mash. The fish meal must be well mixed with the mash.

Duck mashes are always fed moist. Sufficient water should be added to make the material stick together, but the feed should not be so wet as to make it sloppy. If fish meal is difficult to supply meat scraps may be given instead.

Drinking vessels should be kept near the feeders because the ducks move to and fro between the two to wash their beaks of the sticky mash. But as the birds are liable to get into the vessels and make a mess of the water see that they are protected by wire. Instead of a wire guard, you can put a number of stones into the water vessels to prevent the ducks getting in.

SWIMMING WATER: A pond is not necessary for swimming unless you want to produce hatching eggs of high fertility, since ducks mate freely in water and a high degree of hatchability is assured if a pond is available for swimming. But otherwise a pond is not a pre-requisite for duck-rearing. Water, however, should be provided in a trough of some sort because ducks need to wash their eyes and bills regularly in water. If they cannot do this they go off condition quickly.

HATCHING EGGS: The selection of breeding stock is important. Ducks are best bred when they are between one and three years old. Apart from having all the desirable characteristics of the breed they should be fit and active. No bird of either sex which shows signs of moulting should be selected for breeding.

The ideal number of ducks to mate with each drake varies with the age of the male and whether the birds have access to swimming water. A pool is particularly important since the birds mate freely in water and this ensures a much higher degree of fertility in the eggs.

On an average six ducks may be mated to a drake. The number may be increased to eight if the drake is young and vigorous. As ducks usually lay in the night or early morning, it is necessary to confine them to a run or house until about 9 a.m. during this period or many of the eggs may be laid in the pool and thereby lost.

Do not set the first batch of eggs laid by the ducks as these are often infertile or result in the birth of weak ducklings. *Even when later batches of eggs are used they should not be stored for longer than one week before being hatched since the older the eggs the less are the chances of obtaining a good hatch.*

An important point to remember is that the " Muscovy" is distinct from all other breeds of duck and will always remain distinct, because even if it is crossed with any other breed, the progeny will be "mule" ducks, i.e. they will be incapable of reproduction.

The " Muscovy" is also the only duck that will breed equally well with or without access to a swimming pool. Other breeds mate freely only in the water.

The best hatching eggs are those which weigh about 3 ounces each. They may be collected every morning and stored in a cool, dry place up to a week without affecting the hatchability. Longer periods bring about a deterioration of the germ with consequent loss in the number of eggs hatched or the health of the ducklings.

Dirty eggs do not hatch well, so pay particular attention to cleanliness in the nests by changing the litter regularly. But, however punctilious one may be in this practice, ducks being naturally messy birds, some eggs are bound to get soiled. These should be washed in warm water as soon as possible after laying.

Since duck eggs require a lot of moisture to hatch successfully, special care must be taken to sprinkle the eggs regularly with warm water if they are incubated under a hen or in an incubator.

Every time the hen comes off the clutch to feed or stretch her limbs, the eggs should be sprinkled with warm water. This is not necessary in the case of a broody duck because this bird will moisten her feathers before she returns to the nest.

With artificial incubation, the temperature should be about 102°F. The humidity must be maintained by keeping the trays full of water at all times. After setting the eggs in the incubator they should not be disturbed for 48 hours. Thereafter, they should be turned twice daily and sprinkled with warm water till "chipping" commences on the 28th day in all breeds, except the "Muscovy" which takes one week longer. As soon as "chipping" commences a piece of flannel wrung out in hot water should be spread over the eggs till the hatch is complete.

DISEASES: More ducklings die from "sun stroke" and "staggers" than they do of disease. The back of a young duck's neck and head is very sparsely covered and hot sun can completely prostrate a bird very quickly. For this reason see that there is enough shade in the pens. It is a wise thing to put water troughs under a shade tree, because the ducks spend a great deal of time during the day either drinking or bathing their eyes and bills. This way they are assured of protection from the sun.

"Staggers" is caused by ducklings gorging themselves with water. They generally do this if they have been deprived of water for some time. Gorged with water they stagger about and die. To prevent this happening ensure that water is available in plenty at all times of the day.

Turkeys

One branch of the poultry industry that does not seem to have made rapid strides of development is turkey-raising. This is understandable since prohibitive prices have prevented most people from indulging in regular feasts of this delicious meat.

Yet there are many poultry fanciers who are raising small flocks of turkeys to meet the demand of a specialised market around Christmas and other festive occasions or would like to keep a few birds to satisfy their own table requirements.

Turkey-raising is something of a speciality and requires a somewhat different system from that of rearing ordinary domestic fowls, but the important differences are few and easily mastered.

The first difference is that unlike the fattener of table chickens who is able to buy his chicks as day-olds, the turkey fancier must necessarily incubate his own stock since there is no day-old poult trade in this country.

HATCHING EGGS: The first pre-requisite of good incubation is good eggs. Weight, shape and shell texture are important criteria of selection. It is necessary to reject mis-shapen oversized or undersized and poorly textured eggs.

Expeiiments have indicated that without question the best weight for hatching eggs is three ounces, since hatchability—at its best 60 per cent—drops when the weight is above or below this figure.

Even more important is the shape of the egg. Flat-sided or narrow eggs give rise to dead-in-the-shell chicks owing to the embryo being in the wrong position at hatching time. The ideal type of egg is that which is broad at one end tapering off to a round point at the other.

The shell should be firm and hard. Rough "spots" of pigmented calcium which are natural in many turkey eggs do not effect hatchability, but eggs with rough and porous shells should not be selected for hatching.

To ensure a good hatch do not use eggs which are more than a week old. During this period the eggs should be stored in a cool and airy place after washing in warm water to clean the shells of dirt. Do not wipe the eggs dry with a cloth, but allow them to dry quickly on a wire tray.

The eggs may be hatched under a turkey hen or ordinary domestic fowl, but generally the poults (as the young chicks are known) thrive better with a turkey hen. Not more than 15 eggs should be given to a turkey hen and not more than ten to an ordinary hen.

Since turkey eggs take 28 days to hatch—one week longer than chicken eggs—care should be taken to select a good broody hen that will be prepared to sit on the nest through the longer period. Food, water and grit should be put down near the nest so that the hen can come off and feed at will. Do not give mash. Grain feeds are best during the period of incubation.

BROODING: If, on the other hand, you prefer to purchase the poults from a hatcheryman, it will be necessary to brood them artificially in much the same way as ordinary chicks, except that they require twice as much floor space, i.e. 12 sq. in. at the day-old stage, which should be gradually increased to one sq. ft. at the end of two months, after which the birds may be allowed free range. Poults can be weaned off heat in 4 - 6 weeks, depending on the weather.

Up to the age of two months, the poults are subject to colds—the first symptoms are a swelling on one or both sides of the head accompanied by watering eyes and nostrils. To reduce the swelling, bathe the head daily in warm water to which a little boracic acid is added. Also, give daily to each affected bird, until better, three drops of chlorodyne in a teaspoonful of sweet oil and add some chopped onion to the mash in the morning.

GRASS RANGE: Since turkeys are extremely hardy after the first few weeks of growth they can be reared on grass in the open. The grass range system of management is particularly suited to those people who are fortunate to have large gardens. An acre of land rich in grass will be sufficient to rear up to 100 turkeys.

The young turkeys are moved to the grass range when they are 7 - 12 weeks old. The grass run should be one in which chickens have not been reared before for at least two years. This will eliminate the risk of disease infection since chickens often harbour "blackhead" and other disease-producing organisms which can cause serious losses in turkeys.

"Blackhead" attacks turkeys when they are 6 - 12 weeks old. Symptoms are drowsiness, drooping wings, ruffled plumage and sulphur-coloured droppings. Sometimes the head is also blackened. Mortality can be very high. Entramin mixed in the mash will cure the disease. As a preventive measure a lower concentration of Entramin may be fed with the mash throughout the susceptible period from six to twelve weeks.

Normal equipment for a grass run will consist of feed and water troughs, and perches which are erected in a protected part of the compound. No permanent building need be constructed to house the turkeys, although a simple roof-type of structure may be provided above the perches to protect the birds during bad weather.

FEED: In addition to good grass range, a simple ration consisting of 6 - 7 parts of ground cereal, 2 - 3 parts coconut meal and 1 part fish meal should be fed to the birds in the morning. It should be mixed to a crumbly consistency with water. A large handful should be enough for an adult. The same ration may be fed to the poults with a little milk during the first few weeks of brooding. Whenever grass is scarce a mid-day meal of chopped green leaves should also be given. Flint grit and shell grit and a clean trough of drinking water should always be made available at the regular feeding point.

Turkeys to be fattened for the table should be confined for 3 weeks in an open shed or garage and fed a fattening diet of ground paddy and maize meal worked into a wet mash with boiled potatoes and some milk. Two feeds a day of this ration and a mid-day meal of green stuff will put the birds into good heavy condition.

BREEDING BIRDS: Careful selection of breeding birds is very essential to produce good replacement stock. Only the very cream of the flock should be bred from. Select vigorous and healthy birds with long straight breast bones.

Age is an important factor in selecting male breeding stock. Turkey cocks reach a point of sexual maturity in most strains between nine months and one year. After this there is a tendency to regress and regressed males can be very infertile for several days or even weeks after they are introduced to the hens.

Very small or overgrown birds should on no account be selected. The craze for size does harm especially if heavy males are used. The ideal selection for breeding purposes would be female turkeys over eight months and a male just over nine months of age. Ten to twelve hens may be mated to a vigorous cock.

A final word of warning! Avoid inbreeding. Since sturdy vitality is one of the prime factors of insuring success, try to introduce fresh blood every once in two or three years. A few rupees spent on getting a new stock of eggs from a healthy and vigorous flock will be money well invested.

Among the common breeds there are the small-type turkeys like the "Beltsville White" and "Norfork Black", which attain a market weight of 10 - 15 lb at 16 weeks of age. "Bronze" turkeys and the "Broad-breasted Bronze" have a market-weight of 25 lb and upwards.

BEE - KEEPING

Bee-keeping is a fascinating pursuit which combines pleasure with profit. It can be undertaken by practically anyone because it does not involve large capital investment or intensive labour.

Initially the only expenditure involved is on the purchase of a colonised hive or hives. Thereafter the recurrent expenditure is negligible. Moreover, the labour involved in bee-keeping is light, for in this business the bees are the labourers. The bee-keeper's labour is confined to a few routine manipulations which are so easy to master that they can be efficiently carried out by women and children in their spare time.

The beginner in bee-keeping should start with not less than two hives. A minimum of two hives is recommended because in the event of some mishap, such as loss of the queen occurring in one, advantages may be obtained from the other. The number of hives can be increased later when some experience has been gained.

TYPES OF BEES: Three kinds of honey bees are found in Lanka. They are the rock bee or *bambara*, the little bee or *danduvalmessa* and the hive bee or *meemessa*.

Bambaras build large single combs 2 - 3 ft long in the open—on overhanging rocks, e.g. Sigiriya, in the eaves of high buildings and on the branches of big trees. On account of this open-air nesting habit, a migratory nature and a very aggressive temperament, these bees are not domesticated. The *danduvalmessa*, although quite tractable, is also an open-air dweller like the *bambara* and cannot be confined to a box. Moreover, these bees are not economical to keep because they build small combs (slightly larger than the palm of the hand) containing very little honey.

On the other hand, the hive bees (*meemessa*) build their combs in hollow trees etc. This instinct has been exploited by the bee-keeper to raise these bees in wooden boxes or artificial hives, where they are induced to build medium-sized combs which produce economic yields of honey on proper management. Hive bees are also of an equable temperament and can be managed easily. It is with these bees and their management, therefore, that we shall be concerned in this handbook.

In passing, it is necessary to mention that the counterpart of the *meemessa* or local honey bee (*Apis indica*) is the western honey bee (*Apis mellifera*), which is found in temperate countries. In their native habitat western bees produce 10 - 15 times the quantity of honey produced by the local bee, but in a tropical country like ours they are unable to do this because the short honey flow seasons that obtain here do not permit them sufficient time in which to gather the honey that they need even to subsist. Consequently, the bee-keeper will be compelled to keep them alive by feeding as much as 50 - 60 lb of sugar syrup per hive annually—a thoroughly uneconomic position.

LIFE IN THE BEE COLONY: To understand bee management it is necessary to have a basic knowledge of how these insects live.

Honey bees are social insects living in a colony comprising 4,000 - 10,000 members depending on season and locality—the greatest strength being found at the approach of the two honey seasons in February - March and July - August.

Three types of bees are found in a colony, viz., the queen, the drones or male bees and the workers.

There is only one queen and her sole function is to lay eggs after she has been successfully mated by one of the drones. She is easily distinguished from the other members of the hive because she is the biggest bee by virtue of her long and distended belly (full of eggs) and by the fact that the wings do not cover her entire body as in the case of the other bees. The queen lays two types of eggs—fertilized and unfertilized. The former produce the workers and the latter the drones.

The eggs are small, elongated, white objects attached to the bottom of a cell. They hatch in 3 days. The cells are sealed in a week. Queen bees come out in 6 - 7 days after sealing, workers in 11 - 12 days and drones in 12 - 14 days.

Drones are larger than worker bees and are jet black without any band marks on their bodies. Their sole function is to mate with the new queen. After this function is performed they become a burden on the rest of the colony, which is why one often sees them being driven out of the hive in time of food scarcity.

Workers, as their name implies, do all the work in the colony. This includes caring for the young bees in the larval and pupal stages, fetching honey and pollen, ripening the honey and protecting the hive from marauding bees, wasps and other pests. By virtue of the diversity of the functions they perform, the workers comprise the majority of the colony.

HOW HONEY & WAX ARE PREPARED: Worker bees suck the nectar from the flowers and this is converted by enzymic action into the simple sugars contained in the honey we eat. When they return to the hive from a foraging expedition, the bees regurgitate the converted honey into the cells of the combs that they have prepared for this purpose. In this stage the honey is unripe. Condensation and ripening is brought about by the young worker bees in the hive who use their wings to "fan" the honey. After the excess moisture is evaporated by this process of "fanning" the cells are sealed with a thin covering of wax.

