Appropriate Te... ...ervice
121, POINT P... ROAD
NALLUR, JAFFNA
No. ~~2104~~
2462.

KRUSHI

VOL. 8 NO. 2 1985 OCTOBER – DECEMBER

QUARTERLY TECHNICAL BULLETIN FOR RESEARCHERS, EXTENSION WORKERS AND TRAINERS IN AGRICULTURE

DEPARTMENT OF AGRICULTURE, PERADENIYA

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Appropriate Technology Services
121, POINT-PEDRO ROAD
NALLUR, JAFFNA
No. ~~2164~~
2462

KRUSHI

VOL.8 No.2 1985 OCTOBER - DECEMBER

Editorial Board: Mr. A.M.de Mel
Dr. D. Suraweera
Dr. H. Somapala
Mr. K. Vartharasa
Mr. P. Periyasamy
Mr. P. Attanagoda
Secretary : Mr. I.M. Gunawardena

Editor Mr.I.M. Gunawardena

Published by

DEPUTY DIRECTOR (EDUCATION & TRAINING),
DEPARTMENT OF AGRICULTURE,
PERADENIYA.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

CONTENTS

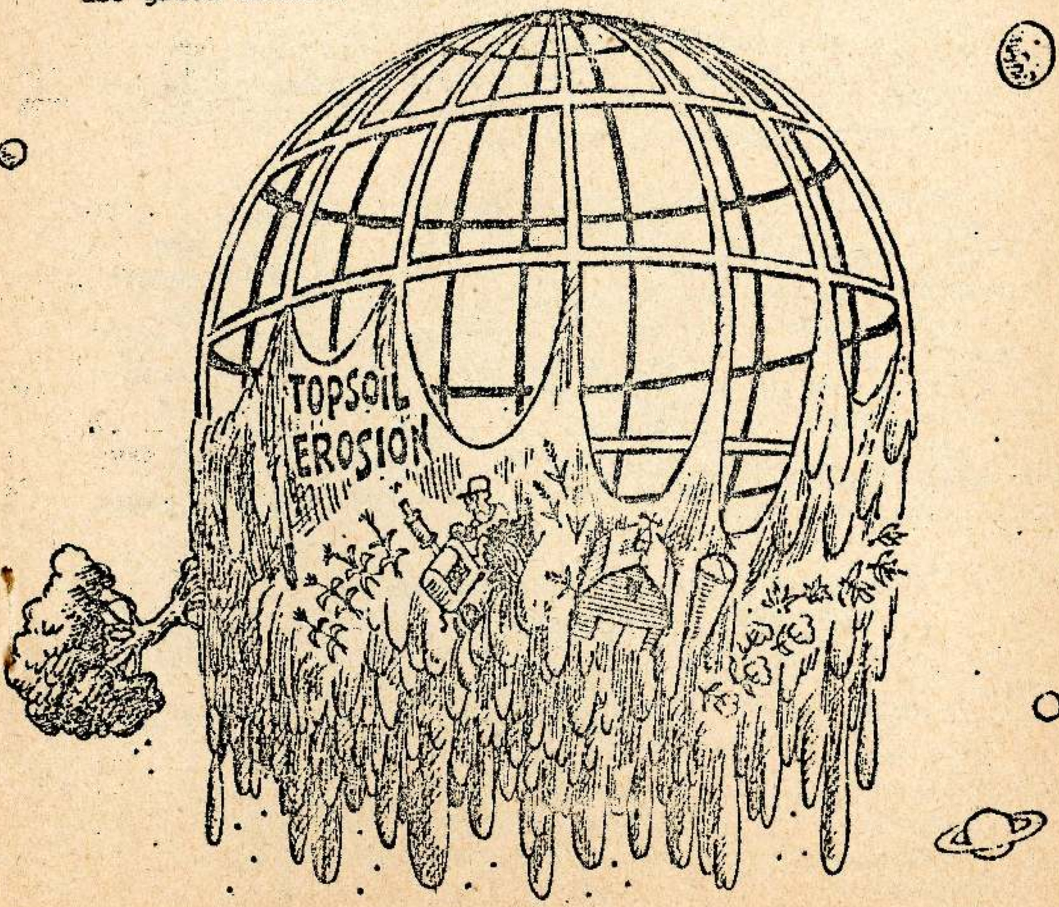
Digitized by Noolaham Foundation.
noolaham.org | aavanaham.org

CONSERVATION FARMING

PART II. *FERTILITY REGENERATING SYSTEMS*

W.L. Weerakoon, R.O., P.H.D. Kusumawathie, E.O. and
A.M. Seneviratne, R.A

Zero or minimum tillage combined with mulching has a beneficial effect on soil structure, soil moisture conservation, fertility improvement, weed control and decreased soil temperature fluctuation (Weerakoon, Bandara and Seneviratne 1985). However, these techniques do not completely arrest soil deterioration due to continuous cropping, nutrient losses by leaching soil fixation and nutrient removal by crops. These limit sustained crop productivity. Therefore, measures to increase soil fertility in combination with other soil conservation measures are needed to develop a sustainable farming system. One method to increase soil fertility is to use green manure.



Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Green manures are bulky. Therefore the use of additional labour for transport and spread green manure may be expensive or difficult due to labour shortage. This stimulated research into systems of mulch production in situ, and integrate it to develop better crop and soil management practices. This is likely to help stained crop production and minimize soil deterioration, and reduction of weed populations. To achieve this objective low growing (live-mulch cropping) as well as high growing (avenue or alley-cropping or agroforestry) plants that can also fix atmospheric nitrogen were used (Weerakoon and Seneviratne, 1982; Weerakoon, 1982, Weerakoon 1983; Weerakoon 1984 a; Weerakoon 1984 b) Nitrogen fixing plants convert nitrogen gas of the atmosphere into soluble forms of nitogen that can be readily used by plants. Furthermore their deeper root systems can obtain plant nutrients from the sub-soil region, and recycle the same to the soil surface.

Avenue Cropping (Alley or Agro-forestry) System:

This system was developed as a long-term blend of arable farming and forestry. This involves growing arable crops between the avenues, hedges or rows of vigorous growing trees and pruning them to regulate shade.

Perennial leguminous shrubs (Example:- *Leucaena leucocephala, Gliricidia maculata) and* Leguminous trees are preferred green manure trees as they can fix sufficient amount of nitrogen to satisfy the requirements of the arable crop. Most of the nitrogen fixed by the leguminous plants are finally deposited in the leaves. These leguminous shrubs can be periodically pruned and the loppings are spread between the rows of trees as a mulch, or green manure. Chemical analysis carried out for L. leucocephala and G. maculata leaves gave the following nutrient compositition. (Weerakoon and Gunasekera 1984, Weerakoon 1984a).

Table I. Nutrient composition by (Percentage) of L. lencocephala and a maculata (dry weight basiS)

Nutrient	L. leucocephala	G. maculata
Nitrogen	4. 7	3.84
phosphourus	0.18	0.18
potassium	1 48	2.00
calcium	0 39	1.01
magnesium	0.18	0.19
carbon	43.7	44.10

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Trials at Maha Illuppallama using L. leucocephala and G. maculata showed that they produce approximately 6 mt/ha of leaf dry matter per year. This is equal to 240 and 230 kg/ha of Nitorgen per year respectively.