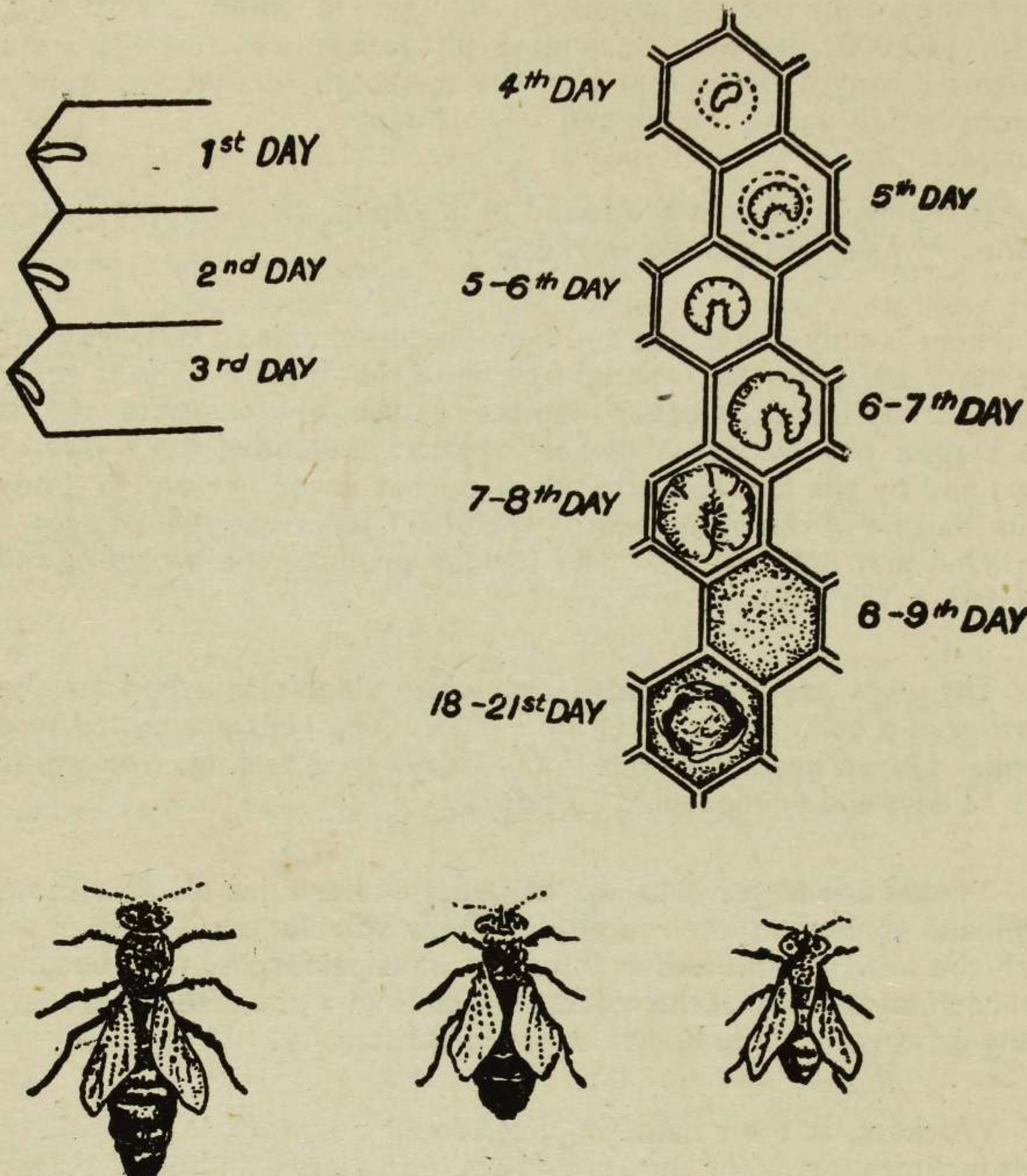


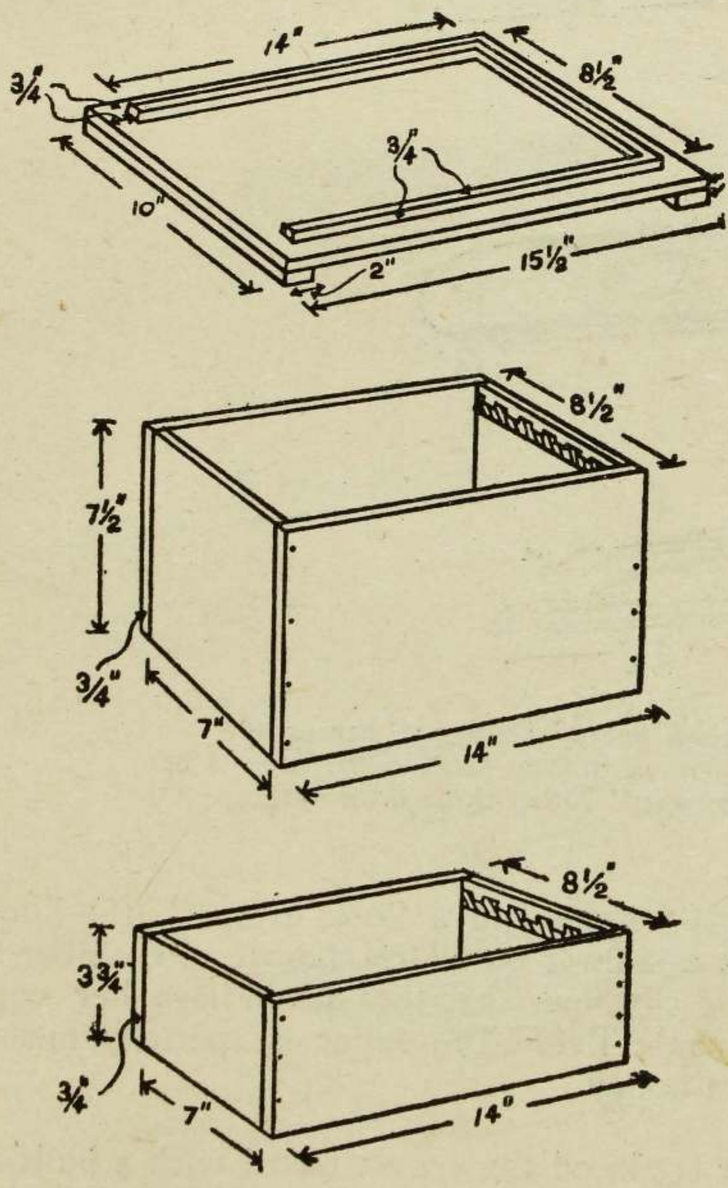
Fig. 7·10

Stages in the life of a bee from egg to adult

Honey is first stored alongside the pollen at the top and in the corners of the brood combs as food to be used for the developing brood. In the dry season, however, when there are plenty of flowers, surplus honey is stored in special honey combs provided by the bee-keeper in the super or second compartment above the brood box. It is this honey that is finally extracted.

Wax is made in the bodies of the bees. It is used to construct the combs in the hive. Bees have to use a considerable amount of honey to do this—as much as 10 to 15 lb to produce the brood nest. This is why modern bee-keepers supply the bees with wax comb - foundation sheets, so that they can construct the combs quickly without heavy consumption of honey.

BEE BOX: The chief feature of the modern bee box is the provision of separate vertical frames on which the combs are built. Each of these frames can be removed independently by the bee-keeper for examination. The frames are placed 3/8 inch apart, allowing just enough space for the bees to work uninterrupted and uncongested. If this minimum space is not provided they will build irregular combs which prevent removal of the frames either for examination of honey extraction without cutting them.



BEE BOX — Floor Board (top), Brood Box (middle) and Super or Honey Chamber (bottom).

Parts of the bee box.

Fig. 7·11

The recommended bee box used in this country is small because it is cheaper and easier to manipulate. It is comprised of the following parts: (1) Bottom Board, (2) Brood Chamber with six movable frames, (3) Super or Honey Chamber, also with six movable frames which are smaller than those found in the brood chamber, (4) Crown

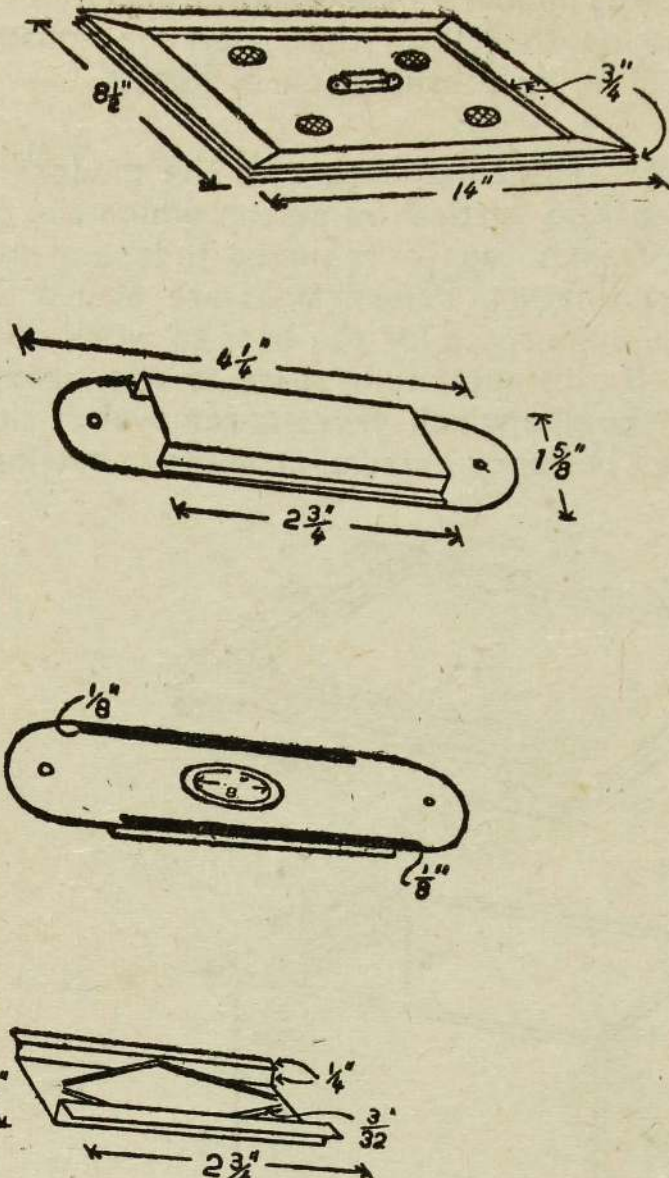


Fig. 7.12

BEE BOX — Crown board showing "bee escape" surrounded by four ventilation holes (top); Aspects of the "bee escape" (other three drawings).

Board with four ventilation holes and a "bee escape", (5) Roof. The bottom board serves as a floor on which the brood chamber is placed. It is in the brood chamber that the queen lays her eggs and the workers and drones live. The super is specially meant for the storage of surplus honey.

On top of the super is placed the crown board with a built-in "bee escape". This serves the function of a ceiling. Besides providing additional protection from the elements, this cover has a special function to perform when one wishes to get rid of the bees from the super at the time of honey collection. This will be discussed later under the section entitled "Harvesting and Handling Honey".

The bee box must be made of seasoned soft timber and accurately constructed. Frames should be well made according to exact dimensions and the bee space should be correct. The roof should be leak-proof, i.e. it should be of wood covered with rubberoid or galvanised iron sheet.

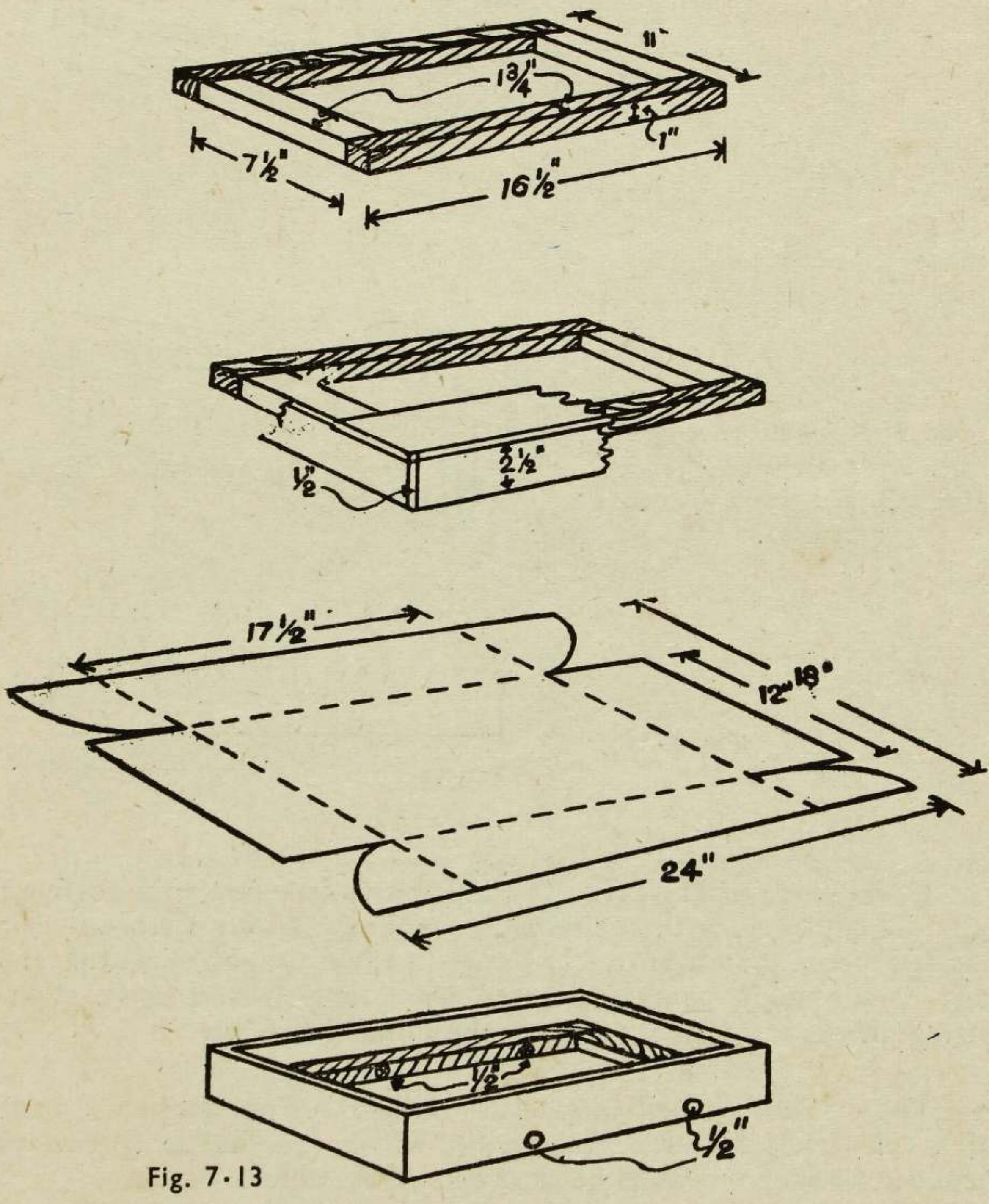
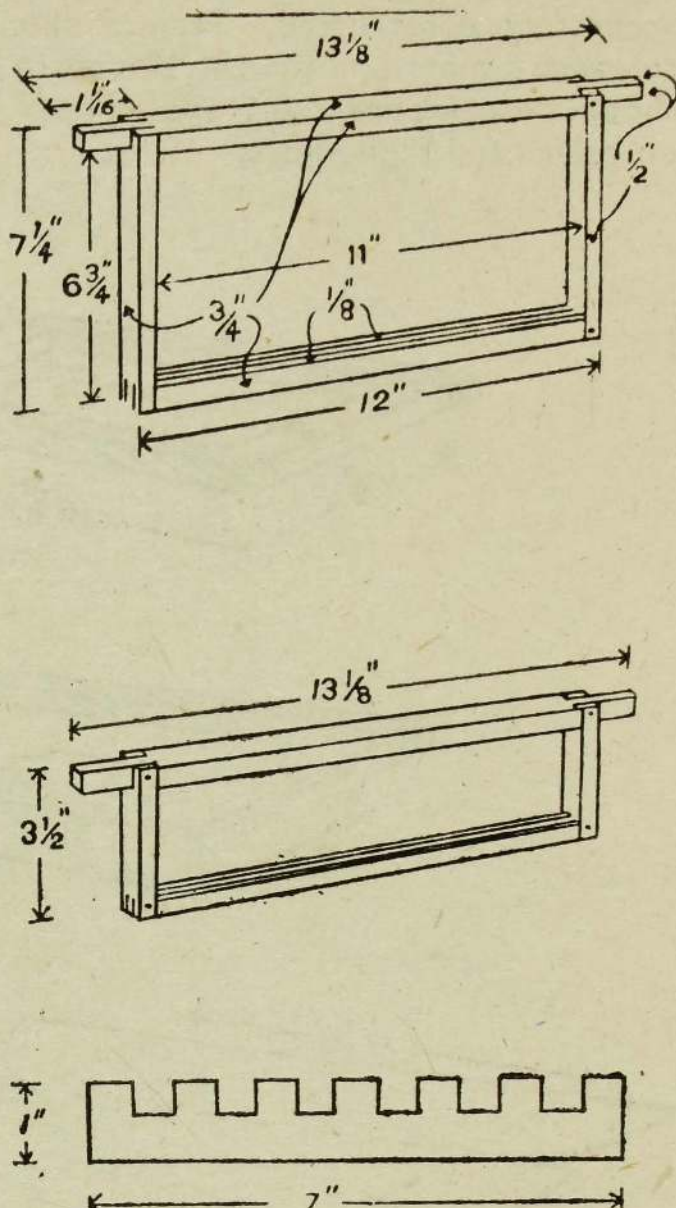


Fig. 7·13

BEE BOX — Various drawings of roof showing wooden frame, rubberoid covering and wooden frame covered with rubberoid (from top to bottom).



BEE BOX — Brood frame (top), Super or Honey Frame (middle); and Spacing Rack (bottom).

Fig. 7·14

OTHER EQUIPMENT: In addition to bee box, the beginner must be equipped with bee veil and smoker. A veil is worn over a hat as a protection against bee-stings in the neck and face area, the rest of the body being protected by a long-sleeved shirt, tight-fitting gloves and long trousers tucked into the socks.

The smoker is used to subdue the bees. The smoker is made of a cylindrical metal container (in which the fuel is ignited to produce smoke) and small bellows to puff the smoke out.

A hand-operated centrifugal honey extractor is another useful piece of equipment. It consists of a cylindrical metal drum with pockets inside, into which the frames filled with honey combs are placed after uncapping. These pockets are rotated around a vertical rod. The centrifugal force generated throws out the

SMOKER

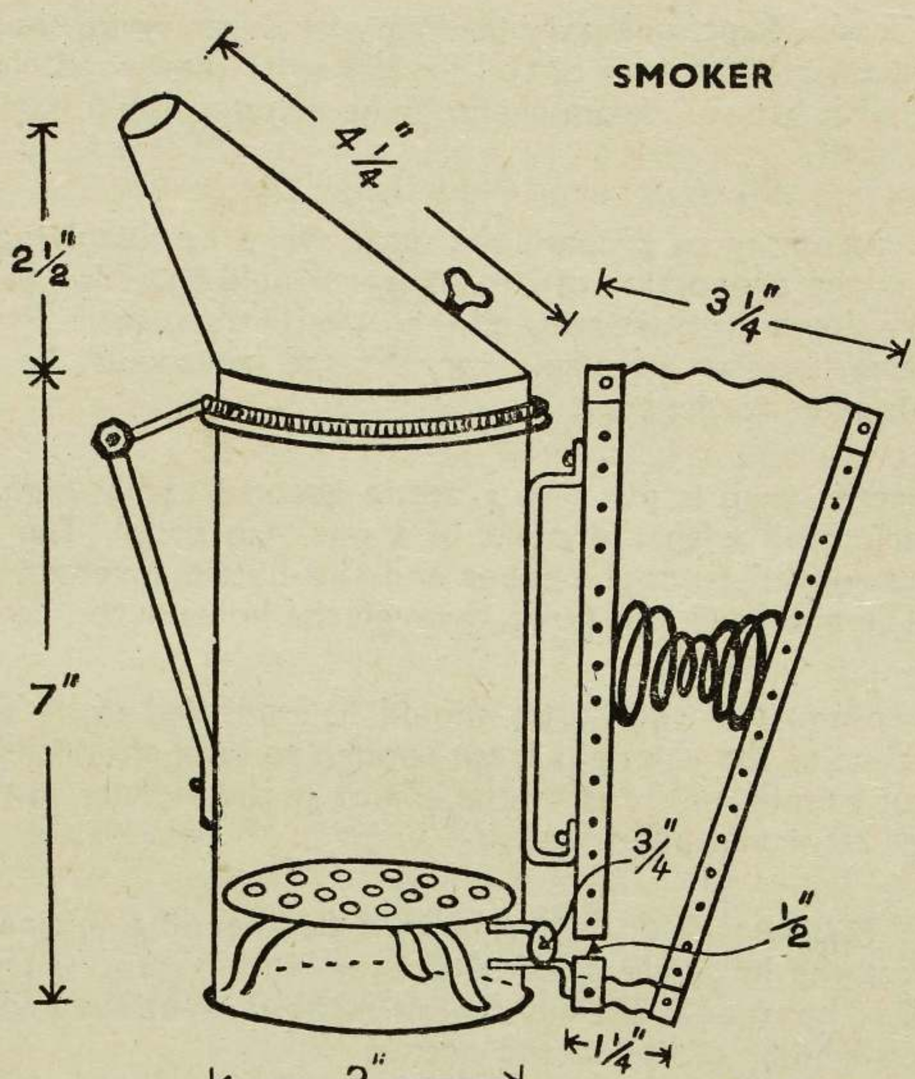


Fig. 7·15

honey which drops down inside the drum and is cleared through a hole in the bottom.

By using such an extractor it is possible not only to remove the honey without bits and pieces of comb, but more important, the combs are left undamaged and may be used again in the hive, thus allowing the bees to get a flying start in the next honey storing season.

If the combs are crushed in extracting the honey and cannot be used again in the hive, this means that the bees will have to waste a lot of honey to build the new wax combs.

HOW TO START: Hiving a wild swarm is something that need not be attempted by the beginner, who will be far better off purchasing a nucleus colony.

A nucleus colony consists of two brood combs of bees plus queen—one comb should be full of brood and the other well stocked with bee feed. Supplementary feeding with sugar syrup should be carried on till at least four of the six frames in the brood chamber are filled with brood. From then on the colony should be able to fend for itself.

It is customary to prepare the sugar syrup by dissolving sugar in water in the proportion of 2:1. Sugar should be added to warm water very slowly while stirring all the time till the sugar is dissolved. Warm water helps to dissolve sugar, but the syrup must be cooled before it is given to the bees.

Prepared syrup is put into a bottle about 3 inches high. The cap is perforated with the point of a one-inch nail. The frames are now removed from the super and the bottle inverted in this space. The bees suck the syrup through the holes in the lid.

The contents of the bottle should be renewed every evening till such time as the colony is large enough to look after itself. Be careful not to spill the syrup on the box or in the vicinity as this will invariably attract robber bees.

BEE FLORA: The first step in a bee-keeping project is to ensure that the hives are sited in an area where there is plenty of bee food. The amount of surplus honey stored in the super depends on the availability of pollen and nectar.

There must be plenty of nectar-bearing flowers within a radius of 750 yards of the hive because this is the maximum flight range of the bees.

In addition to the red and blue gum trees found in the wet up-country and coconut trees in the wet low-country which flower all the year round, bees gather larger quantities of nectar seasonally from coffee, glyricidia, albizzia, rubber, cashew, *mee* etc. In the dry zone there is a fine honey flow season during the dry months from February to April when the gingelly or mustard crop is on the land and the forest trees burst into flower after the *maha* rains from October to December.

But in home gardens in towns and urban areas where the great bulk of this type of flora does not exist, there if often a dearth of bee food, especially during the persistent rainy periods from May to July and October to November. In such places it is advisable to grow a few creepers of the Wood Rose (*Ipomea tuberosa*) in the garden. These plants bloom all the year round—the waxy yellow flowers yielding copious quantities of nectar.

Maximum advantage from one's colonies can be derived by moving them from one place to another according to the flora sequence. For example, in the colder months in the hills when forage is scarce the colonies may be moved to the warm mid-country, and taken back when conditions in the hills improve.

Moving the hives is no problem. All you have to do is to fasten the hive with a band of steel, using a hand stapler and carry it to the car or truck in which you hope to transport it. The hive should be stapled at night after the bees have returned. The entrance guard should be inverted and placed in position to prevent the bees leaving the hive.

SITING THE HIVE: It is important to use good judgement in siting the hive. Protect it from direct winds and the direct rays of the sun. A south-easterly or north-westerly facing is best, and if there is no natural shade some form of artificial shade should be provided.

Place the hive on a stand 3 ft above ground level to keep it off the damp ground and away from pests. The stand should be treated with a suitable insecticide which should be applied with a brush in the undiluted form. If ants are troublesome some 10% BHC dust may be dusted around the base of the stand.

Clear the ground of all vegetation within 3 feet of the site and cut away any low-hanging branches which may serve as a nesting place for red ants (*dimiya*).

Implant the stand firmly and straight to ensure that perpendicular frames and uniform parallel combs of honey are built by the bees. Secure the bee box to the stand by tying it with a rope to prevent it being blown over or toppled by animals, particularly cattle grazing in coconut estates.

EXAMINING THE HIVE: A tendency to open the hive frequently and see what happens in it is bad. The less a working hive is disturbed the better the activities of the bees will be. However, it is necessary to open the hive now and again to see if brood development is progressing satisfactorily, to check on pests, to find out whether the colony plans to swarm and also to remove the honey for extraction.

The best time for opening the hive with least disturbance to the bees is when they are actively engaged in foraging on a bright day.

The smoker should be filled with wood shavings, bits of card-board or old rags. This material is set alight and allowed to burn slowly, producing puffs of smoke when the bellows are pressed.

Begin by blowing a puff of smoke across the entrance of the hive but not into it. This will quieten the guard bees. Then gently lift the roof and super and blow a puff of smoke across the top of the brood chamber.

With the first puff of smoke you will notice a difference in the quality of the hum of the bees. When this settles to a quiet uniform buzz in a minute or two (if not give another puff of smoke) you may remove the roof and super and crown board and place them on the floor. Proceed to examine the frames in the brood box.

A word of advice. Beginners tend to use too much smoke. Don't. This only makes the bees run about all over the frames in fright making it practically impossible to examine the frames. To keep the bees subdued, if they 'boil up', cover the frames with a piece of cloth—except at the end where you are examining the frames. Go through them one by one and see how the brood nest is arranged. It may be in two to six frames with the central frames almost full of brood and the least amount in the other outer combs.

As this is your first lesson in practice you may not be able to locate the queen—but you will eventually, when you gain more experience.

A good queen lays eggs in regular circles. Starting at the centre of the comb she lays her eggs in a spiral until the area of brood covers almost the whole frame of comb with just a border of honey and bee bread (pollen) around the edges.

The brood develops and emerges in the same order in which the eggs are laid. A typical frame will therefore show unsealed cells with eggs and larvae, sealed cells with pupae and adult bees emerging from sealed cells. If you see the queen's handiwork as described above that is enough; do not be concerned if you fail to find her on any particular occasion.

Act deliberately at all times and without nervousness when handling the frames lest you unconsciously move jerkily and cause the bees to reciprocate your own fears. And if you do not want to get stung keep the smoker going, i.e. give it a little puff now and again to keep the fuel burning. On no account should you put it down and forget about it because in case you need it in a hurry you may find that the fire is out—and this might mean you retreating in poor order.

HOW TO PREVENT SWARMING: A colony of bees will split itself into a number of smaller colonies once a year during the dry season in February to April when the colony is at its greatest strength. This is known as "swarming". It is a natural phenomenon whereby provision is made for the procreation and survival of the species.

Unfortunately for the bee-keeper this happens at the height of the honey flow season, with the result that the depleted colonies are unable to make the maximum use of this time to build up their surplus stocks of honey.

If a good harvest of honey is to be expected a large work force of bees should be in the hive during the honey flow season. This means that something must be done to prevent the bees from following their natural instinct of swarming. The answer is "re-queening" or the replacement of the old queen by a new queen before the onset of the honey flow season, i.e. in January every year.

The old queen must be removed with a frame of brood and a frame of honey and pollen stores to an empty bee box at least 400 yards away from the original site. The bee box should be supplied with adequate brood combs and the colony fed with sugar syrup (as explained before) to offset temporary absence of foraging worker bees. A queen-guard should be kept at entrance for at least one week until the risk of absconding is eliminated.

Re-queening should be done within 3 weeks of the appearance of typical drone cells on combs, i.e. large capped cells which stand out of the comb in contrast to the surrounding worker brood cells. With the loss of the old queen the workers will start building a queen cell at the bottom of the brood combs. This cell is easily recognised because it is larger than any other brood cell and is shaped like a peanut or thimble.

The new queen should be out in 14 days and mated in another 3 - 4 days. If, however, re-queening does not take place within a month the two colonies should be rejoined and the bee-keeper is advised to seek expert advice.

ABSCONDING & WHAT TO DO ABOUT IT: Colonies, however, do not always split up normally as a result of swarming. Sometimes, the entire colony is compelled to leave the hive because of lack of food or trouble from pests. When bees leave the hive in these circumstances they are said to "abscond".

During the persistent wet spells that occur in this country from May to July and again from October to November there is an insufficiency of food for brood-rearing. At this time a colony is likely to "abscond" in search of new pastures unless supplementary feeding is carried out with sugar syrup as described before.

Insects are another cause of absconding. The wasp (*debara*) preys on bees at the hive entrance while red ants (*dimiya*) too are a nuisance at times. Be sure, therefore, to see that all wasps and red ants nests in the neighbourhood are destroyed.

Larvae of the wax moth damage the combs by tunnelling into them, particularly in the rainy season when all the combs are not completely covered with bees. Such combs will have to be removed and new foundation sheets given to the bees to re-build their combs.

HARVESTING & HANDLING HONEY: Theoretically, the honey frames should be removed from the hives for extraction when all the cells in them are sealed. But in practice this is not always possible. Hence, the frames are removed when they are about two-thirds filled.

To remove honey without smoking the bees, it would be best for you to use a "bee-escape"—a device fitted to the crown board which permits the bees a one-way passage only, i.e. they can go from the super into the brood box but cannot return the same way.

To insert the crown board with "bee-escape", tilt the super up at one end with one hand, while with the other you blow a few puffs of smoke to make the bees retire. Then you remove the crown board and slide it gently between super and brood chamber, being careful to have it right side up. Let the super down slowly and bring the various parts of the box into alignment.

If this is done before the honey flow has begun seriously to diminish, the bees above the "escape" will not be likely to cut open the sealed honey combs. The use of a minimum amount of smoke also helps to prevent the bees gorging themselves with honey.

Put the "bee escape board" in position in the evening. During the night the bees will leave and they cannot get back. The next morning the super will be ready to come off with but few bees in them. Cappings are then removed with a sharp knife and the combs are placed in a honey extractor.

If you are operating the extractor by hand, turn it slowly till about half the honey is thrown out on one side of the combs. Stop the extractor and reverse the frames. Make another slow start but gradually build up speed to a maximum. This will get the second side of the combs as clean as possible. Reverse the combs again and get the rest of the honey out of the first side.

Strain the honey through a piece of cloth and pour into clear bottles. Honey is slightly acidic and, therefore, cannot be stored in utensils of iron, brass, copper, etc.

Yields of 6 - 8 lb of honey per hive per year are average in the low-country. Higher yields have been recorded in the up-country viz., 20 - 25 lb in the Bandarawela area.

APPENDICES

1. Crop-diversification in Plantation Agriculture
2. Mixed Farming in Plantation Agriculture
3. Recent Research on Grass and Legumes in the Mid-Country and Coconut Triangle
4. Ipil-Ipil as a partial substitute for Coconut Poonac
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9. Mechanisation of Farm Operations in Hours and Acres per day
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15. Nutrient Analyses of Local Leafy Vegetables
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I. CROP DIVERSIFICATION IN PLANTATION AGRICULTURE

Of course there is a silver lining somewhere, but I do not think that any reasonable person can draw much comfort from the thought that plantation agriculture in Sri Lanka is going to be the sinecure it was in the pre-world war II period.

One does not have to be a very close student of economics to know that tea, rubber and coconut have reached the ecological limit of exploitation so far as increasing the area under cultivation is concerned. These plantations are also faced with a static or declining international market for their primary products.

In the circumstances, it becomes necessary to look for a more profitable pattern of agriculture which will give a more profitable return on land and capital. Crop diversification is one way to achieve this objective.

Take tea for example. The international tea market is known to be fiercely competitive. To keep in front we must find ways and means of reducing the cost of production of a pound of tea. One way to do this would be to intensify tea cultivation so as to achieve higher yields from fewer acres.

REDUCING THE EXTENT UNDER TEA . . . In fact the Tea Commission recommended this step in 1968. Their proposal was to gradually replant the existing seedling tea area with more productive vegetatively-propagated tea or VP tea. Since VP tea is expected to up the yield by three times, the Commission accordingly came to the conclusion that the present acreage should be reduced by two-thirds, so that ultimately, there would be only 200,000 acres of VP tea giving the same out-turn as 600,000 acres of seedling tea.

But although the Tea Commission make this announcement in all good faith, subsequent investigations by the Tea Research Institute have revealed that many tea estates replanted with VP tea have not produced much more than when they were originally planted with seedling tea. This means that the total area going out of tea production finally may not be as large as anticipated. In fact, revised estimates indicate that only 120,000 acres may go out of production by 1985, provided the VP replanting programme goes according to plan.

The point is: what do we do with these tea acres that ultimately go out of production? Now, if a crop-diversification programme were to be adopted, then uneconomic or marginal tea lands could be gradually replanted with alternative crops that either have an export market or import-substitution potential.

REPLACING UNECONOMIC TEA WITH CLOVES . . . For instance, old tea can be gradually replanted with cloves. After 5 years 20 per cent of the tea may be uprooted around the developing clove trees. A further 30 per cent may be removed when the cloves are 8 years old, and the balance completely uprooted when the cloves are 10 years old.

There is no loss of income because one-acre of clove fetches just as much or more than one-acre of tea, and the process of replanting is gradual—tea continuing to be produced in diminishing quantities up to the 10th year and cloves coming into production in the 5th - 6th year, increasing to a maximum in 15 - 20 years.

REPLACING UNECONOMIC TEA WITH OTHER CROPS . . . Other alternative crops that have been recommended for diversifying tea are pepper, nutmeg, cocoa, coffee, pineapple, passion fruit, mulberry for silk production and improved grasses for milk production. The recommended practice would be to grow a combination of these crops in a three-tier system simulating natural tropical conditions.

Uneconomic tea, for instance, may be gradually replaced with cocoa or coffee as the main crop. Pepper may be trained to grow on the shade trees provided for cocoa or coffee as an additional crop, and until such time as the cocoa or coffee and the pepper come into bearing intercrops of pineapple, banana or passion fruit may be taken. These intercrops will give an income from the 2nd - 5th year. From then the coffee, cocoa and pepper will give an income for 15 - 20 years.

ADVANTAGES OF SUCH DIVERSIFICATION . . . There are several advantages in this form of crop diversification. Apart from the maximum utilization of land and natural resources such as sun energy and rainfall, this system assures a quick return on your investment from the interplanted short-term crops during the early unproductive phase of the main crop. This is important because very few investors are prepared to sacrifice their current income from tea and also face a capital drain while they wait 5 - 6 years for returns from their new crops. Furthermore, having an extra crop like pepper helps to spread the risk of market fluctuations in the price of the main crop.