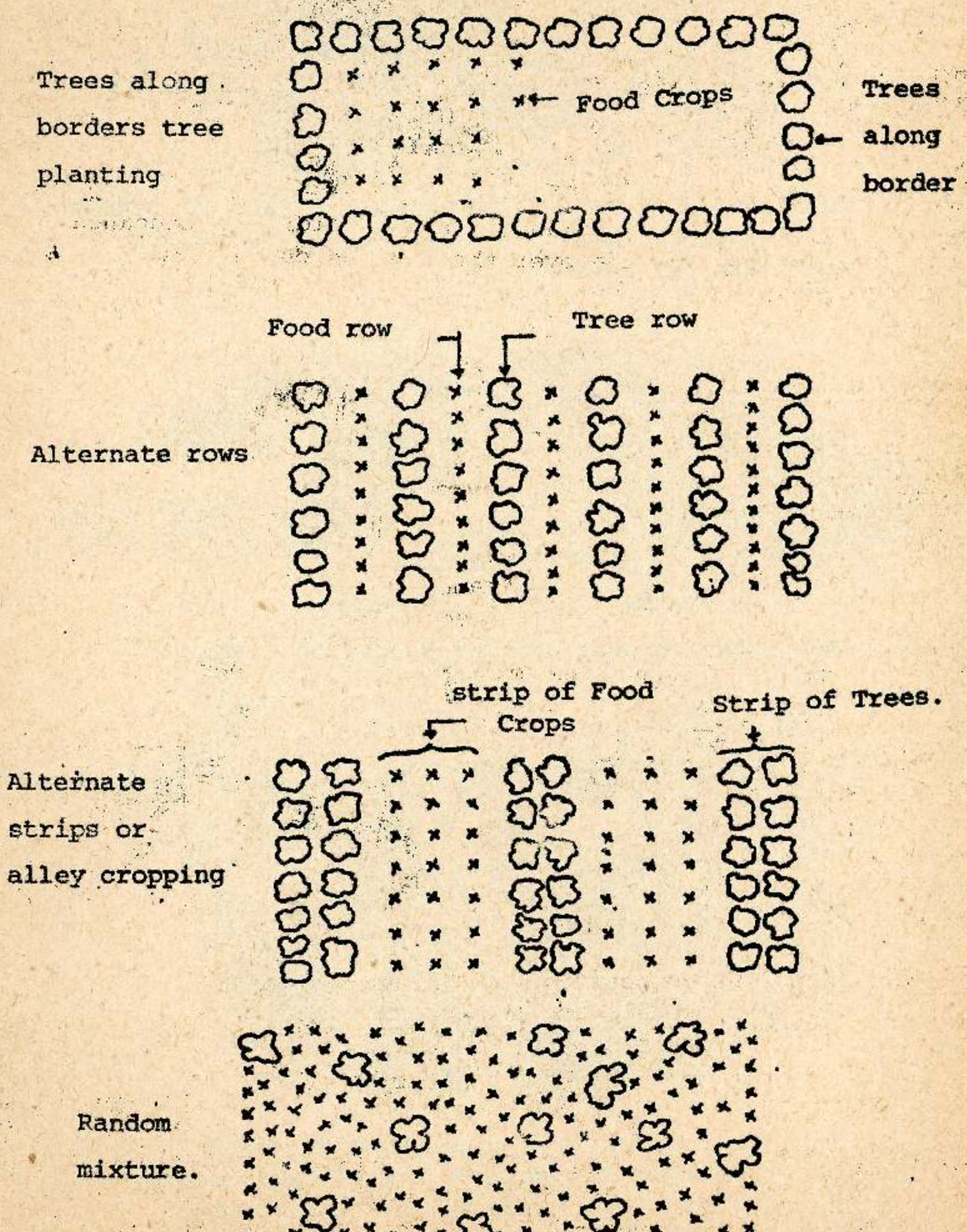


Fig.1. Spatial arrangements of crops in alley cropping.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

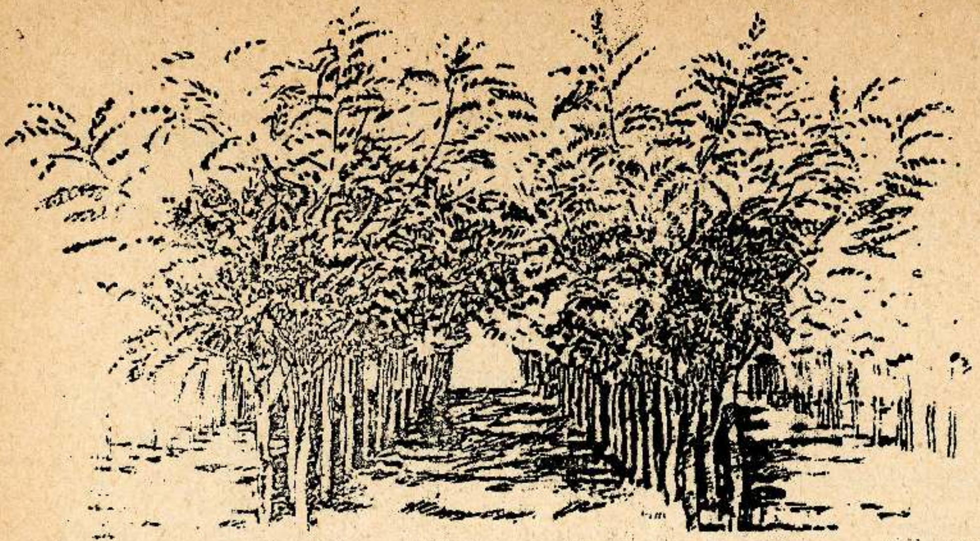


Fig: 2. Double-hedge r-ows planted in Gliricidia or Leucanea to form dense shade over the avenues during dry (non-farming) season.

Fig 3. Hedgerows lopped, and mulch laid on avenues.

Fig 4. Crops growing in the avenues in light shade from the hedge rows that will be topped periodically for "top dressing" mulch and provide optimum light for the growing crop.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

The height of pruning is important for biomass production. Foliage yields are greater when the trees are taller, as shown below in a trial with L. leucocephala and G. maculata.

Table 2. Leaf dry matter production per plant six weeks after the initial lopping.

Stump height (m)	Leaf yield (g)	
	L. Leucocephala	G. maculata
0.5	58.0	95.0
1.0	85.0	184.0
2.0	103.0	253.0

Observations in the avenue planned fields have shown a very considerable suppression in weed growth within the avenues (Weerakoon and Seneviratne, 1982). This is due to the dense shade of the over hanging branches of the hedges, that regrew during the non-arable cropping season. The branching habit of green manure trees seemed to be the major factor influencing weed development. The erect branching habit of G. maculata (erectophile) allowed a higher percentage of solar radiation to reach the ground. resulting in more weeds. The laterally branching (planophile) L. leucocephala shaded even the centre of the alleys and limited weed growth in the centre, as well as the sides of the alleys.

In the most situations C_4 weeds have been observed to be displace by C_3 types which are easily controlled. Both these factors ensures better weed control at a lower cost (Weerakoon 1984).

It has been demonstrated that the grain yield of maize planted in alleys of L. leucocephala hedge yielded up to 45% more when compared with monocropped maize. With G. maculata the maize grain yield could be increased even by 82% (Weerakoon, and Kusumawathie, unpublished data).

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Avenue Cropping on Steep Slopes:

Tree - food crop interplanting should be done either in alternate rows or alternate strips. The close tree spacing along the contour rows makes each multiple row strip an effective barrier that reduces the downward movement of soil from the cultivated strip. In a few years the eroded soil settles down forming terraces naturally with the hedgerows supporting them. The hedgerows are lopped and the food crops are planned on these terraces.

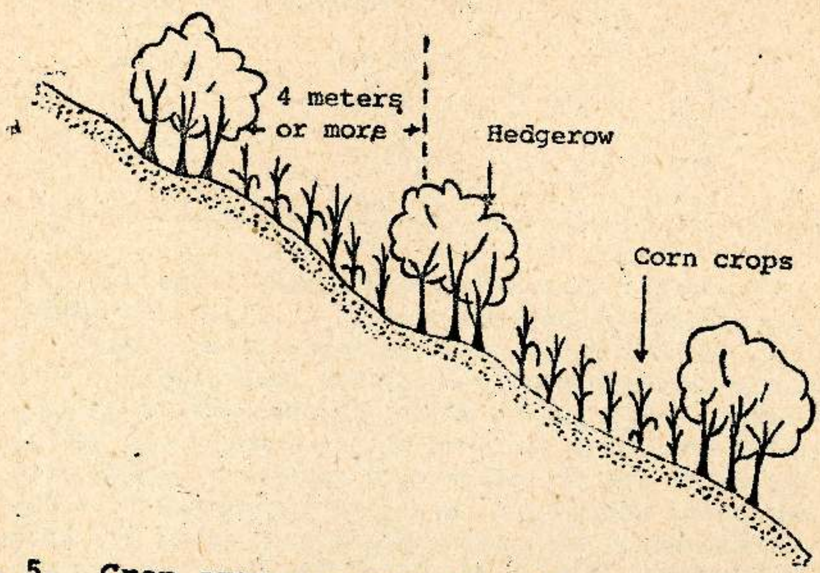


Fig. 5. Crop arrangements in alley cropping

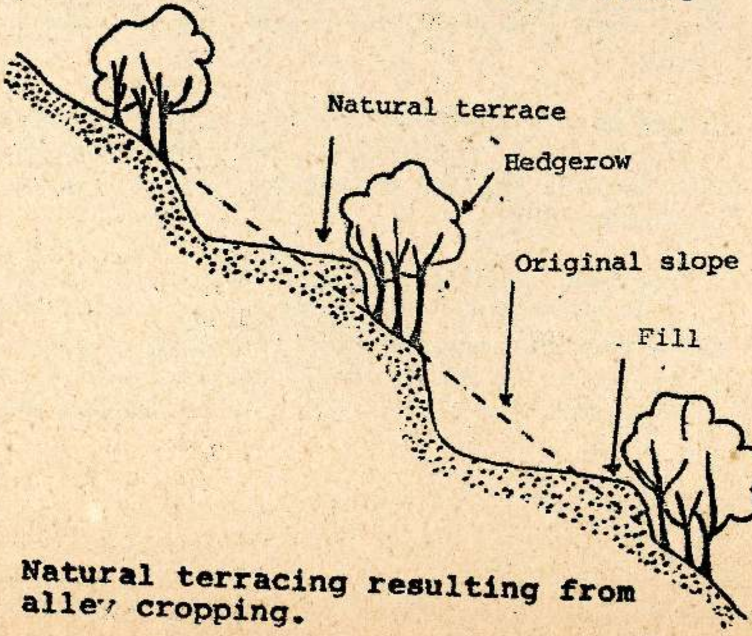


Fig. 6. Natural terracing resulting from alley cropping.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Fodder and Fuelwood Production from Legume Trees:

Many of the pasture legumes are creepers. They are sensitive to over-grazing. If not managed carefully, the legume covers disappear rapidly. Tree legumes such as L. leucocephala and G. maculata are good fodder. The obvious advantages are that while containing higher amounts of protein (27.1% and 24% respectively on a dry matter basis,) they are not too sensitive to over-grazing and are capable of producing foliage even during prolonged periods of drought.

Fodder can be harvested from legume trees by cutting off branches and leaves. They can be taken away to feed animals kept elsewhere. On the other hand, for short duration crops such as upland rice, millets an maize, inter-planting with L. leucocephala and G.maculata trees, makes animal grazing possible periodically, after the cereal crop is harvested, and prior to planting the succeeding food crop.

The main sources of energy used for household purposes in Sri Lanka are :-

a) Electricity (mainly from hydropower)

b) Oil

c) Firewood.

From the above it is evident that firewood is the main source of energy in Sri Lanka. According to the energy coordinating team, Colombo, the average firewood consumption per head/day is 1 35 kg. Therefore, the requirement of a family of 6 person would amount to 3000 kg or 7 to 8 cart loads annually. Research at Maha Illuppallama shows a production of about 6-7 mt/ha of woody biomass/year/ha (dry weight basis) is possible, with conservation farming. This indicates the supply of firewood in this system could meet a substantial part of the farmers firewood requirement.

LIVE MULCH CROPPING:

The concept of cover cropping with leguminous creepers in plantations such as rubber, coconut and oil palm is now being developed for use with annual crops to reduce the need for tillage, for better weed control, and improved fertility Reduced tillage would reduce cultivation costs and erosion problems.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

A good legume or plant for live mulch crop production should:

- be easy to establish and have early horizontal growth and adequate vigour to cover the ground rapidly.
- be weed competitive.
- be a perennial; otherwise annual weeds which die during drought tend to re-establish during the cropping season from their seeds. A perennial cover crop can reduce growth of weeds.
- fix nitorgen at levels required for arable crops.
- withstand slashing or other cultural treatments as would be necessary for food crop establishment. It should grow with minimal competition to the food crop.
- not harbour pests or diseases effecting arable crops.
- be shade tolerant to be able to withstand shading by the food crops grown.
- produce efficient seed for re-establishment.

Amoung the desirable cover crops being investigated are Pueraria phascoloides, Phascolus artropurpureus, Ceutrosema pubesceus, Psophocarpus palustris, Mucuna utilis and Desmodium ovalifolium.

The seeds should be of good quality. Pre-planting treatments such as scarification, soaking are conducted to ensure good germination. It is also advisable to treat legume seeds with the appropriate nitogen fixing rhizobium bacteria.

The crop seedlings emergence through the vegetative cover may be hindered if seeded directly. Therefore, clearing of narrow strips along the row is recommended. Another alternative would be to burn narrow strips (15 cm. wide) through the live mulch cover using paraquat at 2.5 - 4.0 l/ha (formulated product . Paraquat nearly dessicates the leaves of the plant that comes in contact with it. Seeds then can be directly planted into the soil with an injection seeder or by hand with a stick, (Weerakoon 1983).

Proper management of live mulch is necessary during crop growth period, to eliminate competition with the planted crops. Therefore, the foliage of all these legumes are sprayed with a growth regulator (CGA 47283 Ciba - Geigy) at

Digitized by Noolaham Foundation
noolaham.org | noolaham.media

the rate of 8 kg/ha (formulated product) in order to prevent the legume from climbing and smothering the crop (Weerakoon and Seneviratne, 1982).

There is a possibility that this system can also be used where the living mulch dies of drought, provided that the mulch crop produces abundant seeds which germinate before the sowing dates of the crops

At the Agricultural Research Station, Maha Illuppallama the effect of 'different live mulches' on weed growth and crop yield was studied. In this study the least amount of weed growth was found with C.pubescens. Furthermore, the yield of maize was increased upto 148 percent, when intercropped with ground covering legumes in comparison to the control. The legume P.artropurpureus (Siratro) and P. phaseolides showed the highest beneficial effects. Studies were also made to compare several management systems namely: (1) zero tillage, (2) conventional tillage and (3) live mulches (no-till), at three livels each of nitorgen at 0, 25, and 50 kg N/ha.

In the absence of applied nitrogen, the yields were strikingly higher with live mulches than under conventional or zero tillage. Particularly interesting is the evidence that maize - a crop which demands high levels of fertility yielded as much under live mulch with no nitrogen applied as under conventional tillage with 50 kg/ha of applied nitrogen, equivalent to 100 kg of urea.

A problem with live mulch is to prevent it from competing strongly with crops. Some means of discouraging mulch without impediment to the crop is necessary. Growth retardants should be a last resort if mechanical means prove inadequate.

RESEARCH FOR LOWLAND

The potential of avenue cropping techniques is also being reviewed to meet natural fertility for paddy cultivation (Weerakoon an Gunasekera, 1985).

L. leucocephala was grown on rice bunds and lopped twice before and during paddy cultivation, and applied as leaf mulch (2.6 mt/ha) on rice variety Bg.34-8. This treatment increased the grain yield by 74 percent. L. leucocephala foliage supplemented with half the recommended amount of nitrogen gave a grain yield of 2.8 mt/ha.This resulted in a 121 a percent yield increase, compared with application of half the amount of recommended inorganic nitrogen.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

The nodulation of Sesbania sesban and its contribution as green manure was studied in a rice based cropping system. S. sesban is an annual legume weed that thrives in moist soils in the dry zone. It is a fast growing shurb and produces approximately 4 mt/ha green leaves (dry matter basis) at the spacing of 0.25 m^2 within a two month period. This amount of green material would contribute nearly 130 kg N/ha/ season.

Table 3:

Percent Nutrient Composition of S. Sesban
(dry wt. basis)

Nutrient	Percentage
Nitrogen	3 31
phosphorus	0.24
potassium	0.92
calcium	1.69
magnesium	0.17
carbon	43.30

About one thousand nodules (or about 1.7 gms) (dry weight) develop on the roots of a 12 week old Sesbania Seban plant. Here peak nodulation occurs at the podding stage. This is about the 12th week after seeding (Weerakoon and Senarathne, unpublished data).

Green manure can be obtained by growing S. sesban in paddy fields prior to sowing paddy. This could be achieved by broadcasting the seeds of S. sesban into a standing rice crop shortly before harvesting. Seeds can also be broadcasted into rice stubble without any cultivation. Therefore, in sita application of S. sesban as a source of green manure in rice crop could be of practical importance for farmers. Expensive inorganic fertilizer inputs may beyond their reach.

In the above study the weed infestation decreased due to shade created by S. sesban by an average of about 70 %, (0.25 m^2 spacing) compared to S. sesban free control plots. Most of the pernicious weeds listed by Weerakoon and Gunawardena (1983) could be controlled by this method. These results indicated an added advantage because S. sesban helps to reduce weed infestation without cost. This may eliminate at least one tillage operation during land preparation.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

A preliminary study has shown green manuring with S. sesban increased the average grain yield approximately by 400 kg/ha which is equivalent to 50% of the yield increase over the control. Green manuring supplemented with 1/4 the recommended amount of nitrogen fertilizer resulted in a grain yield comparable to the yield from plots which received the recommended amount of N fertilizer. The above findings suggest that the use of S. sesban could replace a substantial amount of inorganic nitrogen fertilizer now being used in rice production. Besides providing nitrogen to the rice crop, a good cover of S. sesban could also suppress weed growth in the paddy fields.

REFERENCES:

Weerakoon, W.L. (1982. Recycling of Organic Matter in Asia for Fertilizer.