CROP-DIVERSIFICATION & EMPLOYMENT . . . So much for land and capital! What about employment? How does a crop-diversification programme in unproductive tea land affect the employment situation? That depends. Because some crops are more labour-intensive than others. Tea is a suitably labour-intensive crop with 220-250 man days per acre per year. But mulberry is even more labour-intensive with 450 man days up to the stage of cocoon formation. The cultivation of improved varieties of pasture and fodder that are meant to be cut and stall-fed (zero-grazing) to cattle is also highly labour intensive with about 300 man days.

On the other hand, the spice crops viz., pepper, cloves and nutmeg are not very labour-intensive. Pepper and nutmeg require about 85 - 90 man days and clove only 20 man days. Cocoa, coffee, pineapple and passion fruit are moderately labour intensive: they find a place between mulberry and the grasses on the one hand and the spices on the other. If the need to provide a high level of employment is a necessary component of the crop diversification programme in tea, then it would be necessary to select labour-intensive crops for cultivation, provided of course that they are otherwise suitable.

RUBBER & COCONUT . . . What applies to tea, applies to rubber and coconut too, although to a lesser degree in rubber since the rubber market is more resilient. Pineapple and passion fruit may be interplanted in young rubber holdings until the rubber begins to give an economic return. Coffee and cocoa may be underplanted in adult-rubber.

A wide range of alternative crops may be used with coconut. There are one-million acres of coconut. This capital stock supports a work force of about 100,000 at present—that is, one worker to every 10 acres. On the other hand, the work force in tea is one worker per acre. If, therefore, coconut could be widely diversified with alternative crops, then the labour intensity per acre could be increased considerably and brought closer to tea. This would mean an increased work force of up to about one-million in coconut lands—a significant breakthrough in the employment potential of agriculture in the wet zone. In the circumstances, let us look a little more closely at crop-diversification in coconut.

C. R. I. TRIALS . . . Crop-diversification in coconut land is not a new idea. Traditionally, small-holders have intercropped coconut with manioc and *kiri-ala*, pineapple, bananas, and also condiments like turmeric and ginger. And today the Coconut Research Institute has accepted this idea.

In fact, the Research Officers of this Institute are presently engaged in conducting a number of trials to study inter-cropping patterns with several other seasonal crops viz., sweet potato and dioscorea yams, pulses, chillies, vegetables, castor, passion fruit and permanent crops like coffee, cocoa and pepper.

Trials with manioc and *kiri-ala* have shown quite conclusively that good results can be obtained provided the two crops are given fertilizer applications separately to satisfy their individual requirements. Manioc intercropped 3 ft apart has given 3 tons per acre and *kiri-ala* at a spacing of 4 ft by 3 ft 4 tons in the wet zone.

Trials have also shown quite conclusively that the wet zone coconut belt is not suitable for intercropping pulses and chillies. The excessive shade and humidity combine to depress flowering and fruiting, and also cause problematic diseases. These crops are better cultivated under coconut in the dry zone during the rainy *maha* season.

On the other hand, experiments with permanent crops like coffee, cocoa and pepper have only just begun and no conclusions can be drawn as yet. This is a pity because there is a keen interest in the intercropping of these money crops. For several reasons: Firstly, they are currently very profitable and their prospects too appear to be bright both in the domestic and international market; secondly they are permanent crops which are *not* labour intensive; and thirdly they usually require shade which is already provided by the coconut crop.

COCONUT IS PERMANENTLY INTERCROPPED WITH COCOA IN MALAYA . . .

Even though the C. R. I. trials are yet incomplete, there is evidence of cocoa, coffee and pepper having been successfully intercropped with coconut—both here and in other countries. For instance, in Malaya there are 20,000 acres of coconut *cum* cocoa from sea level up to 1,500 feet. The two crops have been found to benefit one another, the coconut giving the cocoa the shade it requires, and cocoa provides certain micro-organisms which are useful in releasing soil-bound phosphorus to the roots of the coconut. These micro-organisms develop as a result of the rich mulch of leaves that is deposited under the cocoa trees.

But as you are no doubt aware, the present practice of intercropping coconut in this country is restricted to the first five years of the coconut crop and to its later life after the palms are 30 years old. All the C. R. I. trials are being conducted to fit this intermittent intercropping pattern, because it is said that the shade cast by the palms in the intervening period from 5 - 30 years is too intensive for raising other food crops.

IS PERMANENT INTER-CROPPING ECONOMICALLY FEASIBLE IN SRI LANKA . . .

However, it seems such a pity that a quarter-century of the economic life period of a coconut plantation is wasted—in the sense that it cannot be used for raising food crops from the time it is 5 - 30 years of age. In the circumstances, we must ask ourselves whether it is possible to have a permanent system of inter-cropping from 0 - 60 years by planting the palms further apart as they do in Malaya.

In Malaya the palms are planted 30 feet apart with a density of 48 palms to the acre. This allows for a permanent system of inter-cropping with cocoa. The standard spacing in Sri Lanka, however, is 26 ft or the square system with 64 palms to the acre. Cannot we increase the spacing and in this way develop a permanent system of crop diversification?

Experiments carried out by the C. R. I. at various spacings, involving densities from 100 palms to 40 palms per acre, have indicated that a spacing of 35 ft by 24 ft with 51 palms to the acre would be best for a permanent system of inter-cropping—the wider rows being planted in a N - S direction so that the closer planted rows would have the full benefit of the sun in an E - W direction over the plantation. This way maximum flowering and fruiting is assured.

The only snag is that at this greater planting distance the producer will have 13 palms less to the acre than if he had planted at the standard spacing of 26 ft by 26 ft. Is it economical to sacrifice 13 palms per acre at a crucial period like this when we require all the coconut we can produce? Will the return from the inter-crop or inter-crops compensate for the reduced yield of coconut? These are two questions that we must consider.

It is well known that coconut producing countries like Malaya and the Philippines concentrate on the export market and use only relatively small quantities of coconut for domestic consumption. Sri Lanka, on the other hand, uses 50 per cent of total production for domestic consumption. In the face of this fact and the knowledge that our population is expected to reach 20 millions by the turn of the century, can we expect our planners and policy makers to advocate a planting policy of less than the standard number of palms per acre?

But, on the other hand, if our coconut producers can be persuaded to utilize the generous government-subsidies provided to rehabilitate their run-down plantations so that the statistics will show a significant increase in the number of improved seedlings planted, in the quantity of fertilizers applied and in the ensuing output of their plantations, then it may be economically feasible to promote a permanent system of crop diversification. For under the envisaged improved plantation conditions it would be reasonable to expect a higher yield of coconut than at present even from a lower planting density. At the same time, the return from a valuable intercrop like pepper, cocoa or coffee could appreciably enhance overall profits and foreign exchange earnings.

It is still too early to compare the economics of a permanent system of crop diversification in coconut with an intermittent system of crop diversification. But this does not mean that we should fail to explore the possibilities of a permanent system while intesifying and "cashing-in" on the possibilities of a intermittent system. Because our objective, whether it be in our own interest or for posterity, must always be directed towards the maximum utilization of our scarce land resources. That is the formula for survival!

2. MIXED FARMING IN PLANTATION AGRICULTURE

Experiments conducted by the Coconut Research Institute have been shown quite clearly that coconut can be undercropped with productive pastures and fodders without adversely affecting the yield, provided:

(i) such undercropping is practised in areas that receive not less than 85 inches of rain a year, and

(ii) the manuring of the grass crop is systematically undertaken independently of the manuring of the coconut crop.

The only factor likely to limit the growth of grass is inadequate light. Even when grass is manured, the shade cast by the palms tends to depress the yield up to about the 20th year. That is, assuming that coconut is planted at the usual spacing of 26 ft by 26 ft (on the square system) to give 64 palms per acre.

Dairy-farming therefore is a feasible proposition only in coconut plantations that are over 20 years of age.

RECOMMENDED GRASSES & LEGUMES...

BRACHIARIA: Both *Brachiaria brizantha* and *Brachiaria miliformis* grow well under coconut. But *B. miliformis* is the more favoured grass because it gives a higher yield of dry matter under shade viz., about 8,000 lb per acre annually.

Since a medium-sized milch cow (800 lb) requires about $2\frac{1}{2}$ tons of dry matter a year, this means that a Brachiaria pasture can support 1 - $1\frac{1}{2}$ cow equivalent annually—the higher stocking rate being possible with *B. miliformis*.

A Brachiaria pasture is established by planting 12 - 18 inch long cuttings 2 ft by 1 ft apart after the land is lightly ploughed and disced a couple of times. 7 - 8 cwt of planting material are required to plant one acre.

In addition to dung and urine, fertilizers must be applied regularly. Two complete dressings of NPK are given every year at the beginning of each rainy season viz., 50 kg (1 cwt) sulphate of ammonia (or 25 kg urea,) 25 kg ($\frac{1}{2}$ cwt) superphosphate and 25 kg ($\frac{1}{2}$ cwt) muriate of potash per acre at each application. And in between an application of urea, if necessary, at 25 kg ($\frac{1}{2}$ cwt) per acre.

The pasture may be cut or grazed 3 - 4 months after planting when it is well established and about 18 inches high. Cutting or grazing may be arranged at 5 - 6 weeks intervals, since this is the usual time taken by the grass to recover after it has been cut or grazed down to 3 inches.

Brachiaria pastures will remain productive for about 12 years if they are 'rejuvenated' every 3 years. The process of rejuvenation involves allowing the grass to grow for 3 - 4 months without cutting and then disc-harrowing it into the ground. Cutting may recommence in $1\frac{1}{2}$ - 2 months.

Since *B. brizantha* and *B. miliformis* are both susceptible to water-logging, depressions and other poorly-drained spots on the land would be more advantageously undercropped with *B. mutica* (water grass) which thrives in very wet conditions.

GUINEA GRASS: Guinea grass (*Panicum maximum*) also grows well under coconut. It is propagated from root-divisions planted 2 ft by 2 ft apart. About 10 cwt of planting material (with soil adhering to the roots) or 7 cwt (without soil) are required per acre. In 4 months the fodder should be ready for cutting. Cuttings can be made as often as once a month, and the annual yield is about 50 - 60 tons per acre under good management.

There are three types of Guinea grass viz., Guinea A, Guinea B and Guinea 435. Unlike Guinea B and Guinea 435 which are succulent protein-high grasses, Guinea A is a wild-growing coarse type with less protein. But all in all this wild variety is easier to establish and maintain since it is more tolerant of poor fertility and drought. And the deficiency in protein can be made up by adding some leguminous green fodder.

LEGUMES: Legumes will have to be raised independently of the grass since attempts to include them as a pasture component in the tropics has not met with much success. Three creeping legumes, in particular, do well under coconut viz., *Centrosema pubeescens* (Centro). *Pueraria phaseoloides* (Tropical Kudzu) and *Phaseolus artropurpureus* (Siratro). They may be raised from seed (6 lb/acre) and planted in strips in between but separate from the grass at a spacing of 2 ft between rows. These legumes respond to heavy dressings of cattle urine. They should be cut and fed every 4 - 6 weeks. (see Appendix 3)

Leguminous tree fodders may also be planted to advantage as strips or fences, Gliricidia (*G. maculata*) and Horse Tamarind (*Leucaena gluaca*) are recommended for their quick growth and rejuvenation under constant lopping. Gliricidia is propagated from 6 - 8 feet long cuttings, 1 - $1\frac{1}{2}$ inches thick; horse tamarind from scarified seed immersed for 2 - 4 minutes in boiling water. (see Appendix 4)

Legumes possess a higher crude protein content than grasses and this protein is generally very digestible. When added to the starchy grass diet they give it variety, body and a welcome protein boost.

"CUT-AND-CARRY" VS GRAZING: Grasses may be either cut and fed to cattle in their stalls, or grazed by cattle *in situ* if they are pasture types like the Brachiarias. Grazing would appear to be the more convenient form of feeding since the animals are merely let out to fend for themselves, whereas in the other system labour has to be employed to cut-and-carry the grass to the animals in their stalls. But there are several disadvantages. We cannot allow European breeds and their crosses to wander around in search of food. The energy they expend in doing this leaves them unfit for milk production.

Then there is the problem of ticks. This blood-sucking pest can cause a serious limitation to milk production.

There is also the question of fencing and the construction of several paddocks and outside water troughs to ensure a proper rotational grazing pattern. This is a very expensive business today.

And finally, there is the problem of pasture under-utilization. Have you watched cattle grazing? Have you noticed how they selectively choose their spots and move on from choicest bit to choicest bit of pasture, leaving a lot of grass untouched and wasted?

Taking all these things into consideration it is more economical to cut and feed grass and legumes to the animals in their stalls.

RECOMMENDED DAIRY BREEDS: It is an accepted fact that the milk yields obtained from European breeds and their crosses are markedly superior to those obtained from Sinhala and Indian breeds and their crosses. However, the adaptability of these European breeds and their crosses to the high temperatures and humidities obtaining in the coconut triangle has been subject to some speculation. But today, the concensus of opinion is that no harm can result so long as the animals are permanently housed under shade and fed in their stalls.

FRIESIAN CROSSES: Friesian crosses are considered more suitable than Jersey crosses for the cocount triangle, because they produce an appreciably higher milk yield and carcass weight. Carcass values too have to be taken into consideration when selecting a dairy breed because breeding for beef is part and parcel of the dairy programme.

It should be noted however, that while the milk yield in the F_1 cross is high owing to hybrid vigour, production falls off appreciably when F_1 animals are allowed to breed *inter se* or are backcrossed to the same European parent. *To maintain hybrid vigour and high milk yields therefore it is necessary to adopt a rotational cross-breeding system.*

In the coconut triangle where milch cows are permanently housed under shade and fed in their stalls this would mean upgrading the Friesian F_1 cross further by using the Jersey as male parent. However, in circumstances, where the cows are under a grazing system and managerial conditions are poor, further upgrading to an European parent is not recommended. Instead, the F_1 animals are mated to good Indian milch breeds such as the Sahiwal or Red Scindi.

This scheme can operate indefinitely either as a two-breed or three-breed rotation, utilizing the artificial insemination facilities offered by the Department of Agriculture.

3. RECENT RESEARCH ON GRASS AND LEGUMES IN THE MID-COUNTRY AND COCONUT TRIANGLE

Grass—like any other food crop—has graduated to a position of top priority in the agricultural economy of this country. So long as coconut poonac was cheap and easily available, dairy farmers neglected the development of grass, even though suitable varieties were available to them. But times have changed! Today they realize the importance of grass in the diet of milch cattle, and as such they want to know how to get the most from grasses like *Brachiaria brizantha*, *B. miliformis*, *B. Ruziziensis*, Guinea Grass and Setaria which have been recommended for the mid-country and coconut triangle, where intensive dairy development is expected to take place in the future.

There is no doubt about the adaptability of these grasses, but a great many dairy farmers are dissatisfied with their performance. For one thing it has been observed that the Dry Matter Content of these grasses does not measure up to what has neen said about them. Or, in other words, the DMC per acre actually realized falls far short of expectations. Recent research, however, attributes this shortfall to the adoption of too wide a spacing at the time of planting and also the use of poor planting material.

The original spacing recommended was 2 ft × 2 ft or 2 ft × 1 ft. This is obviously too wide a spacing because the grass takes an unduly long time to establish. As a result weeds invade the crops and growth is retarded. Better results have been obtained at a closer spacing of 12 inches between rows of Brachiaria, the cuttings being placed end to end, and 12 × 6 inches or 18 × 6 inches for Guinea and Setaria. The closer spacing also helps to check soil erosion in tea lands in the mid-country.

Experiments have shown that quicker establishment and more vigorous growth are possible when grass is propagated from seed instead of vegetatively by cuttings and root divisions. Seeds are first planted in a nursery and the seedlings transplanted when they are fully two months old. At present there is a dearth of seed, so propagation will have to continue vegetatively. Better results may be obtained however, if the cuttings — at least in the erect types are sprouted before planting.

The present practice is to plant root divisions or cuttings of Guinea grass and Setaria straightaway in the field without giving them time to put out fresh shoots or tillers, and consequently establishment and regrowth is poor. On the other hand, if these root cuttings are stacked for one week in a shady place and sprinkled with water regularly to induce the sprouting of 2 - 3 shoots or tillers per cutting prior to transplanting, then the performance of the grass is found to be far more convincing. So, until such time as propagation by seed becomes the rule, be sure to induce sprouting prior to planting when handling Guinea grass or Setaria cuttings.

Perhaps the greatest disappointment is that our grasses do not give the same economic results as grasses in temperate countries. Or to put it in another way: why don't our milch cows give as high yields on a diet of grass alone as milch cows in temperate countries?

There are several reasons. In the tropics grasses flower and mature much earlier. Consequently, they are poorer-yielding and less palatable. What is more, they are also less nutritious because they do not grow in natural association with rich protein clovers and their like as they do in temperate countries.

Research workers in Sri Lanka have spent many years searching for suitable grass-legume combinations. Two creeping legumes, namely, *Centrocema pubescens* (Centro) and *Pueraria phaseoloides* (Tropical Kudzu) showed early promise. But as they were inclined to overrun the grasses, it was necessary to grow them in separate lots or in wide intervening strips in the grass.

Recently two other creeping types viz., *Phaseolus artropurpureus* (Siratro) and *Stylosanthus gracilis/guianensis* (Stylo) have shown much greater promise in that they integrate well with grass. Siratro and Stylo are propagated from seed and grown in between alternate rows of grass, at a spacing of 6 - 9 inches, placing 2 - 3 seeds at each point. At this spacing 2¼ lb of seed are required per acre.

Since the bacteria required for nitrogen-fixation by these two legumes are not found in our soils, it is necessary to treat the seeds with the requisite bacterial culture prior to planting. Seed and culture are available in small quantities to *bona fide* dairy producers in the mid-country and coconut triangle from the Grasses Research Unit of the International Development Association for Dairy Development at Getambe, Peradeniya.

The culture is mixed with a sugar solution (one teaspoon of sugar to 4 teaspoonsful of water), poured on the seed placed on a clean polythene sheet and mixed well till all the seeds are coated. Place the treated seed in the shade for 24 hours before planting. Plant in moist soil for best results.

In fact, to get the best results the use of a bacterial culture alone is not enough. Legumes also require plenty of phosphate and sulphur. This will have to be provided in the fertilizer mixture. Fertilizer experiments are still in progress but the interim recommendation for a grass-legume mixture is 25 kg of ordinary superphosphate and 25 kg of muriate of potash per acre prior to planting and every six months thereafter.

Do not confuse ordinary superphosphate with concentrated superphosphate. Ordinary superphosphate is recommended because it contains both phosphate and sulphur. While this mixture (25 kg superphosphate and 25 kg muriate of potash per acre) is suitable for coconut soils and ordinary soils in the mid-country it may be wanting in sulphur when applied to eroded, infertile, tea lands in the mid-country, since it has been noticed that nodulation (development of bacterial nodules on the roots) is still poor in such areas. Consequently, the addition of 20 lb flowers of sulphur to the above fertilizer mixture is recommended until investigations are completed.

NOTE: In a *pure grass* stand in addition to the six-monthly application of 25 kg superphosphate and 25 kg muriate of potash per acre, top dressings of urea should be given after each "cutting"— 18 - 20 kg per acre. This is necessary because there is no legume to provide the necessary nitrogen.

4. IPIL-IPIL AS A PARTIAL SUBSTITUTE FOR COCONUT POONAC

The chief cattle concentrate feed in Sri Lanka is coconut poonac. So long as coconut poonac was cheap this did not matter. But, subject as it is to the vagaries of the market, price-hikes are quite common. When the price is high dairy farmers are faced with crippling feed bills. And since they are unable to get the same results by feeding grass alone as in temperate countries, they are often compelled to "shut-up-shop".

In temperate countries grasses are more palatable and nutritious than they are in the tropics. Consequently, much higher milk yields can be obtained on grass alone. The grasses remain palatable for a longer period of time because they take much longer to mature. And they are more nutritious because they grow in close natural association with high-protein clovers and such-like pasture legumes. In the tropics, however, because of the harsher climate, grasses tend to flower and coarsen quickly. This reduces their nutritive value and palatability. Furthermore, high-protein clovers do not thrive in close association with grass.

The alternative, of course, would be to provide an inexpensive substitute for coconut poonac. In the search for such a substitute the National Livestock Board introduced a leguminous fodder tree from the Philippines in 1977—a high-protein selection of *Lucaenia leucocephala* (also known as *L. gluaca*) containing about 24 percent protein—a higher content than is found in coconut poonac. This small fodder tree is called Ipil-Ipil.

Unfortunately, Ipil-Ipil cannot be fed *ad lib* because it has a poisonous alkaloid called "mimosene", which can cause calf mortality and have depilatory and sterilization effects in adult animals. Experiments have shown that a safe limit would be a 1 : 2 mixture of Ipil-Ipil and grass. Since a 1,000 lb (450 kg) cow can eat as much as 140 - 150 lb of bulky food a day, it is suggested that 100 lb of grass and 40 - 50 lb of Ipil-Ipil a day would be an ideal mixture. Under good management it is said that a 1,000 lb cow of European origin—or a mixed breed like the Cape Cow—can give up to two gallons of milk a day on this diet alone, without any concentrates at all.

In the circumstances, Ipil-Ipil can be used as a partial substitute for coconut poonac and this should bring about a welcome relief to dairy producers where the feed bill is concerned. The more expensive coconut poonac may be reserved for supplementary feeding only during the critical period in the life of the cow from two months before to two months after calving when the foetus is developing rapidly and the milk yield reaches a maximum. At this time 3 - 5 lb (or more up to 8 lb) may be given daily in addition to a bulky feed containing 100 lb of grass and 40 - 50 lb of Ipil-Ipil.

Ipil-Ipil is propagated from seed. Since the seed coats are tough they need to be softened prior to planting. This is done by wrapping the seeds in a cloth and dipping them in hot water—about 80°C—each dipping should not be for more than one minute. In the alternative rub the seed on sand paper or some other rough surface and then soak in cold water for 12 - 18 hours before planting. You can sow the seeds direct in the field, or you could grow them first in a nursery and then transplant the seedlings when they are 2 - 4 months old. At this age the plants should be about 20 cm (8 in.) tall.

You have the choice of planting Ipil-Ipil as a hedge/hedges on the boundary of your allotment or in your grass fields, or as a separate monocrop. If you should decide to cultivate Ipil-Ipil as a hedge, then space the plants one metre between rows and 30 cm in the row. Let the plants grow up to about 1 metre in height and then start pruning and feeding the leaves to cattle. Pruning should be done every 1 - 3 months depending on subsequent re-growth.

The same spacing may be used to plant Ipil-Ipil as a monocrop. But first the land should be ploughed, harrowed and fertilized with about 50 kg of an NPK fertilizer mixture per hectare. Six months after planting when the plants are about 40 cm (16 in) high they may be pruned back to about 12 inches above ground. Low-prunings of this nature are done every three months.

Being a leguminous plant Ipil-Ipil is able to manufacture all the nitrogen it requires. Occasional applications of phosphate and potassium however, are necessary to maintain good cropping. Under favourable conditions 10 - 15 metric tons of fodder may be harvested in a year from one hectare of Ipil-Ipil planted as a monocrop 1 metre between rows and 30 cm between plants in the row. 5 kg of seed are required to plant one hectare this way i.e., $2\frac{1}{2}$ lb per acre.

Ipil-Ipil will grow well mostly anywhere in Sri Lanka up to an elevation of 4,000 ft. Two limitations to successful growth are acid soils and waterlogged conditions. Be sure, therefore, to plant on well drained land, and if your soil is very acid remedy this condition by the application of lime every 2 - 3 years—about 500 kg/hectare.

5. ESTIMATING THE WEIGHT OF CATTLE

A practical and ready means of estimating the weight of cattle where there is no access to platform scales is a necessary safeguard for the breeder who does not wish to be thwarted by the wiles of the rapacious butcher.

Fortunately, there is sufficient evidence to suggest a relation between body weight and body dimensions, and on this basis it has been possible to estimate weights from heart-girth measurements. Heart girth is obtained by placing a tape around the animal just behind the forelegs and shoulder tight enough to ensure an accurate reading without indenting the flesh (see tables below):

In the case of cattle the following formula may also be used to calculate weight:

$$\frac{L \times G^2}{300}$$

where L is the length in inches from point of shoulder to point of tail bone, G is the heart girth in inches taken just behind the forelegs.

Estimated Weights for various Heart-Girth Measurements of Cattle

Circ of Chest (ins)	*Wt in lbs*	*Circ of Chest (ins)*	*Wt in lbs*	*Circ of Chest (ins)*	*Wt in lbs*
30.0	100	51.0	414	72.0	1064
30.5	103	51.5	424	72.5	1085
31.0	107	52.0	434	73.0	1104
31.5	112	52.5	445	73.5	1126
32.0	117	53.0	456	74.0	1146
32.5	121	53.5	467	74.5	1169
33.0	127	54.0	476	75.0	1191
33.5	131	54.5	495	75.5	1213
34.0	137	55.0	510	76.0	1236
34.5	141	55.5	521	76.5	1263
35.0	146	56.0	534	77.0	1285
35.5	152	56.5	545	77.5	1308
36.0	157	57.0	562	78.0	1331
36.5	162	57.5	577	78.5	1354
37.0	167	58.0	590	79.0	1377
37.5	173	58.5	605	79.5	1400
38.0	179	59.0	616	80.0	1423
38.5	186	59.5	629	80.5	1446
39.0	193	60.0	647	81.0	1469
39.5	199	60.5	668	81.5	1492
40.0	206	61.0	684	82.0	1515
40.5	214	61.5	700	82.5	1538
41.0	223	62.0	716	83.0	1561
41.5	229	62.5	732	83.5	1584
42.0	239	63.0	748	84.0	1607
42.5	247	63.5	762	84.5	1629
43.0	255	64.0	778	85.0	1650
43.5	270	64.5	790	85.5	1673
44.0	283	65.0	815	86.0	1692
44.5	293	65.5	828	86.5	1718
45.0	298	66.0	848	87.0	1741
45.5	307	66.5	866	87.5	1764
46.0	315	67.0	883	88.0	1788
46.5	323	67.5	891	88.5	1812
47.0	334	68.0	904	89.0	1833
47.5	344	68.5	923	89.5	1857
48.0	354	69.0	942	90.0	1981
48.5	364	69.5	962	90.5	1905
49.0	374	70.0	982	91.0	1929
49.5	384	70.5	1002	91.5	1952
50.0	394	71.0	1022	92.0	1975
50.5	404	71.5	1043		

(*Source*: National Livestock Board)

6. STATISTICS OF CATTLE AND BUFFALOES RAISED UNDER LOCAL CONDITIONS

Breed	*Colour*	*Mature weight of a cow (lb)*	*Milk production per lactation of 305 days (Pints)*	*Fat %*	*Age at 1st calving*	*Birth weight of calf (lb)*
Friesian	Black & White	1000—1200	7000—8000	3—3.5	$2\frac{1}{2}$—$3\frac{1}{2}$	65—75
Jersey	Brown to dark Red	700—800	4000—5000	4—4.5	2—$3\frac{1}{2}$	45—55
Scindi	Red	600—750	2000—2500	4—4.5	3—$3\frac{1}{2}$	30—40
Sahiwal	Reddish	600—750	2000—2500	4—4.5	3—$3\frac{1}{2}$	30—40
Sinhala*	Varying Colours	300—400	300	4.5—5	4	25—30
Murrah	Black	1000—1200	2500—3000	7—7.5	$3\frac{1}{2}$—4	65—75
Surti	Greyish	800—1000	2000—2500	7—7.5	$3\frac{1}{2}$—4	50—60
Local Buffalo*	Greyish	400—550	300	7—7.5	4—5	30—40
Ayreshire	Red, Brown and White	800—900	5000—6000	4	3—$3\frac{1}{2}$	55—65
Milking Shorthorn	Red, very light tinge	900—1000	5000—6000	4—4.5	3—$3\frac{1}{2}$	60—65

* Lactation length only about 90 days.

(*Source*: Department of Agriculture)

7. TRINITY FARM—A FINE EXAMPLE OF INTEGRATED FARMING

In these critical times when there is an urgent need to maximise thes ue of natural resources like land, water, sun and organic manures, and to minimise our dependence on limiting inputs such as tractors, fertilizers and agro-chemicals, the Trinity Farm has blazed a trail that warrants the attention of all progressive agriculturists.

Situated at Pallekelle about 10 miles from Kandy, in the Intermediate Zone where the annual rainfall is between 50 - 75 inches, the Trinity Farm is a 50 acre unit. About 11 acres are taken up for buildings and roads. The balance 39 acres are farmed on a mixed farming system where livestock and crops have been integrated. The chief livestock are 132 head of dairy cattle and 400 pigs. There is also a large flock of poultry and some rabbits. The main crops are coconut, banana, coffee, pepper, sweet potato, velvet bean and grass (1977).

This is briefly the inventory of crops and livestock, and on the face of it one might wonder what is so different about this farm from several other mixed farms in this country. The difference is that not only are the two categories of livestock and crops mixed in this system of farming so as to benefit one another, but also that the crops themselves are mixed in a *three-tier* pattern so as to maximise the use of land, water and sunlight.

THREE-TIER PLANTING: Three crops are planted in the same piece of land where only one crop is usually planted by most farmers. These three crops are at different heights so as to make the maximum use of the sun's energy. There are tall crops like coconut and banana which need all the sunlight they can get; medium crops like coffee, and pepper trained to grow on gliricidia which benefit from light shade; and ground crops like velvet bean, sweet potato and grass which can tolerate under-planting at minimum levels of sunlight.

GRASS: Grass, today, because of the high cost of coconut poonac, has assumed the importance of other food crops. There are 25 acres of *ali thanakola* (Guinea 'A') at Trinity Farm. This grass crop is so well tended—irrigated when necessary and manured regularly—that the Farm Manager is able to get the maximum stocking rate of 1 : 5 (under local conditions) on a zero-grazing or cut and carry system of feeding.

To make up for the slightly low protein value of this wild grass however leguminous fodders like velvet bean (*Stylozobium derringianum*) and gliricidia are mixed with the grass and fed to the dairy cattle along with an ample supply of mineral mixture. In this way it has been possible to reduce the rate of concentrate feeding to an average 2 lb a day per cow without any adverse effects on milk production.

Apart from its value as a cheap and nutritious cattle feed, grass has other advantages too. It acts as a natural cover, preserving the valuable top-soil from erosion; its matted root system and leaf fall maintain the humus condition of the soil; and its thick cover suppresses weed growth. Consequently there is no need to employ a large labour force to keep the farm clean-weeded.

RECYCLING STOCK WASTE: All in all this is a slick system of making the maximum use of natural resources. And a very efficient one too if we take into account the fact that all the cattle dung and urine and pig droppings are utilized to manure the fields.

A large proportion of the NPK, and to a lesser extent the organic matter (OM) consumed by livestock is excreted as dung and urine (see table below). This is collected in cement pits and diverted into cement drains which take it to the fields. To allow for a gravitational flow of this liquid excreta, the cattle sheds and pig pens are sited on high ground. Soiled litter from the poultry houses is also collected and returned to the land. As a result of recycling stock waste in this manner it has been possible to cut down considerably on fertilizer inputs at the Trinity Farm.

Nutrients and Organic matter recovered from feed

	N	P_2O_5	K_2O	OM
% Consumed	20	20	10	50
% Excreted	80	80	90	50
	100	100	100	100

NO FUEL PROBLEM: There is also no fuel problem at Trinity Farm because no tractors are used. Owing to the semi-permanent cropping system that is adopted and the perennial ground cover, this farm is able to manage with a few labourers and traditional implements like *mamoties*, *alavangos*, *kathis* and scythes.

CATTLE TICKS? On the whole this is a wonderful achievement, and one would expect Mr. W. A. V. Sinnethamby, Director of Trinity Farm, to be satisfied. On the contrary, still brimful of ideas, this great innovator is exploring the possibility of eliminating the use of another imported input, namely Asuntol, a pesticide that is used to control tick infestation of cattle.

He proposes to construct one or more pools near the cattle sheds to breed fish with a view to using them as tick - eliminators. The idea is to allow the cattle to stand in these pools and have the fish consume the ticks as part of their piscine diet.

8. TWO - WHEEL TRACTORS — THEIR OPERATION AND MAINTENANCE

Two-wheel tractors are costly by Sri Lankan standards. Owners therefore must be interested to prolong the lifetime of their machines. This can be achieved by correct maintenance and operation.

OPERATION: When starting the tractor, keep the gear lever in neutral position and the main clutch in the off position. Then open the throttle full, and insert the starting handle. Press the decompression lever completely and crank the engine with the starting handle. After 5 - 10 turns release the compression lever sharply. When you start driving push the steering handles down and release the clutch gently. To stop the engine move the throttle into stop position.

The tractor may be used for ploughing, discing or rotary-tilling. When ploughing you can use either the rigid mould-board plough or the reversible mould-board plough. With the reversible mould-board plough one-side ploughing is done i.e. you move the plough down the length of the field, reverse it and move down on the same side again. This is known as adjacent or reciprocating tilling. In the case of the rigid mould-board plough, tilling has to be done round the field, starting from the outside and working towards the middle.

Where disc-tillers are used for harrowing already ploughed land, the tractor is worked around the field in such a way that the land harrowed by one set of tillers is overlapped by other set as the tractor moves round the field again.