Asian Productivity Organization, Tokyo 197-216

Weerakoon, W.L and Seneviratne, A.M. (1982) Managing a sustainable farming system in Sri Lanka.

Proc. 1982 British Crop Protection Conference 2, 689-696

Weerakoon, W.L. (1983). Conservation Farming in the Commonwealth.

Papers from a Training Workshop, Sri Lanka 1983.

Weerakoon, W.L. and Gunawarena, S.D.I.E. (1983) Rice Field Weed Flora of Sri Lanka. Tropical Agriculturist 139, 1-14.

Weerakoon, W.L. (1984a) Use of Nitrogen Fixing Trees in Agriculture.

Paper presented at the Seminar on Nitrogen Fixation. Organized by the Institute of Fundamental Studies (IFS), 19th May, 1984.

Weerakoon, W.L. (1984b). Report on the conservation Farming Program in the South Pacific Report submitted to the Commonwealth Secretariat London.

Weerakoon, W.L. and Gunasekera, T.G.L.G. (1985) In situ application on Leucaena leucocephala (Lam) de Wit. as a source of green manure in rice.

Accepted for publication in the Sri Lanka Journal of Agricultural Science.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Weerakoon, W.L. Bandara, K.M.C.* an Seneviratne,
A.M. (1985). Conservation Farming Part I.
Zero tillage or No - till Farming.
KRUSHI VOL.8 No.1 JULY-SEPTEMBER (1985)

[redacted]

ABSTRACTS

IITA Rolling Injection Planter

This is a hand pushed machine designed for planting seeds of crops such as Maize, Cowpea and Rice. This planter works well on tilled land, although it was designed for use in no-tillage systems. The machine has a sustained planting speed of over 10,000 hills per hour. Therefore I hectare of land can be planted with Maize seed in 3½ hours. The spacing in the row is fixed at 25 cms.

(Extracted from IITA Research Briefs, Vol.6 No.2 June, 1985).

Tapak - Tapak Pump.

Lifting water for small farm irrigation can be faster easier and cheaper if a Tapak-Tapak pump is used. This pump is suitable for lifting water from wells, canals or rivers with no priming required upto a depth of 5 meters. The capacity of the Pump is 180 l/hr for a 2 meter lift and 120 l/hr in a 4 meter lift.

A Tapak - Tapak Pump can be turned out easily using locally available materials.

(Extracted from RNAM News letter No.22, April 1985).

AGRO FORESTRY

To meet the increasing demand for firewood and timber scientists are experimenting on growing trees along with food crops.

The greatest chances of success in Agro-forestry is likely to be in dry zone areas, and also it may prove to be the most stable agricultural system for those regions. In a field planted with leguminous trees in rows 5 m apart and 2 m within the rows, at the beginning of the rainy season cereal, or pulse crops could be planted between the tree rows. The trees are pruned to allow sufficient sunlight for the planted agricultural crop. The tree crop acts as a wind break thus reducing soil erosion due to wind. The leaves can be used as a mulch to reduce soil moisture loss as well as weed growth.

Continued on Page 18.

Digitized by Noolaham Foundation
noolaham.org | noolaham.media

'Appropriate Technology Services
121, POINT PEDRO ROAD
NALLUR, JAFFNA
No.

SOYBEAN SEED PRODUCTION IN SRI LANKA - PROBLEMS AND SOLUTIONS -

V. Arulandhy, Research Officer
Soybean Project, Gannoruwa

OPERATION	ANTI IPATED PROBLEM	POSSIBLE SOLUTION
Planting.	Poor seeding eme gence and stand establishment due to - - Poor quality seed - Deep planting - Surface crust formation - High soil temperature - Seed-and soil-borne microoganisms.	Use high quality seed. Adopt recommended depth of planting. (2.5 - 3 cm). Use surface mulch to get over highsoil temperature and surface crusting. Treat seed with appropriate fungicide that does not affect the nodulation, to protect germina ing seed from seed-and soil borne micro-organisms.
	Loss of seed quality if crop matures during wet weather are attributable to - Purple seed disease caused by Cercosphora sp (fungi) - pre-harvest sprouting on plant - Poor seed vigour and viability due to seedborne disease infestation. - Seedcoat cracking.	Plant at correct time so so that maturation and harvest falls into dry period. Late October to mid November in Maha Season and early to mid May in Yala seasnn, depending on the crop duration of the cultivar used.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

OPERATION.	ANTICIPATED PROBLEM	POSSIBLE SOLUTION
Inoculation	Poor nodulation resulting from	Follow the recommended practice of seed inoculation. Teach farmers the technology of inoculation and field conditions required. Improve facilities for storage of inoculants. Emphasise on the expiry date of the inoculant utilized.
Water Management	Severe drought during pod filling reduces seed yield quality and germination drastically and also reduces the storage potential of seed.	Use early maturing cultivars to avoid moisture stress at flowering and pot filling stages. Pract ce zero tillage and mulching to conserve soil mosture. Irrigate of possible especially from flowering to pod filling. Moisture is the most critical at pod filling.
Weed Control	Weed competes with soybean crop during early stage. Weed at maturity reduces seed quality and makes harvest difficult.	Early weeding. Give 2 weedings at the 2nd and 4th weeks after the establishment of the crop. Maintain good plant stand to supress weed growth.

Digitized by Noolaham Foundation.
noolaham.org | aavanaham.org

OBSERVATION	ANTICIPATED PROBLEM.	POSSIBLE SOLUTION
Insect Control	Leaf eating catterpillars damage the leaves. Serve defoliation result in reduction of seed field. Pod sucking insects and pod borers reduce germination and storability of seed.	Spray with effective insecticides when insect population is reasonably high. Do not postpone the time of spray. Spray the right type of insecticides and the dose recommended at the proper time.
Disease Control	Some diseases cause reduction in seed yield and germination. - Bacterial pustule causes premature defoliation and reduction in yield. - Yellow mosaic virus disease in the early stage of crop reduces seed yield. - Purple seed disease reduces seed quality and germination.	Plant esistant cultivars. Choose locations where disease incidence is low. Adhere to the right time of planting.
Harvesting	Delayed harvest reduces seed germination It also causes shatterin and thus reduces the yield. Immature seed does store and germinate well.	Harvest at optimu maturity when 95% of pous turn brown.

CARE WITH THE SEED
JOY WITH THE HARVEST
- Psalm 126 -

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

OBSERVATION	ANTICIPATED PROBLEMS	POSSIBLE SOLUTIONS
Drying	Sundry-ing under high relative humidity does not lower the seed moisture to safe level for storage. High drying temperature (artificial drying) kills the seed. Seed with high moisture content does not store well.	Use artificial drier if necessary and possible. Set the temperature at about 40°C. Dry seed to 10-12% moisture for storage.
Threshing	Mechanical damage reduces germination. Damaged seed does not store well.	Thresh carefully to reduce seed damage. Do not dry the seed and pod too much before threshing.
Storage	High temperature and relative humidity of storage environment cause rapid seed determination and shorten the life of seed. High initial seed moisture also reduces the life of seed in storage. Poor quality seed deteriorates rapidly.	Keep seed at low temperature and relative humidity. Select locations with low temperature and/or relative himidity. Use cold storage Pack seed in moisuture proof containers or bags. However, dry the seed well before packing.
Marketing	Disposal of the seeds produced by the farmers.	Develop a feasible system for purchasing seeds directly from th farmer at his door-way.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

A NEW PREDATOR OF COCCINE IDAE BEETLE

Micraspis discolour (Fabricius)

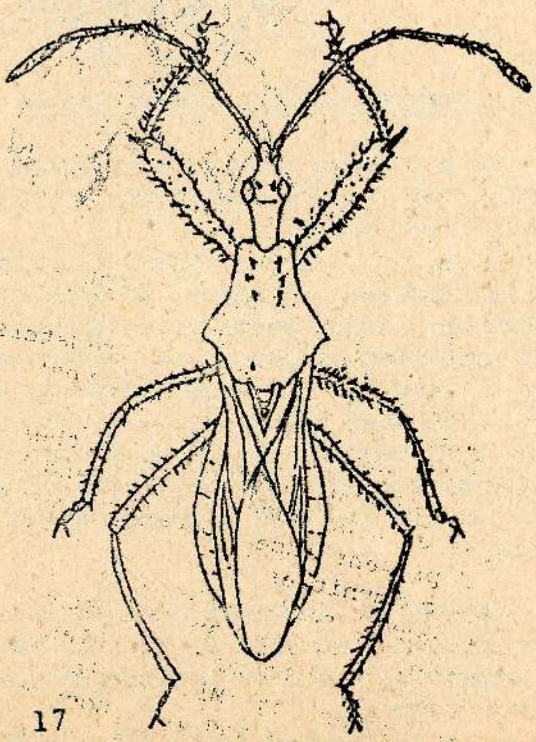
A NATURAL ENEMY OF RICE INSECT PESTS

Devika Delpachitra, Research Officer(Entomology)

Regional Agricultural Research Centre, Bombuwela

Natural enemies play an important role in the control of populations of the rice pests. Coccinelidae beetles specially Micraspis discolour (Febricius) is a important component in the faunal composition of natural enemies of rice pests in Kalutara district.

When insects were collected by net sweepin and further studies made, a new kind of Hemipteran bug was found to prey on a beetle Micraspis discolour. These two kind of insects were kept in a cage for further observations. New hemipteran bugs seemed to suck the body sap from the beetles. This new predator was identified from "An Illustrated Guide to some natural enemies of rice pests in Thailand, Part I, JICA" as Scipinia horrida (stal) (Hemiptera, Reduviidae) (Fig.1). Body length is about 1 cm. Body orange yellow, abdomen with brownish band on each tergite. Vertex with three pairs of long erect bristles and another two or three pairs of smaller ones posteriorly. Dorso-apical part of fore famora with a long bristle. Under side of tibia with two rows of small bristles.



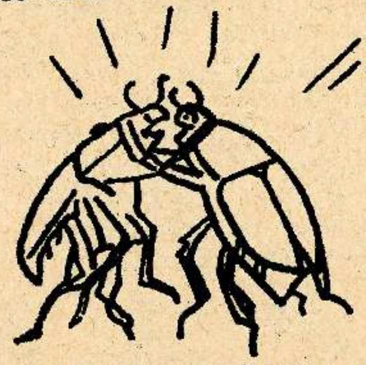
Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

It is of utmost importance to control predators that destroys usefull insects. The above identified Hemipteran bug could therefore be also considered as a insect pest and suitable measures should be taken for its control. Though this insect is a predator of a natural enemy it was also reported as a predator of the larvae of Lepidoptera from India, Philippines and Thailand.

Continued from Page 12.

Thus a piece of land can be used to produce a perennial fodder crop, a grain or pulse crop, and the trees can also be cut for poles, firewood or timber.

(Extracted from At ICRISAT, No.9, Jan-March 1985)



Natural Enemies of Rice Insect Pests:

Natural enemies are Predators, Parasites and diseases that attack insect pests and keep their populations under control.

Biological control whether natural or induced, creates a balance of pests and beneficial spiecies and prevent insect pests from causing economic damage. The communities of predators, parasites and diseases of pest insect in the rice ecosystem are rice and diverse. The wolf spider attacks rice stem borer moths. It can kill 10-20 Brown Plant Hoppers per day. The predaceons bug (Microvelia) lives on water and kills plant hoppers and leaf hoppers, wasps attack leaffolder larvae.

As our knowledge of natural enemies of rice insect pests improves, we will be able to develop long term, less expensive and more ecologically acceptable pest control programs.

(Extracted from "IRRI Reporter" 1/85 March, 1985)

Continued on Page 28.

Digitized by Noolaham Foundation.
noolaham.org | aavanaham.media

BREEDING SOYBEAN VARIETIES FOR SRI LANKAN CONDITIONS.

V.Arulandy,
Soybean Breeder, Agricultural Research Station,
Maha Illuppallama

Soybean being a profitable crop is grown commercially for human consumption. At present soybean is one of the five major grain legumes cultivated in Sri Lanka; the others being cowpea, mungbean, blackgram, and groundnut. Soybean is recognised as a potential food crop that can bridge the gap between the national nutritional needs and the availability of protein,,as well as edible oil requirement in Sri Lanka. Soybean protein is considered a complete protein because it supplies (in sufficient amounts) the various amino acids needed by the human body. (Thus it is called as "the meat of vegetarian") Recent dietary surveys have indicated that the diet of average Sri Lankan is deficient in proteins. This deficiency can be rectified by an increased consumption of grain legumes such as soybeans. Soybeans have the highest amount of protein (40 percent of the Seybean produces the highest yield of protein per unit area of land. (Soybeans, is the richest, the cheapest, and the easiest form of protein and has a vast multiplicity of uses as a cereal, a pulse, an oil seed, vegetarian meal and milk.) Thus Soybean rightly deserves the title of "wonder crop".

Correlations between total soybean production.Hectarage and average production suggests that generally total production is dependent upon hectarage.

Table 1. Correlations of total soybean production with total hectarage and average yield in Sri Lanka. (1974 to 1983.

Correlated variables	1981	1982	1983
Production: Hectarage	**	**	**
Production: A erage yield	NS	NS	NS

** Significant r at P = 0.01 NS: Not Significant.

Soybean planted area increased by about 15,000 ha and the production increased by 10,000 mt. during the period 1974 to 1983.- Table 2.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Table 2: Total production, area used for cultivation, and average yield of soybean in Sri Lanka (1974 to 1983)

Year	Area (ha)	Production (mt)	Average Yield (mt/ha)
1974	1308	1000	0.76
1982	16867	11140	0.66
1983	14631	10610	0.73

The average yield of soybean in Sri Lanka is 0.7 mt/ha as compared to 1.1 mt/ha for the Asian countries while the world average is 1.6 mt/ha. Therefore, there is considerable room for improving the average soybean yield in our country .

CROPPING PATTERN OF SOYBEAN

The greater part of the land under soybean is presently confined to the northcentral region of Sri Lanka. (Table 3)

Table 3: Targets of area and production of soybean in the year 1982/83

Production area	Season	Total area	Total Production (mt)
North Central region	Maha	8250	12250
Entire	Maha	10322	14037
Country	Yala	5806	8360

Soybean is grown during (the major rainy season) the months of November to February (Maha season) as well as during (the minor rainy season) the months of May to August (Yala season) Table 4). In Maha season, soybean crop is grown on highland under chena or stabilized cultivation system purely as a rainfed crop. In lowland areas where water is in-adequate to grow rice during Yala season soybean and other upland crops are grown, (primarily as monocrops) following the wet land rice. This appears to be the best rotation or larger tracts of irrigable land in the dry zone where the availability of water is inadequate to grow a second crop of rice during Yala Season. Under irrigation in previously puddled rice fields, about 70 cm. of water is required fo a crop of soybean during Yala

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

season, when the evapotranspiration is as high as 6 - 9 mm per day.

Season	Rainfall (mm)
Major rainy season (Maha)	860
Minor rainy season (Yala)	390

There is a tremendous potential for intercultivating other crops including Soybean in coconut plantations. The area under coconut in Sri Lanka is 45,000 ha. At full bearing age (25-30 years) coconut plants utilize only 25-30 percent land and about 40-50 percent sunlight. Therefore a great potential exists for intercultivation of coconut with soybeans, some soybean varieties yield well under partial shade of coconut trees. The performance of some soybean cultivars under coconuts is shown below in Table 5.

Table 5: Yield of soybean cultivars g own in pure stand and under coconuts in Sri Lanka.

Cultivar	Grain yi ld (mt ha)	
	Pure Stand	Under Coconuts
Improved Pelican	3.5	0.8
Bossier	2.3	0.5
Pb-1	2.2	0.

PRODUCTION CONSTRAINTS

The soybean production in Sri Lanka faces several constraints which (singly or collectively) bring about a reduction in seed yield.

Poor Seedling Emergence and Stand Establishment

A major constraint to expansion of soybean cultivation in our country is slow seedling emergence particularly in the dry zone where most of the soybean is grown. Emergence and establishment of soybean seedlings is erratic and freuently poor. Non uniform seedling emergence may be due to:-

1. Soil surface crusts up, after heavy rains and heavy irrigation follo ed by drought. This makes it difficult for cotyledons to penetrate through the soil surface;

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

2. High soil temperatures (during the dry season) inhibit hypocotyl elongation;

Unemerged seedlings become infected by micro-organisms.

Poor Seed Quality:

Rapid loss in viability of stored soybean seeds in Sri Lanka is another constraint. The combination of high humidity and high storage temperature causes rapid deterioration of soybean seed. Also production of poor quality seed occurs when adverse conditions exist during postmaturation and preharvest periods. This is a common phenomena in this country and some other Asian countries as well.

Pest and Disease Infestation:

At present there are no serious diseases or pests that threaten soybean cultivation in Sri Lanka. With intensified cultivation, diseases like Soybean Yellow Mosaic Virus and acterial Pustule may be potential threats in the future. Leaf eating caterpillars attack the soybean crop. However, they can be controlled easily by insecticides. Pod Borers and stink bugs are observed occasionally.