The rotary tiller—fitted with straight blades—may be used to pulverize the soil. This is possible as a primary operation in soft soils. (e.g., paddy fields), which have to be puddled. The puddling is done by operating round the field in a circuit fashion. But on most highland soils which are hard to work in this country (especially in the dry zone) rotary-tilling is done as a secondary operation after ploughing. In this instance, it is done up and down the field as an adjacent or reciprocating tilling operation.

If a ridger is available this may also be used to make ridges after the field has been rotary-tilled. Ridges are generally constructed wherever furrow-irrigation is to be practised. Set the ridger as instructed and work it along with the rotary-tiller equipped with curved blades.

Generally the wheels have to be changed according to field conditions—rubber tyres on soft soils and iron wheels on hard soils. But it is the general practice in this country (owing to the high cost of tyres) to keep the tyre wheels only for road haulage and to use the iron wheels for all field operations. Whenever the rubber wheels are removed and refitted, check that the tyre pattern is in the direction of the drive.

MAINTENANCE: Maintenance procedure may be divided into five categories viz., (i) daily chores, (ii) weekly chores, (iii) three-monthly chores, (iv) six-monthly chores, and (v) annual chores.

DAILY CHORES: Check the water in the radiator daily and top-up with clean soft water (rain water) to avoid the formation of dirt and calcium deposits.

Also top-up the fuel tank after work using a strainer. Clean the fuel filter at the same time with a soft brush or by shaking it in clean fuel.

Check the oil level with the dip stick before starting the engine. The level should always be between the maximum and minimum mark on the dip stick.

Keep the cooling fins clean to ensure free air flow. If a fan belt is used to drive the cooling fan check for tension between tension pulley and cooling fan pulley. The play should be about 15 - 20 mm.

Ensure that the clearance of the main clutch is as recommended; check every 50 working hours.

WEEKLY CHORES: Once a week, or every 50 working hours, check the following nuts and bolts for tightness: cylinder-head nuts, fuel pump fixing bolts, pressure pipe nuts and engine stand nuts. This is necessary in a new tractor. In an old tractor, however, this can be done at a longer duration (every 300 working hours).

Check the braking effect. Adjustment is possible by shortening the brake cable. Oil the cable.

Check the clearance between steering lever and handle grip—it should be the width of a forefinger when one wheel is lifted and rotated freely. Adjustments can be made by shortening or lengthening cables. Oil the levers.

Check tyre inflations: this varies according to nature of work (i.e., tillage or transport).

Use engine oil to lubricate all wires and levers.

Check the oil level in gear box and top-up if necessary.

THREE MONTHLY CHORES: Every three months, or 300 working hours, change the engine oil as recommended and clean oil strainer and filter with diesel fuel. At the same time check the condition of the wire mesh, and if there is a magneto drain plug clean it too.

SIX-MONTHLY CHORES: Every 6 months, or 600 working hours have the valve clearance checked and adjusted by a workshop.

Change the oil in the gear box. This should be done immediately after work when the oil is still warm. Use only the correct grade of oil (SAE 80 - 90).

ANNUAL CHORES: After one year, or every 1,200 working hours, it is necessary to clean the fuel tank if there is a drain cock. (Earlier cleaning, however, may be necessary if the filter bowl shows excess water). The fuel filter and the filter bowl should also be cleaned. After fitting the filter bowl check whether it is properly sealed.

Clean the radiator with caustic soda solution and see that the cover screen and cone are particularly clean so that air can circulate freely.

The following services have to be carried out in a workshop: checking the engine compression and the performance of the injector nozzle. It is also necessary to tighten the cylinder head nuts and crankshaft bearing nuts.

MAINTENANCE CHART

Chores	Every Day	Every Week (50 WH)	Every 3 Months (300 WH)	Every 6 Months (600 WH)	Every Year (1,200 WH)
1. Radiator & Fuel Tank	√				x
2. Fan Belt Clearance	√				
3. Engine Oil	√		o		
4. Engine Oil Strainer	√		x		
5. Air Cleaner	√				
6. Fuel Filter	√				
7. Bolts & Nuts		√			
8. Valve Clearance			√		
9. Compression Pressure Injector Nozzle					√
10. Gear Oil		√	o		
11. Main Clutch adjustment	√				
12. Brake-lever & Steering lever adjustment					
13. Oiling wires and levers		√			
14. Tyre Pressure		√			

√ = CHECK
o = CHANGE
x = CLEAN

COST OF OPERATION: There are fixed costs and variable costs. Fixed costs are incurred no matter whether the tractor is worked or not: they include depreciation, interest on investments, insurance and housing costs. Variable costs, on the other hand, are incurred only when the tractor is used viz., repairs, spare parts, fuel and lubricants.

Suppose the purchase price of a tractor with implements is approximately Rs. 14,000/-, then the total cost of working this tractor per hour (i.e. fixed cost plus variable cost) may be worked out as shown below. The more you work your tractor the lower are the total costs per hour. In this instance: Rs. 19.06 for 200 hours per year, Rs. 11.04 for 400 hours, Rs. 9.02 for 600 hours and Rs. 7.53 for 800 hours (see accompanying table).

AN EXAMPLE OF HOW TO DETERMINE THE WORKING COST OF TWO-WHEEL TRACTOR

Purchase Price of Tractor & Implements Rs. 14,000/-	*Percentage of Purchase Price per year*	*Rs. per year*	*Costs per hour based on number of hours worked per year*			
			200	400	600	8000
1. Fixed Costs						
(*a*) Depreciation	16.5	2,310	11.55	5.28	3.85	2.74
(*b*) Interest & Investment.	04.0	560	2.80	1.40	0.93	0.70
(*c*) Insurance & Housing	01.0	140	0.70	0.35	0.23	0.18
Total Fixed Costs	21.5	3,010	15.05	7.03	5.01	3.52
2. Variable Costs						
(*a*) Repairs, Spare parts and Maintenance Costs per hour (2.2% of purchase price per 100 working hours)			3.08	3.08	3.08	3.08
(*b*) Fuel & Lubricants per hour			0.93	0.93	0.93	0.93
			4.01	4.01	4.01	4.01
TOTAL FIXED & VARIABLE COSTS PER WORKING HR:			19.06	11.04	9.02	7.53

9. MECHANIZATION OF FARM OPERATIONS IN HOURS AND ACRES PER DAY

	Approximate No. of hours/ acre	*Approximate No. of acres/ day*
Two-Wheel Tractors:		
Ploughing	8.0	1.0
Rotary tillage	6.0	1.3
Four-Wheel Tractors:		
Disc Ploughing	4.0	2.0
Disc Harrowing	4.0	2.0
Tyne Tilling	3.5	2.3
Ploughing with rotavator	2.75	3.0
Threshing & Winnowing (Normal yield)	5.0	—
Ridging	5.0	1.6
Seed Drilling	5.0	1.8 (1.6)
Heavy Machinery (*D8 Type*)		
Jungle Clearing	8.0	1.0
Rooting	1.6	5.0

(1 day is taken as equal to 8 working hours).

10. LABOUR REQUIREMENT FOR DIFFERENT CULTURAL PRACTICES AND TASKS

Paddy:

Hand tillage of wet land	12 - 15 labour days/acre
Ploughing with wooden plough	0.35 - 0.5 acre/day
Ploughing with mould board plough	Approx. 0.75 acre/day
Broadcasting	Approx. 1 labour day/acre
Transplanting	Approx. 6 - 8 labour days/acre
Manual weeding	8 - 12 labour days/acre
Spraying (applicable to other crops too)	0.75-1 labour days/acre
Top-dressing fertilizer	0.75-1 labour days/acre
Harvesting & carrying to the threshing floor	8.12 labour/days/acre

Other Crops:

Hand tillage dry land	Approx 20 labour day/acre
Mammoty weeding	6 - 8 labour days/acre
Manual weeding	10-12 labour days/acre
Digging Pits 1′×1′	60 per labour day
—do— 2′×2′	20 per labour day
—do— 3′×3′	6-8 per labour day
Digging trenches	100 cu.ft./ labour day

Grass cutting:

Pasture type grass	600 lb/labour day
Fodder type grass	1,000 lb/labour day

11. SPRAYERS AND DUSTERS

HAND KNAPSACK SPRAYER — LEVER OPERATED:

This is the commonest type of sprayer. It consists of a tank with a capacity of 2 - 3 gallons, pump, pressure cylinder, delivery hose, lance and nozzle. The pump is connected to a lever, and the sprayer is equipped with shoulder straps to enable it to be carried on the back of the operator. When the lever is moved up and down the spray fluid is forced through an air cylinder. The compressed air forces the spray fluid through the hose, lance and nozzle. Some sprayers have built-in agitators to keep the spray fluid well mixed. This agitator is essential when wettable powders are used. 40 - 60 gallons of spray solution are required to spray 4,000 sq. m. (1 acre) of crop. Because this is a large volume of spray the knapsack, hand-operated sprayer is referred to as a high volume sprayer in contrast to a power-operated knapsack sprayer or mist-blower which required only 10 - 15 gallons to spray the same extent of crop. Power sprayers are therefore referred to as low-volume sprayers.

KNAPSACK SPRAYER — POWER OPERATED:

These sprayers have a two-stroke engine which operates a fan. The air stream from the fan is directed through a large rubber hose into which the spray fluid is passed via a regulator.

The fuel tank is first filled with a clean petrol-oil mixture—one part of SAE 30 or SAE 40 (not multigrade oil) to 25 parts of ordinary grade petrol (not the superior grade). The spray fluid is next poured into the tank through a filter and the lid tightly closed.

The starting switch is now put into position, the fuel cock and choke fully opened and the throttle set at half speed. The engine is started by pulling the cord in the recoil starter and then gradually built up to maximum speed. It should be maintained at maximum speed while spraying. Spraying is done by aiming the nozzle down about 2 metres in front, opening the spray jet and walking at an even pace through the crop. The nozzle is moved from side to side to cover a wider range of crop. To stop the sprayer use the switch or throttle and at the same time turn off the fuel.

The spray tank has a 2 - 3 gallon capacity and the whole unit weighs less than 15 kg.

HAND DUSTER:

The fan type or rotary duster is suitable for dusting field crops. The fan is fitted to a crank-handle, which when turned by the operator discharges the dust through the hopper. The duster is supplied with shoulders traps.

POWER DUSTER:

The knapsack power duster consists of hopper, agitator, power unit, air chamber and fan. Larger power dusters are usually operated by the tractor-take-off mechanism.

HINTS ON SPRAYING & DUSTING:

Weather is an important consideration when spraying or dusting. Rain shortly after spraying or dusting will rapidly reduce the effectiveness of the pesticide. Hence avoid spraying or dusting in rainy weather, and also in windy weather since spray and dust drifts result in a waste of the chemical as well as poor crop coverage. If unavoidable, when spraying in windy weather keep the pressure as low as possible.

Dusting is best done between five and seven in the morning or late in the evening when the air is usually calm. Plant surfaces are also moist during these periods enabling the pesticide to adhere more effectively. This particularly applies to copper dusts. Sulphur dusts, however, adhere satisfactorily even when leaf surfaces are dry.

DILUTION RATES:

Correct dilution is essential to ensure effective results. If, for instance, the recommended rate of application of the pesticide is 20 fl. oz. per acre, you will require 40 gallons to spray one acre using a hand-operated knapsack sprayer. The dilution rate in this instance is 1:2. If your spray tank capacity is 2 gallons, this means mixing 1 fl. oz. in 2 gallons water at each application and making 20 applications in all to achieve the desired results.

On the contrary, should you use a power sprayer of 2 gallons capacity where only 10 gallons are required to spray one acre, then the dilution rate would be 4 fl. oz. in 2 gallons of water at each application, and the total number of applications would be five if the recommended rate is 20 fl. oz. of pesticide per acre. By using a power sprayer instead of a hand-operated sprayer you do the job four times faster.

MAINTENANCE OF HAND - OPERATED KNAPSACK SPRAYERS:

Nozzle-blocking is a frequent fault. It is caused when (i) unfiltered water carrying sediment is used from streams and ponds,

(ii) wettable powder formulations are used which tend to clot, specially in sprayers that are not fitted with agitators, (iii) out-dated emulsifiable concentrate formulations are used which also tend to clot.

Remedial action is taken by removing the nozzle and filter and washing it in clean water. If the orifice remains blocked give the nozzle a sharp tap on the palm of the hand. At no time should you place the nozzle in your mouth and attempt to blow out the obstruction as most pesticides are poisonous. Use a coir fibre or thin soft wire to clear the obstruction.

You must also examine your sprayer regularly for worn-out washers which could be made supple again by applying castor oil (never use mineral oils). Valves too need frequent examination: rubber and plastic valves swell when certain formulations are used: ball valves also tend to stick when worn out. Leaking spray fluid is an indication of worn-out valves.

MAINTENANCE OF POWER - OPERATED KNAPSACK SPRAYERS:

The same care and attention should be given to nozzles, washers and valves, but in addition look out for and remedy the following abnormalities in spray discharge. Intermittent spray discharges take place when the spray tank is less than one-third full—the liquid feed pipe becomes uncovered when the sprayer slips to a side on the operator's back, thus allowing air to enter. To prevent this happening see that sprayer is carried high on the operator's back. The flow of spray can stop altogether when there is a block in the liquid flow regulator, or an air leak from filler cap resulting from a worn-out seal or the cap not being fitted tightly.

If the engine fails to start check the following: (i) that the fuel cock is opened, (ii) that the air vent in fuel tank is not blocked, (iii) that there is water in the carburettor feed bowl, (iv) that the float needle is not stuck.

Should the engine run erratically and stop, check the following: (i) that there is no dirt or floating debris in fuel system, (ii) that main jet is not blocked, (iii) that the high tension lead is not loose and short-circuiting on metal parts, (iv) that there is no leak in gasket, (v) that plug is clean, (vi) that contact breaker points are not wasted or dirty.

Overheating of the engine can result from (i) incorrect petrol-oil mixture, (ii) retarded ignition, (iii) silencer and exhaust being choked with carbon.

IMPORTANT: Knapsack sprayers, whether hand-operated or power-operated must be cleaned out at the end of each spraying operation. On no account should spray solutions be retained for subsequent spraying the next day. Fill the tank with clean water and work the pump for some time to flush out spray residues through the nozzle. Thereafter, remove the nozzle carefully and work the pump once again. This will remove any further traces of pesticide sediment in the tank, hose, lance and filters.

12. GENERALIZED PEST CONTROL MEASURES

Pesticides should only be used when insects and other micro-organisms multiply into such large numbers that they become a pest on the crop, damaging it to such an extent as to cause severe crop loss. Spraying or dusting with these poisonous chemical deterrents is therefore a last line of defence to be used only when other cultural methods have failed to check the multiplication of the pest.

Anti-pest cultural methods include:

(i) the use of resistant plant varieties;

(ii) the use of selected planting material that is free of pests and diseases;

(iii) soil sterilization by burning trash on the nursery beds;

(iv) plant sanitation by the removal or burning of all infected or infested crop residues and debris;

(v) crop-rotation to prevent the build-up of a particular insect or fungus or bacterium in a particular area;

(vi) clean weeding;

(vii) and attention to the general health of the crop by judicious watering and manuring when necessary to give the crop the necessary vigour to "grow-away" from pests and diseases.

In addition to the several modern pesticides that have been recommended in this book there are some "old-faithfuls" which are far less poisonous and yet quite effective when used on a small scale in home gardens and allotments. Kerosene Emulsion, for instance, is effective against scales, aphids and other soft-bodied bugs. Tobacco Wash has the same effect.

There are two preparations of Kerosene Emulsion viz.,

(i) Kerosene oil — 4 bottles

Bar Soap — $1\frac{1}{2}$ lb

Water — 10 gallons.

The soap is shaved into thin slices and dissolved in one gallon of boiling water. Remove the boiling water from the fire and add the kerosene while hot, and keep on stirring until the mixture becomes a creamy emulsion. Add water to make up 10 gallons and commence spraying.

(ii) Kerosene oil — 2 gallons

Hard Soap (Bar)— 1 pound

Water — 1 gallon

One pound hard soap is shaved into one gallon of boiling water. The water is removed from the fire and the kerosene added immediately and stirred until a creamy emulsion is formed. No free oil should separate on cooling. For spraying, this solution should be diluted at the rate of one part to 10—15 parts water.

Tobacco Wash is prepared as follows: 1 lb tobacco leaf, stems and refuse and 2 gallons water.

Place the tobacco leaves etc. in 2 gallons of boiling water and allow it to simmer for some time. When cool strain the liquid. To render it more effective you may add one ounce of soap to each gallon of liquid.