Weed Competition:

Weeds are a problem in many soybean fields. Soybeans planted after wet land rice succumbs to weed competition, especially if the land is not well prepared before seeding. Hand weeding is a hard job on muddy or hard soil and is time consuming. On the other hand, herbicides are fairly expensive for the average farmer today.

Drought Stress:

Soybeans planted during the dry season (Yala season) after wet land rice, may experience moisture stress. Moisture stress causes poor crop growth poor pod setting, an in complete seed filling. Eventually the seed yield is remarkably reduced.

Ineffective Inoculation:

In areas newly planted with soybeans, rhizobium bacteria are not present in the soil. The present soybean cultivars require inoculation with Rhizobium japonicum for satisfactory nodulation, Although inoculation is performed by the farmers inoculation technology is not properly applied. This results in poor nodulation. The conditions necessary for storage and usage of soybean inoculents must be provided

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

so that the innoculation will not be a problem for the farmer.

Minimum Inputs:

If the inputs needed for soybean cultivation are kept as low as possible, this adversely affects growth of the crop and the seed yield. The introduction of improved technology packages to the farmers is essential to enable the farmers to get economically optimum yields.

MAJOR BREEDING ACCOMPLISHMENTS

Breeding for high yield alone is not sufficient. The other attributes that contribute to yield stability are equally important.

Adaptability to Farmer's Conditions of Cultivation:

One of the major tasks for soybean breeders is to improve the plant type to suit the prevailing conditions. This entails developing cultivars resistant to lodging, shattering and also have high pod set. In view of the difficulties often encountered in establishing optimum plant population due to, excessive rainfall or high soil temperature, soybean cultivars possessing small to medium seed size are more suitable to overcome these conditions. This helps to obtain uniform emergence and food crop establishment. Soybea plants should be capable of branching to compensate for deficiency due to non-uniform emergence. Determinate growth is a means of reducing height and controlling lodging and also ensure synchronous maturity. Selection of cultivars should be done under conditions similar to the actual conditions under which it is to be grown.

Seed Viability

In Sri Lanka soybean seeds deteriorate and lose viability rapidly (under regular ambient storage). Most of the present high yielding cultivars can not be stored with good viability for even three months. Therefore breeding for better seed longivity is essential.

Earliness

A soybean crop grown in low land during dry season (Yala season) following wet land rice may face water shortage. In such cases the farmer needs short duration cultivars which mature in 70-80 days with reasonable yield. High yields can not be expected from short duration cultivars because earliness is inversely correlated to yield. Earliness is useful to avoid drought effects during generative stage.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Season Specificity:

Soybeans are grown during wet season (Maha Season) and dry season (Yala season) in Sri Lanka. The environment of wet season soybean is characterized by:-

1. Excessive and extended rainfall.
2. Low sunshine due to clouds and rains.
3. High soil fertility under chena system.

The dry season crop planted after wet land rice experiences,

1. Compact soil structure.
2. Poor drainage.
3. Drought during generative stage.
4. High soil and ambient temperatures.
5. Longer sunshine hours.

Cultivars should be selected for cultivation in Yala and Maha Seasons considering these factors.

Sjade Tolerance:

Soybean intercropped with cereals like maize or subsidiary food crop like chilli or plantation crop such as coconut needs to tolerate shade. Shading may reduce seed yield. Shade tolerant soybean cultivars are required to obtain high yields under these conditions.

Disease resistance:

After development of soybean cultivars suitable for an area, more attention must be given to developing varieties that can resist diseases. Several diseases have been identified as causing yield or quality reduction in soybeans. Attempts are to be made to incorporate genetic resistance to one or more of these importan diseases. Disease resistant ability must be added to the present cultivars without losing the existing desirable attributes or introducing new undesirable ones. Breeding for Soybean Yellow Mosaic Virus and Bacterial Pustule are urgently required in Sri Lanka. Development of cultivars resistant to Soybean Rust and Charcoal rot diseases must also be considered.

Insect Resistance:

Insect pests are one of the principal hazards involved in growing soybeans in Sri Lanka and other Asian countries.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

The advantages of insect resistant soybean cultivars are reduced production costs and increased net income to the producers. There are other benefits; such as protecting the environment, reducing hazards to beneficial insects and other species. Identification of source of resistance to the important insect pests such as leaf eating caterpillars, pod borers, stink bugs and incorporating them into promising cultivars must be seriously considered. While it is difficult to combine all resistant genes into one single cultivar, it is feasible to breed cultivars resistant to one or two insect pests.

Efficient Nitrogen Fixing Ability:

It has been often found that soybean cultivars of tropical origin nodulate profusely under the existing bacterial complex present in soils even without the application of the suitable bacterial culture. Such genetic potential existing in soybeans for nodulating under a broad spectrum of bacterial strains designated as "promiscuous" nature must be exploited for efficient nitrogen fixation. One must be cautious and specific in selecting the genotypes that produce effective nodules with high nitrogen fixing ability.

Identification of Efficient Strains of Rhizobia:

Realizing the importance of biofertilizer, program of research to identify the efficient strains of Rhizobium spp. suitable for the improved cultivars under local conditions and to evolve measures for longer viability with their higher efficiency of nitrogen fixation should be launched.

Protein and Oil

Soybeans are primarily grown for two products, oil and seed meal extracted from the seed. Soybean meal is an excellent protein source (with exceptionaly high nutritional value as an animal feed) Depending on the demand for the protein meal or oil, breeders can select their breeding objectives. Recent investigations, however, has focussed on the area of protein quality by searching for soybean strains with high level of methionine and cystine, (the limiting aminoacids of soybean protein. The reduction of linolenic acid through breeding has also received recent emphasis. Linolenic acid causes soybean oil to be unstable, have an objectionable odour. Hydrogenation is necessary to remove the influence of Linolenic acid. Oil from cultivars with low level of linolenic acid would not require hydrogenation thereby reducing processing costs and placing

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

soybean oil in a more competitive position. A negative correlation between protein and oil makes it difficult to increase one without decreasing the other.

BREEDING METHODOLOGY:

Soybean breeding program needs to include:

- Screening technique -
  - * Selection of suitable parents.
  - * Identification of source of resistance.
- Crossing
- Breeding methods
  - * Conventional method
    - * Pedigree method
    - * Backcrossing method
    - * Bulk population method
  - * Newer method
    - * Single Seed descent
    - * Recurrent selection.
- Testing program

The genetics of the characteristics must be correctly understood and breeding objectives must be clearly defined before initiating the breeding program. Many alternate methods are available, as mentioned earlier, for developing the suitable cultivars. However, the selection procedure depends on the objectives of the breeder, the availability of resources (man power, equipment, budget) and preference of the breeder.

VARIETAL IMPROVEMENT

Varietal improvement of soybean in Sri Lanka began with the INTSOY program in 1973. This was followed by the introduction of advanced breeding lines and cultivars and their selection for adaptability in the different agro-climatic zones. A local breeding program was initiated in 1978 using the promising introductions and local cultivars. Some of the U.S. cultivars yielded more than 4 mt/ha under local conditions (Table 6); however, they were found to be poor in

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

storability under humid tropical conditions prevailing in Sri Lanka. The U.S. cultivars Bossier, Improved Pelican Davis and a cultivar Pb-1 from India were recommended and released for cultivation.

Table 6: Performance of soybean cultivars at the Agricultural Research Station, Maha Illuppallama, Sri Lanka.

Cultivar	Country of origin	Grain Yield (mt/ha)
Hardee	U.S.A.	4.8
Bossier	U.S.A.	4.6
Pb-1	India	3.0

The advanced breeding lines evolved from crosses of exotic cultivars with an indigenous cultivar Nuwara Eliya local gave 11-12 percent yield increase over Pb-1, the most popular cultivar among farmers (Table 7). The newly developed breeding lines received the superior storability traits from indigenous cultivar.

Table 7: Some Characteristics of Improved Soybean lines developed in Sri Lanka*

Cultivar/Line	Grain yield (mt/ha)	Days to maturity	100 seed weight (g.)	Storage** period in months
PM-78-6-5-13	3.6	85-90	12 0	4-6 -
PM-78-2-5-25	3.4	95-100	9.0	6-8 -
Pb-1	3.0	85-90	13.0	3 -
Nuwara Eliya Local	2.0	100-110	7.0	9-12

* Evaluated at the Agricultural Research Station, Maha Illuppallama, Sri Lanka.

** Period during which 8 percent germination was maintained.

Three advanced breeding lines of short duration were identified from the screening program (Table 8). They would be more suitable for cultivation during dry season (Yala

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

season) in lowland as a post rice crop. They would have great potentiality in areas where short duration soybean cultivars are in demand.

Table 8: Grain yield and some agronomic characteristics of short duration advanced breeding lines.*

Breeding line	Days to maturity.	Plant height at maturity (cm)	100 seed weight.	Grain yield (mt/ha)
GC 50106-26-8-6	75	50.6	12.6	2.6
GC 50226-2-7-6-6	75	61.6	14.2	2.3
GC 60058-18-1-8-7-6	78	54.9	12.2	2.1

* Evaluated at the Agricultural Research Station, Maha Illuppallama, Sri Lanka.

OUTLOOK

The goal of soybean breeding program in Sri Lanka is to continue the develop cultivars with improved yield and other characters of economic importance. An important factor in yield improvement is genetic resistance to diseases and insect pests. As soybean production intensifies in Sri Lanka in the future, the intensification of hazards and also the emergence of new hazards can be expected. Therefore a long term breeding program to evolve new varieties for overcoming the problems that arise with time, will be highly desirable.

Continued from Page 18.

Applying communication Technology for Rural Development

The existing communication technology is not being applied to rural development on more than a tiny scale. Communication is not yet viewed as a powerful force for change and as a means of passing on know-how economically and effectively. Communication media through used widely and successfully for achieving political and commercial goals, are not used to resolve the problems of millions of people who live in a state of such misery as to be an affront to human dignity.

(Extracted from Agricultural Information Development Bulletin Vol.7, No.2 June, 1985).

Continued Page 34.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

NITROGEN FIXING LEGUMES

AN ALTERNATIVE TO EXPENSIVE FERTILIZER

Malkanthi Gunathilake - Research Officer
Central Agricultural Research Institute, Gannoruwa,
PERADENIYA.

Since World War II, the increased agricultural production has depended enormously on the availability of abundant, cheap sources of energy that promoted the use of fertilizers, agro-chemicals and mechanization. However, the economic circumstances did not remain static and at present energy is no longer cheap. As a consequence, the prices of fertilizers, specially nitrogenous fertilizers escalated tremendously.

The chemical fertilizers (such as urea) have a number of short comings, such as the need of a sophisticated industry to produce them, an efficient mode of transportation and storage facilities and the possibility for them to pollute the atmosphere.

In the light of these facts the modern scientists have given much attention to ways and means of improving two basic biological processes. The first is photosynthesis that constitutes a series of reactions carried out by green plants using the energy of sunlight to produce carbohydrates. Secondly, biological nitrogen fixation, which fixes atmospheric nitrogen into ammonia, a form which can be utilized by plants.

Biological nitrogen fixation is confined to microorganisms. Only procaryotes such as actinomycetes, blue-green algae (cyanobacteria) and bacteria can reduce nitorogen to ammonia. The bacteria that can carry out biological nitrogen fixation can be free-living organisms for eg. <u>Azoto bacter</u> and Clostridium or those that can form symbiotic associations with higher plants such as legumes. For eg. <u>Rhizobium.</u> Rhizobia are soil bacteria, characterized by their unique ability to infect roots of legumes and form nitrogen fixing nodules on the roots.

The legume-rhizobium association is most probably the most efficient and important source of fixed nitrogen on a global basis. Nitrogen fixation by legumes amounts to 20% of the estimated biological nitrogen fixed each year on earth far superior to any other single nitrogen fixing system. Hence, fixing it has a very important role to play in agricultural production. Table 1, shows the estimated rates of biological nitrogen fixation for some of the major grain legumes. Legumes are the only crops that can be self-sufficient in nitrogen nutrition.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Table 1. Estimated nitrogen fixation rates of the major tropical grain legumes.

Legume	Estimated Nitrogen Fixed Kg/ha.
Soybean	40 - 206
Peanuts	49
Pigeon pea	90 - 150
Cowpea	90 - 354
Chick pea	41 - 270

The family Leguminosae is the third largest family of flowering plants. Legumes have wide geographical distribution growing in temperate zones, humid tropics and arid zones. Some legumes are aquatics.legumes have a variety of uses. They are useful mostly as food for animals and humans, and as a green manure. The lesser known uses of legumes are as floricultural crops, timber, medicinal plants, spices, and for extraction of dyes, gums, resins, fibers and paper manufacture. Many of the legume seeds are composed of 20-30% proteins and hence are highly nutritious. For comparison a non-legume like corn, contains only 10 - 15% protein. Legumes are important as a complement to carbohydrates specially in the developing world where malnutrition is prevalent and animal protein is seldom affordable.

The principal nitrogen fixing legumes important in world agriculture are peas, beans, soybeans, chick pea, lupins, lucerne etc. Most of the legumes can be infected by bacteria of the genus Rhizobium. Rhizobia are soil saprophytes but their populations are usually greater in the plant rhizospheres than in root free soil. Legume rhizospheres contain more rhizobia than non-legume rhizospheres.

An active population of rhizobia is essential for timely nodulation of seedlings. Infection of the root hairs and the formation of a nodule are a highly specific series of cellular processes. The susceptibility of legume host to a particular rhizobial strain is genetically determined. Some legumes are infected by a single strain of Rhizobium or a very narrow range of rhizobial strains. Others may be infected by rhizobia isolated from a wide range of legumes.

When the soil does not contain high numbers of viable rhizobia, specific for the legume we want to cultivate,

Digitized by Noolaham Foundation.
noolaham.org | aavanaham.org

successful nodulation does not occur. This can be remedied by adding an inoculum containing effective strains of rhizobia in sufficient quantities. An effective strain of Rhizobium is one that is not only able to infect the host system and form nodules, but also fix atmospheric nitrogen. This method of artificially introducing rhizobia into soil or inoculation, is done by coating the seed with a dried rhizobial culture in a previously sterilized, inert material like Peat, before planting, A successful inoculum should provide at least 1000-5000 rhizobia per seed for small seeds like clover and at least 10,000-1000,000 rhizobia per seed for large seeds like soybeans.

Inoculants cannot be treated like other inert agro-based market products such as fertilizers. They are living, biological products and hence need proper storage and handling. They are heat and light sensitive. They should be stored away from chemicals. Available scientific data indicate that most of the agro-chemicals at recommended levels may not affect nitrogen fixation. But repeated application of some agro-chemicals could lead to the build up of residual compounds toxic to most of the nitrogen fixing bacteria.

Inoculants are sold in the form of a powder, pellets or liquid, the powder form being the most popular. Usually an inoculant consists of a mixture of an inert carrier and an active culture of rhizobia. The carrier protects the rhizobia and helps the rhizobia to adhere to the seed. Products such as crop waste, clay, straw, charcoal, compost, peat etc. can be used as the carrier. The choice of aparticular carrier is usually determined by its easy accessibility. However, peat is the best carrier so far as the stability of the inoculant is concerned.

The quality of an inoculant depends on the number of viable rhizobia they contain and their effectiveness in fixing nitrogen with the intended host. However, the quality should be judged by their field performance under varying situations. Since the multitude of factors that determine the final performance of a living organism in different situations differ so widely it would be unrealistic to set rigid standards of quality evaluation for a product of this nature.

Inoculation is beneficial when the legume crop is introduced into a new locality for the first time, where indigenous rhizobia cannot be expected to be available in sufficient quantities for successful nodulation.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Failure of an inoculum to show a positive Performance can occur due to several reasons, such as, incompatibility of the Rhizobium and the legume host, insufficient rhizobia per gram of the inoculum, presence of large populations of indigenous rhizobia which are poor nitrogen fixers but superior in terms of nodule formation and a multitude of yet unknown factors.

Nodule formation and nitrogen fixation involve a series of cellular processes and complex biochemical re-actions which require energy as well as plant nutrients such as phosphorus, boron and molybdenum. Hence, when the plant is not healthy enough or when the soil is deficient of the elements mentioned above, nodulation can be affected adversely.

The following guidelines should be considered in selecting a suitable inoculum.

1. The inoculant should contain large numbers of viable rhizobia (10,000-1,000,000 per seed).
2. These should be capable of producing nitrogen fixing nodules on the intended host.
3. The inoculum should not contain any other micro-organism which could have a harmful effect on the rhizobial population or the young seedling.
4. The carrier medium should protect the viable rhizobia.
5. It should be easy to apply and it should stick well on the seed.
6. The package should protect the rhizobia till it is been used by the farmer.
7. The packing material should allow for exchange of gases and retain the moisture within the package.
8. The package should contain clear directions as to how it should be handled and used. The following items should be stated clearly.
   - (a) On which legume crops it could be used profitably.
   - (b) Date of expiry.
   - (c) The number of viable rhizobia each seed would get when used according to instructions provided.
   - (d) Ideal conditions for its storage.
   - (e) Name and address of manufacturer.