A remedy for boring-beetles which attack the branches and trunks of fruit crops, spice trees and other permanent crops, is a Borer Wash prepared from the following ingredients;

Crude Carbolic Acid — 1 pint

Soap — 2 lb

Water — 2 gallons

Dissolve the soap in one gallon of hot water, add the carbolic acid and stir well. Now add six gallons of water to this mixture and again stir well. The resulting mixture could be applied to the trees in the form of a drenching spray or more cheaply by applying it with a brush.

And finally, there is Bordeaux Mixture. Although a fungicide this pesticide serves the dual purpose of also acting as a temporary deterrent to most insect pests:

1 lb Copper Sulphate

$1\frac{1}{2}$ lb hydrated lime

10 gallons water

Dissolve 1 lb of Copper Sulphate crystals in 1 gallon water in a wooden, earthenware or polythene vessel. Add $1\frac{1}{2}$ lb of freshly hydrated lime (prepared by slaking freshly burnt coral lime) to 9 gallons of water. Gradually add the copper sulphate solution to the lime suspension while constantly stirring the mixture. After straining, the resultant mixture may be sprayed. A fresh solution must be prepared every time spraying is done.

13. VEGETABLE CULTIVATION — READY RECKONER

VEGETABLES	RECOMMENDED VARIEITES	SEED RATE PER ACRE	NURSERY	FIELD SPACING	HARVESTING	YIELD PER ACRE	INSECT PESTS	REMARKS
BANDAKKA	MI-5, MI-7 & V.T.	3-4 lb	—	3′ x 2′	1½ - 2 months	6,000 lb	Leaf-eating & pod-boring caterpillars	All these varieties have been bred for resistance to leaf virus
BEANS (POLE)	Kentucky Wonder, Lanka Nil	40-50 lb	—	3′ x 9″	60-65 days	5,000 lb	Bean flies	Provide stakes 5′ high Kentucky Wonder is available both as a green bean and butter bean
BEANS (BUSH)	Top-crop, Wade Cherokee Wax	60-80 lb	—	2½′ x 4″	45-50 days	3,000-4,000 lb	Bean flies	Cherokee Wax is a butter bean
BEET	Crimson Globe, Top Market, Dark Red Queen's Globe	5 lb	—	12″ x 4″	2½ - 3 months	18,000 lb	Cutworms	—
BRINJAL	Departmental Selection	4 oz	Transplant in 4-6 weeks	3′ x 3′	3 months	15,000 lb	Leaf-eating & pod-boring caterpillars	—
CABBAGE	Hercules, Atlas, Leo, KY. AS SD	6 oz	Transplant in 4-6 weeks	2′ - 2½′	3-4 months according to variety	25,000 lb	Cutworms, Caterpillars, Bagrada bugs	—
CURRY CHILLI	Hungarian Yellow, Dept. Selection	4-6 oz	Transplant in 4-6 weeks	2′ x 2′	3 months	4,000-5,000 lb	—	—
CARROT	Top-Weight, Cape-Market, Nantes	4 lb	—	8″ x 8″	3 months	15,000 lb	Cutworms	—
COWPEA	Hawari-me, Murunga-me, Polon me	20 lb	—	3′ x 1′	2 months	2,500 lb	Pod-boring caterpillars	Provide supports, 4-5 ft high
CAULIFLOWER	Early Phenomenal (for up-country Early Patna (for dry zone)	6 oz	Transplant in 4-6 weeks	1½′ x 1½′	9-12 weeks	—	Cut-worms Caterpillars	Blanch heads by covering with leaves
CUCUMBER	Dept. Selection	2 lb	—	2′ x 2′	2 months	15,000 lb	Fruit flies	—
SNAKE GOURD	Dept. Selection	5 lb	—	5′ x 4′	2½-3 months	15,000 lb	Fruit-Flies, Aulacophora Beetles	Train to pandal 6-7 ft
LUFFA	Dept. Selection	3 lb	—	4′ x 4′	2½-3 months	15,000 lb	Fruit-Flies, Aulacophora Beetles	Train to trellis 4-5 ft
BITTER GOURD	Dept. Selection	5 lb	—	4′ x 3′	2½-3 months	15,000 lb	Fruit flies, Aulacophora, Beetles	Train to trellis 4-5 ft
KNOL KHOL	Early White Vienna	8 oz	—	15″ x 6″	3-4 months	6,000 lb	—	—
LETTUCE	Grand Rapids Great Lakes	6 oz	Transplant when 2nd leaf forms	1′ x 1′	3 weeks	2,000 lb	Cutworms Caterpillars	—
LEEKS	Large Long Summer	4 oz	Transplant in 4-6 weeks	8″ x 6″	6-7 weeks	20,000 lb	Cutworms Caterpillars	Blanch stems by earthing up
PUMPKIN	—	1-1½ lb	—	6′ x 6′	4 months	20,000 lb	—	—
RADISH	Japan Ball, *Beeralu*	4 lb	—	12″ x 6″	6-7 weeks	10.000 lb	—	Japan Ball is large and round. *Beeralu* is thin and long
TOMATO	Marglobe, Roma, Wilt-Resistant	4 oz	Transplant in 4-6 weeks	2′ x 1″	2½-3 month	10,000 lb	—	Marglobe & Roma must be staked (4-5 ft high) Wilt Resistant is grown as a bush
MURUNGA	—	Cuttings 5′ x 1½″ thick	—	8′ x 10′	12 months (pods)	—	Caterpillars	—
KATHURU-MURUNGA	—	Seed	—	8 ft	12 months (Leaves, Flowers)	—	Caterpillars	—
SPINACH	Dept. Selection	Seed	—	1½′ x 1′	3 months	15,000 lb (Over 4½ months)	—	Train over low pandal (2 ft high)
THAMPALA	Dept. Selection	Seed	—	6″ x 6″	3-4 weeks	—	—	—

14. NUTRIENT ANALYSES OF LOCAL LEAFY VEGETABLES

Vegetable	Moisture %	Protein %	Fat %	Carbo-hydrate %	Fibre %	Mineral Matter %	Calcium %	Phos-phorus %	Iron mgm per 100 gm.	Calorific Value per 100 mgm.
Tampala ...	87.14	4.53	0.19	3.28	2.08	2.80	0.248	0.076	9.23	33.0
Kura-tampala ...	87.45	3.46	0.18	4.97	1.31	2.63	0.295	0.070	6.30	35.3
Spinach ...	94.53	1.70	0.19	1.59	0.66	1.33	0.152	0.041	2.97	14.9
Kathurumurunga ...	78.97	7.03	0.54	9.83	1.19	2.44	0.490	0.072	7.71	72.3
Kohila ...	91.34	2.17	0.20	3.52	1.34	1.44	0.100	0.042	2.08	24.6
Kankun ...	86.51	4.41	0.45	5.70	1.57	1.36	0.064	0.023	2.95	44.5
Radish ...	90.72	1.88	0.21	5.04	0.89	1.26	0.112	0.011	5.74	29.6
Gotukola ...	84.26	2.89	0.34	8.63	1.79	2.09	0.206	0.041	9.59	49.1
Mukunuwenna ...	86.45	4.05	0.31	4.89	1.93	2.38	0.179	0.048	17.46	38.6
Murunga Leaf ...	77.12	8.05	0.92	10.66	1.01	2.24	0.387	0.075	5.20	82.9

Source: Department of Agriculture.

15. NUTRIENT ANALYSES OF LOCAL FRUITS

Fruit	Edible Portion %	Moisture %	Protein %	Total Carbohydrates %	Total Sugar %	Fat %	Fibre %	Mineral Matter %	Calcium mgm%	Phosphorus mgm%	Titratable Acidity c.c. N/10 per 100 gm.	Calorific Value per 100 gm.
Sour Plantain ...	69	73.6	1.1	24.4	16.6	0.1	—	0.7	13.4	15.8	49	103.4
Kolikuttu Plantain ...	72	65.9	1.3	31.7	22.6	0.2	—	0.9	9.9	19.5	8	133.9
Avocado Pear ...	28	75.6	0.9	5.0	—	17.6	—	1.0	10.9	35.4	12	181.2
Grape Fruit ...	55	88.3	0.5	10.7	5.6	0.1	—	0.4	20.4	12.5	173	45.9
Orange ...	53	86.4	0.6	12.3	5.9	0.2	—	0.6	37.0	18.7	171	53.0
Lime ...	55	90.3	0.5	8.6	—	0.2	—	0.4	18.8	16.1	954	37.9
Papaw ...	67	85.1	0.4	14.1	7.7	0.1	—	0.4	18.8	6.3	12	58.4
Jaffna Mango ...	54	80.0	1.1	17.1	13.1	0.2	0.2	0.4	24.0	20.9	69	74.5
Parrot Mango ...	56	85.9	0.6	12.7	11.4	0.1	0.3	0.4	19.3	7.4	45	53.9
Tomato ...	97	93.9	0.6	4.9	—	—	—	0.6	15.7	9.5	132	22.1
Tree Tomato ...	79	84.6	2.0	9.9	3.4	0.5	2.2	0.8	13.3	30.5	263	52.1
Pineapple ...	42	87.8	0.5	10.9	8.2	0.1	0.3	0.4	13.5	15.0	158	46.2
Mangosteen ...	70	82.6	0.6	16.6	8.4	0.2	—	0.2	5.7	9.4	81	69.8
Jak Fruit ...	31	68.8	1.8	27.5	18.4	0.3	0.7	0.9	16.9	17.0	35	120.0
Sour Sop ...	69	82.4	0.9	15.0	7.2	0.2	0.8	0.8	19.4	31.9	124	65.1
Bullock's Heart ...	41	66.4	2.1	29.4	7.3	0.5	—	1.6	64.1	19.9	88	130.7
Custard Apple ...	47	76.4	2.1	20.4	9.6	0.2	—	0.8	17.8	14.1	78	92.3
Sapodilla ...	86	71.5	0.8	25.2	16.7	1.1	1.0	0.5	4.3	23.9	17	113.7
Guava ...	100	82.0	1.1	10.0	5.3	0.3	6.0	0.7	19.8	11.5	79	46.8
Durian ...	29	68.7	2.4	25.0	8.5	2.1	0.6	1.3	41.5	40.0	52.3	128.4
Rambutan ...	32	82.3	0.5	16.0	8.7	0.1	0.2	0.9	10.6	12.9	271.0	66.6
Uguressa ...	77	74.4	0.4	24.2	9.4	0.2	0.4	0.4	24.1	12.5	321.4	26.5
Lovi-Lovi ...	82	86.6	0.3	11.4	—	0.2	1.1	0.4	—	—	468.3	48.4

Source : Department of Agriculture.

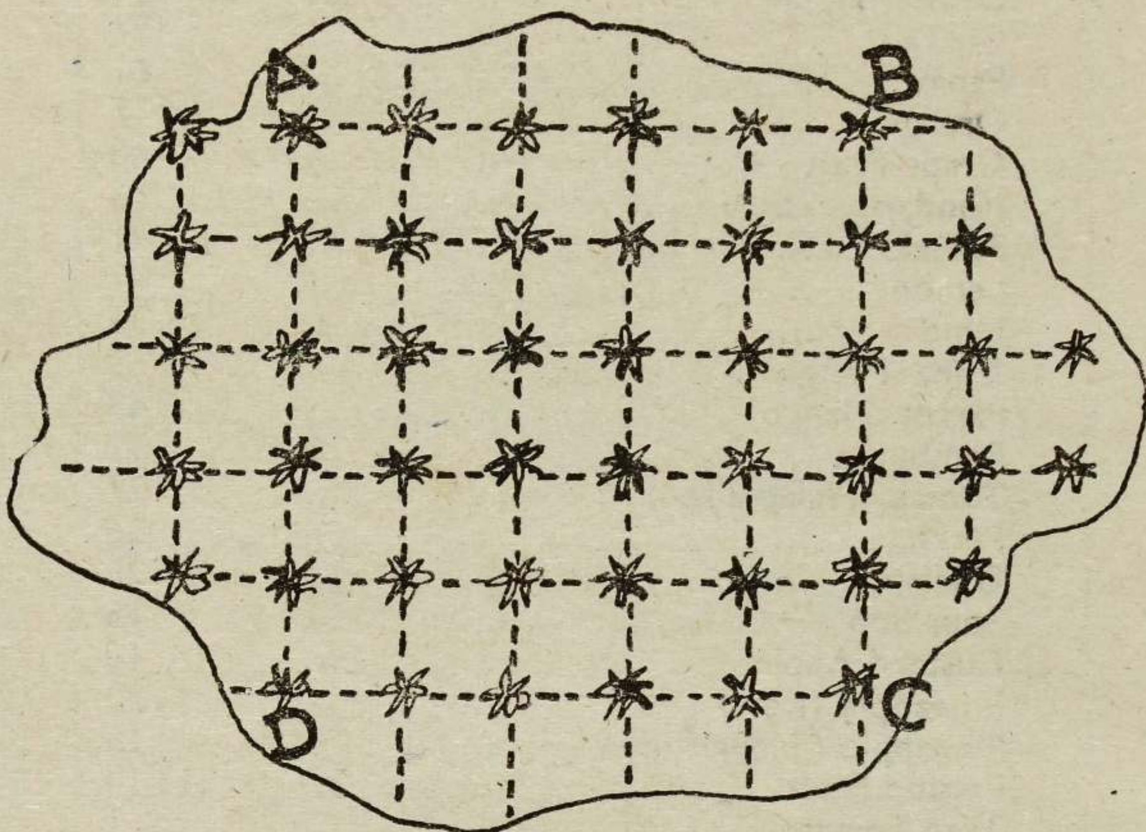
16. VITAMIN "C" CONTENT OF SOME LOCAL FRUITS AND VEGETABLES

	Vitamin C Mgm per 100 gm or c. c.
Fruit	
Nelli	468-479
Cashew Apple	320-350
Guava	127
Papaw	61
Orange	57
Grape Fruit	48
Mandarin	45
Pomelo	41
Lemon	37
Lime	31
Jaffna Mango	55
Parrot Mango	48
Rambutan	35
Tomato (Salad Type)	27
Peach	26
Durian	25
Sour Sop	15
Custard Apple	16
Pineapple (Kew)	20
Pineapple (Mauritius)	15
Passion Fruit	13-14
Tree Tomato	1
Banana	8-12
Mangosteen	1
Ripe Jak	7
Pomegranate	4
Grape	1
Avocado Pear	3
Apple	2
Vegetable	
Kathurumurunga	181
Drumstick (Pods)	80
Drumstick (Leaves)	236-240
Spinach	66
Chillies (Large)	98
Mukunuwenna	33
Onions (Small)	11
Gotukola	14
Ash Plantain	less 1

Source: Department of Agriculture

17. LAYING OUT AN ORCHARD

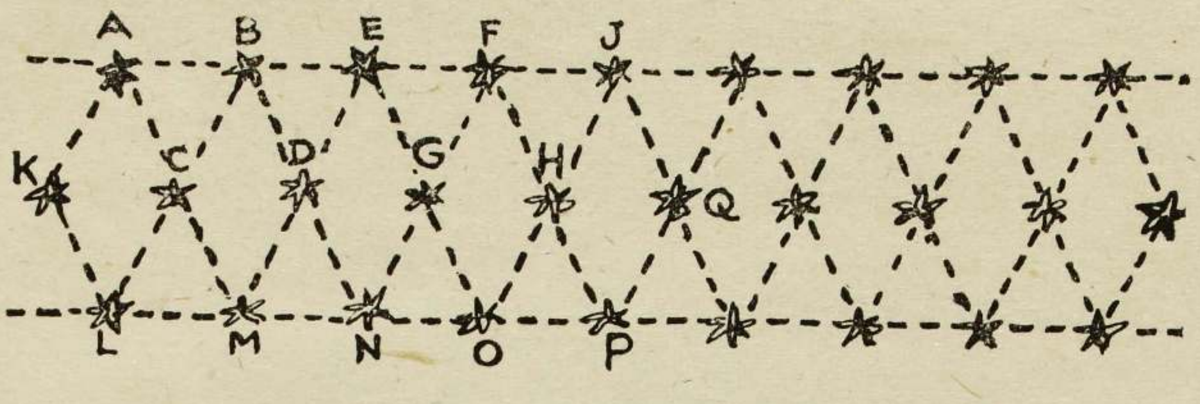
The commonest system of planting on flat land—and all commercial orchards are generally planted on the flat—is the square system. In this system a tree is planted at each corner of a square whatever the spacing. Depending on the shape of the land to be planted a large square should be established e.g. A B C D.



If the planting distance is 20 ft., this distance should be marked off along the four sides of the square and roped off—the ropes being extended beyond the square to the peripheiy of the plantation. Wherever the ropes cross a stake should be placed to mark the position of the planting holes. Twenty-foot distances should also be marked off on the ropes extenidng beyond the square and staked accordingly.

Some orchardists adopt the hexagonal system of planting in order to get more trees per acre, especially in those areas where land is expensive and very fertile with reliable irrigation facilities. In this method the trees are planted at the corners of a equilateral triangle. This way six trees form a hexagon with the seventh in the centre.

In laying out the field a base line is taken along one side. A triangle of rope with each side the length of the planting distance is placed on the base line in the positions ABC, BDE, EGF, FHJ and so on, and the corners marked off with stakes.



The triangle of rope is then placed in the position KCL, CDM, DGN, GHO, HQP and so on till the whole area is laid out. You will notice how the hexagons are formed at ABDMLK, EDNOHF and so on.

The following table shows the difference in the number of trees planted per acre at different spacings in the two systems:—

Planting Distance feet		*Square System*		*Hexagonal System*
15	...	193	...	222
20	...	109	...	125
25	...	69	...	79
30	...	48	...	55
35	...	35	...	40
40	...	27	...	31

The contour system of planting is usually followed on hills with steep slopes. With the aid of a road tracer contours are marked off across the slope of the land at the required planting distance. Stakes are then driven into the ground along each contour at the required planting distance and the holes dug at these points.

18. INCOME TAX & THE FARMER

Income from agriculture is liable to income tax. However, certain special tax incentives and concessions have been granted for Agriculture. The exemptions and deductions granted are as follows :—

1. Exemptions

The following are exempt from Income Tax—

(*a*) Profits and income derived by the owner or cultivator of any paddy land from the sale of paddy (cultivated on such land) to the Paddy Marketing Board or to any authorised purchaser or to the Director of Agriculture or to any officer authorised by the Director;

(*b*) Any sums paid from the Rubber Replanting Subsidy Fund;

(*c*) Any sums paid from the Tea Subsidy Fund, or under the Cocoa Planting Subsidy Scheme.

2. Deduction of Capital Expenditure

(*a*) Expenses incurred in opening up land

All capital expenditure incurred in opening up land for cultivation, animal husbandry, poultry farming or horticulture is allowed as a deduction from a person's income. Capital expenditure which is normally incurred in this connection will include such items as—

(i) clearing land of trees, scrub or undergrowth

(ii) destruction of weeds

(iii) filling up and draining marshy land

(iv) terracing

(v) constructing fences

(vi) constructing access roads and tracks

(vii) constructing irrigation channels

(viii) sinking wells

(ix) preparation of land for planting and

(x) cost of young trees or plants.

(*b*) Maintenance of Immature Areas

The full cost of maintenance of immature areas in an estate is allowed as a deduction from a person's total income.

(*c*) Replanting Expenses

The full cost of replanting an estate with the same crop or with a different crop (including the cost of clearing and preparing the land for replanting) is allowed as a deduction from a person's income. This is in addition to the exemption of subsidies paid by the Government.

Capital expenditure incurred in erecting buildings and sheds and in installing Plant and Machinery will not qualify for a deduction as lump-sum depreciation and development rebate are granted on this type of expenditure as follows:—

(i) Lump Sum Depreciation:

(*a*) durable Plant & Machinery 50% (estimated life 18 years)

(*b*) normal machinery 66 2/3% (estimated life 11 years)

(*c*) short lived equipment 80% (estimated life 6 years)

(*d*) depreciation at 33 1/3% is allowed on the cost of any buildings constructed by the person carrying on the undertaking for use as a staff welfare building or for occupation as a dwelling house by any member of the subordinate staff or for occupation for the purposes of the undertaking *other than as a dwelling house.*

(ii) Development Rebate:

A development rebate of 40% is granted in respect of new Plant, Machinery and Fixtures to be used at any time in an Agricultural undertaking.

A development rebate of 40% is granted in respect of buildings constructed by the undertaking to be used as a staff welfare building or as a dwelling house by any member of subordinate staff or for occupation for the purposes of the undertaking other than as a dwelling house.

3. Losses in Agriculture

When a loss incurred in an agricultural undertaking cannot be set-off against a person's income from any other source, it can be carried forward indefinitely and set off against the income of future years. Losses incurred on the sale of paddy to the Paddy Marketing Board, the Director of Agriculture or any person authorised by the Board or the Director cannot be allowed as a deduction from other income.

BUSINESS TURNOVER TAX

Agricultural undertakings are not liable to this tax. The term (Agricultural undertaking) includes any business of animal husbandry.

CHANGES IN THE BUDGET SPEECH 1978

I. Capital Allowances

Depreciation and Development Rebates referred to in paragraph 6 (*a*) and (*b*) will be abolished and in lieu of these the following new allowances will be granted as a deduction in arriving at profits with effect from the year of assessment 78/79.

(*a*) Plant, machinery and fixtures will qualify for an allowance equal to the entire cost of such plant, machinery or fixtures. Where such plant, machinery or fixtures are sold, the sale proceeds will be taxed as a receipt of the undertaking.

(*b*) 50% of the cost of buildings constructed for use in an agricultural undertaking as a staff welfare building or for purposes other than as a dwelling house will be allowed as a deduction.

Where the buildings are sold or otherwise disposed of, the difference between the sale proceeds and 50% of the cost of construction will be treated as a receipt of the undertaking and taxed.

(c) Entire cost of construction will be allowed as a deduction on building used as dwelling houses by the labour and non-executive staff.

2. Tax holiday

Limited liability companies incorporated on or after 15th Nov. 77, approved by the Minister and engaged in animal husbandry or food production (other than Tea, Rubber, Coconut & Paddy) will not be liable to income tax on profits made upto 31st March, 1983.

3. Subsidies

Any subsidy paid after 1st April, 1977 by the Coconut Cultivation Board will be exempt from tax.

Income and Expenditure account for the year ended 31st March, 19...

Repairs to Plant and Machinery	2,500	Sale of produce	38,000
Replacement of tools	200		
Wages	6,000		
Ploughing	2,000		
Transport	3,000		
Fertiliser	2,400		
Insecticides	1,200		
Medical Aid	500		
Plucking	1,500		
Miscellaneous	2,000		
Profit	16,700		
	38,000		38,000

Capital Expenditure incurred during the year:—

New Water Pump	Rs.	3,000
New Tractor	Rs.	20,000
Expenses in connection with clearing land, sinking wells, etc.	Rs.	10,000

For purposes of taxation, the profits will be calculated as follows:—

	Profit as per statement of accounts		16,700
Less:	Lumpsum Depreciation @ 80% on tractor	16,000	
	Development Rebate @ 40% on tractor	8,000	(24,000)
Less:	Lumpsum Depreciation @ 66 2/3 on pumps	2,000	
	Development Rebate @ 40% on pumps	1,200	(3,200)
Less:	Expenditure on opening up of land for cultivation (100% of expenditure)		(10,000)
	Loss for tax purposes		20,500

The loss of Rs. 20,500 is available for set off against income from other sources for the same year. If such income is not available or not sufficient to absorb the loss, the unabsorbed loss will be carried forward for the next year. An interest of 4% could be added to the unabsorbed lumpsum depreciation carried forward.

Example I—Animal Husbandry

Income and Expenditure Account for the year ended 19 .

Poultry mash, Cattle fodder, Wages, Miscellaneous expenses	25,000	Sale of Milk	10,000
		Sale of eggs	25,000
Net Profit	10,000		
	35,000		35,000

Capital expenditure incurred during the year:—

Purchase of cattle	10,000
Purchase of chicks	5,000

For tax purposes the amount spent on the purchase of cattle and chicks are allowed as a deduction as they are kept on the land

Net profit		10,000
Less purchase of cattle	10,000	
Less purchase of chicks	5,000	15,000
Loss for tax purposes		5,000

The loss of Rs. 5,000/- can be set off against income from other sources for the same year. If such income is not available or not sufficient to absorb the loss, the unabsorbed loss can be carried forward for set off during the next year.

New scheme of Capital Allowances for 78/79

As from the year of Assessment 1978/79, the deduction for tractor and pump will be 100% and not 120% and 106 2/3% as under the existing scheme of deductions:—

Profit as per statement of accounts		19,400
Capital Allowances—		
Tractor 100%	20,000	
Pump 100%	3,000	
Opening of land for cultivation 100%	10,000	33,000
Loss for tax purposes		13,600

The loss is available for set-off against other income. The unabsorbed L. S. D. will not be increased by 4% when carried over to the next year. If the assets are sold, the sale proceeds will be added to profits during the year of sale.

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Grow

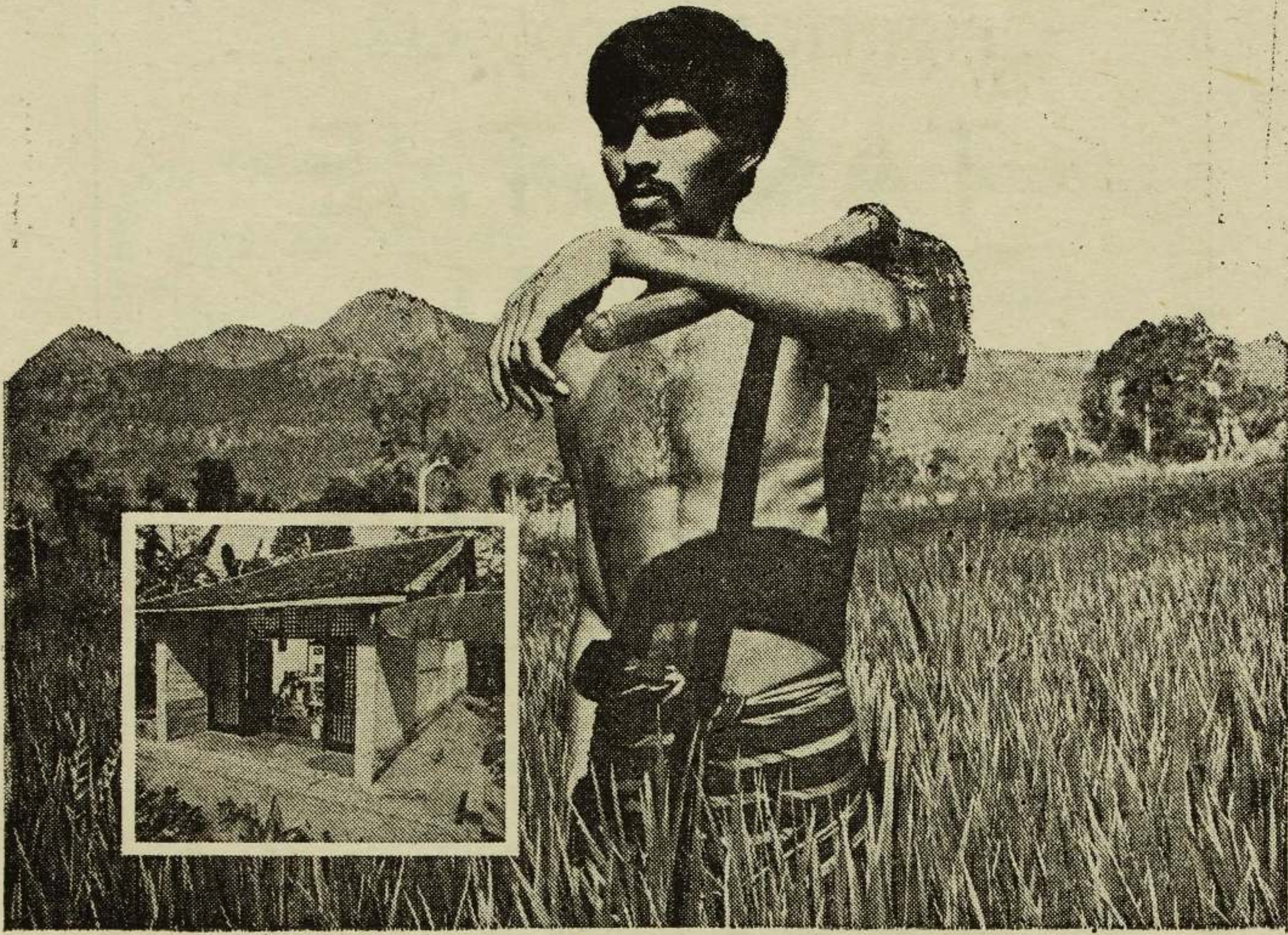
One tiny seed,
a little earth,
sunshine and moisture,
and the
tender loving care
of one tiny tot
has produced a miracle.
The miracle of growth.
And pretty soon
he'll grow up
to find that
things are not
what they used to be.

They're better.
And LANKEM will be there.
LANKEM research and
expertise is helping
people to better the quality
of life, to see that it's a
better place for people
(especially little people)
to grow in.

LANKEM

Towards an abundant
tomorrow

A model colony.



MAHIYANGANA

We have contributed to the Food Production Drive in the country by developing 500 acres at Mahiyangana as a colonisation scheme and settling sixty landless peasant families. The land was demarcated into convenient plots of two acres paddy land and one acre of highland per colonist.

An efficient system of lift irrigation provides a perennial source of water. Cottages with modern facilities have been built at the Company's expense for all the colonists.

Expert technical advice provided by the Company has resulted in the colonists obtaining some of the highest paddy yields in the Island, ranging from 80-150 bushels per acre.

The Company derives no financial benefit from the scheme but continues to provide assistance by the provision of irrigation and other facilities.

CTC

Ceylon Tobacco Company Limited

GARADS

Tobacco and the rural farmer

It has been our policy to progressively encourage the growth of cigarette tobacco in many parts of the Island, undertaking to purchase crops from cultivators at guaranteed prices and assisting generally with advice and supervision of the growing and curing of tobacco at every stage of operation to enable production of quality tobaccos equal to international standards.

Tobacco cultivation has been made into a highly labour intensive operation and a source of lucrative employment to at least 120,000 in the rural areas during the Maha and Yala seasons.

CTC

Ceylon Tobacco Company Limited

GARADS

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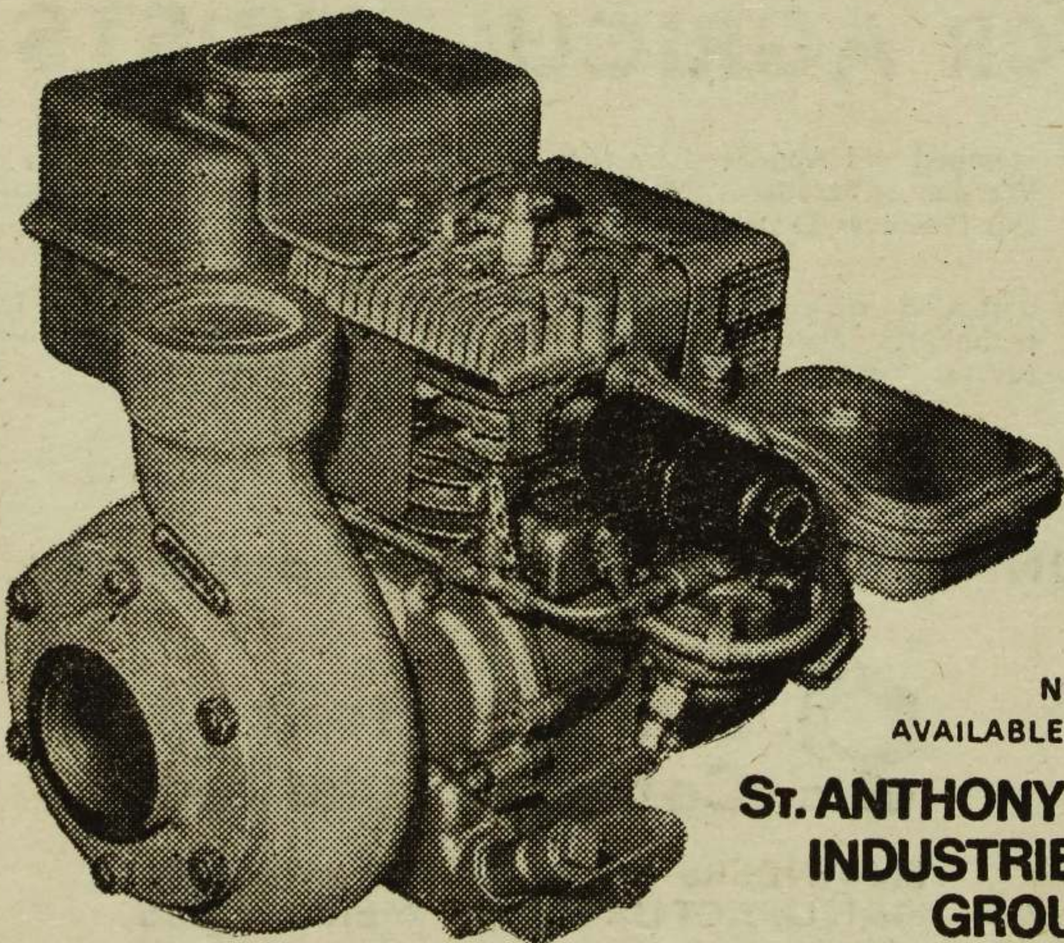

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