Digitized by Noolaham Foundation.
noolaham.org | aavanaham.org

(f) Serial number for future reference.

The following instructions would help a farmer to use his inoculum more effectively.

1. Store the inoculum in a refrigerator or in a cool place.
2. Keep it out of direct sunlight.
3. Protect it from drying.
4. Inoculate seed just before planting.
5. Use minimum quantity of water just enough for good adhesion of the inoculum on to the seed.
6. Keep inoculated seed in a cool place away from sunlight and protect from drying.
7. Leftover inoculum should be packed well to prevent drying and stored in a refrigerator at 4°C.
8. Agro chemicals such as fungicides and pesticides applied to seed or soil as they could be toxic to rhizobia and lower the effectiveness of the inoculum.

If an agro-chemical has to be applied, use a higher quantity of inoculum than the manufacturer's recommendation.

However, even when an optimum is reached in terms of all the factors mentioned, nodulation can be poor if the soil is rich in fixed nitrogen. Soil conditions such as the pH too influence the extent of nodulation, for the rhizobia have a low survival ability in acid conditions. Under such conditions application of lime or seeds coated with limestone can improve nodulation.

Once the nodules are fully formed the amount of nitrogen fixed by the legume-rhizobium system is influenced to a great extent by many chemical and physical factors which affect the development and effective functioning of the nodule. The overall nutritional status of the plant plays a major role in determining the long term beneficial effects of this symbiotic association.

There is no doubt that considerable improvement has been achieved in terms of legume breeding. The breeders have attempted to achieve the best combination of certain characters suc as high yielding capacity, resistance to pests and pathogens, tolerance to environmental stresses, easy storage and consumer acceptability. Very often the

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

breeders have either given less importance to characters such as efficiency of biological nitrogen fixation, nature of legume rhizobium strain selection or the survival ability of the rhizobium in the soil ecosystem.

In terms of the demand for nitrogenous fertilizers and in view of their high costs it would be more economical to use a rhizobial strain capable of forming a more efficient legume-rhizobium complex. Also, if the rhizobial strain used in commercial inoculum has the capability to survive as a free living organism in the soil ecosystem competing with the multitude of other soil microorganisms, then it will not be necessary for the farmer to inoculate his seed every season.

It is safe to predict that increasingly stringent demands will be made in the near future by farmers for improved and varied types of legume inocula as harsher environments are opened up for legume cultivation.

The problems of feeding the ever increasing populace in the developing world, providing each individual with a diet adequate in quantity and rich in quality are inescapaly tied up with less expensive ways of producing more and more plant proteins. Hence, a more concerted effort by agronomists, breeders and microbiologists could help to bring forth an improved technology for legume cultivation.

~~#################~~

Continued from Page 28.

Nursery Management for Kurakkan (Finger Millet)

With Co 11 variety of Finger millet, studies were done to ascertain the influence of nursery practices on grain yield. In this study transplanting 20 day old seedlings gave a higher yield (3373 Kg/ha) than 30 day old seedlings (3012 kg/ha). Application of Nitorgen at 90 kg/ha gave 4 yield was 2850 kg/ha when 45 kg/ha of Nitorgen was applied.

Planting 20 day old seedlings form a manured nursery and application of 90 kg n/ha gave significanly higher net income than planting 30 day old seedlings from unmanured nurseries and application of 45 kg N/ha respectively.

Continued on Page 50

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

REHABILITATION, PROMOTION, AND EXPANSION OF MANIOC AND SWEET POTATO PRODUCTION.

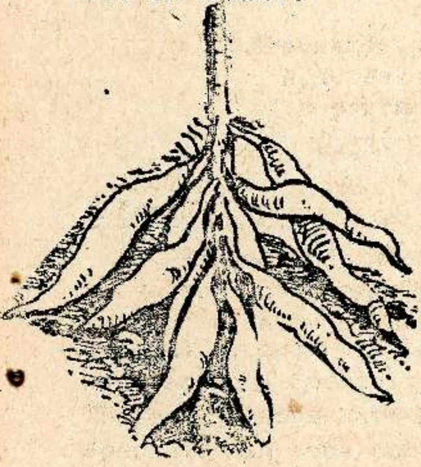
P.O.S. Abeywardene (Deputy Director - Extension) and
H.B. Basnayake, A.O., (Roots and Tubes).
Department of Agriculture, Peradeniya.

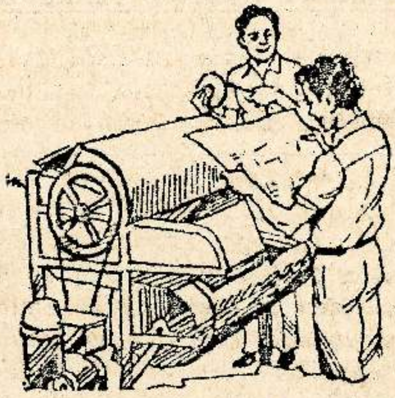
Introduction:

Manioc and Sweet Potato are two food crops that deserve much greater emphasis interms of research and extension than at present. These two crops grow and produce well under less than optimum conditions of cultivation and management. Specially during periods of "Crisis Situations" These two crops have helped to overcome food shortages. Specially in some rural areas manioc is the second most important food crop. (The first being rice).

Present Situation:

Manioc has a great potential both as a human food and animal feed. Manioc tubers are a useful raw material for several agro-industrial products. Inspite of the potential for large scale production of animal feed, starch, glucose, and industrial alcohol, manioc still assumes mainly the role of a home garden crop. A few farmers grow manioc on a slightly larger scale than a home garden crop, to satisfy their domestic needs plus a little extra produce for sale in the local market. However such farmers are too few in number.





Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

When the supply of rice and other cereals in the market is adequate for the consumers, the traditional root crops are almost always neglected. Unless appropriate measures are not adopted, very few farmers would consider production of these crops as worth while. Table 1, illustrates the declining trendin cultivation of manioc and sweet potato in Sri Lanka.

Extent cultivated (Hecares)

Year	Manioc	Sweet Potato
1974	91,000	23,000
1977	54,500	11,000
1980	27,000	6,400
1983	26,000	6,100
1984	22,500	4,609

Perhaps most of the farmers who planted manioc and sweet potato in 1974, would have decided either not to grow these crops or drastically reduce their cultivated extent gradually from year to year.

If this is the trend then the future of manioc and sweet potato is bleak. To avoid this situation a decision was made in May, 1984 to -

1. Establish demonstration plots in selected school gardens with improved manioc and sweet potato varieties. This will help to produce planting materials for neighbouring schools and farmers.
2. Provide in-service training for the extension staff on root crops.

Uses of Manioc: -

Dried and processed manioc tubers is a very useful ingredient to make poultry feed. Annual import of this material to Sri Lanka is 5000-8000 metric tons, at a cost of Rs.3500-3600 per metric ton. Thus the annual expenditure for importing processed manioc for animal feed is Rupees 17,500,000 to Rs.28,800,000.

At present Sri Lanka imports around 100 metric tons of starch for use in the textile industry. At Rs.6000 per metric ton, 100 tons is worth Rs.600,000. Manioc starch can be used in the textile industry. If high quality manioc starch could be produced in Sri Lanka, all this money can be saved.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Proposed action jprogramme.

In view of the economic importance of manioc and sweet potato the following activities could be useful to reap the protential benefits from manioc and sweet potato crops.

(1) On a home-garden scale.

1.1. Extend school garden demonstration plots so that each school in each district will have demonstration plots of manioc and sweet potato.

1.2. Establish and maintain demonstration plots of recommended manioc and sweet potato varieties at the premises of Agricultural services centres.

1.3. Extend manioc and sweet potato cultivation in Agricultural settlements including the Mahaweli settlements.

(2) On a commercial Scale.

2.1. Identify the potential areas for cultivation of manioc and sweet potato. Then initiate action programs at district level to popularise their cultivation.

2.2 Encourage farmers to adopt the recommended package of practices (including the use of recommended varieties, correct spacing weed control and fertilizer application.)

(3) Research needs.

3.1. Study the feasibility of underplanting manioc and sweet potato in coconut lands.

3.2 Develop techniques for processing manioc tubers into high quality starch, as a cottage industry.

(4) Marketing facilities.

4.1. Organize purchasing points for sale of processed manioc products for farmers convenience.

4.2 Provide incentives for processing manioc tubers into flour or starch.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

4.3 Provide a guaranteed price for processed manioc tubers.

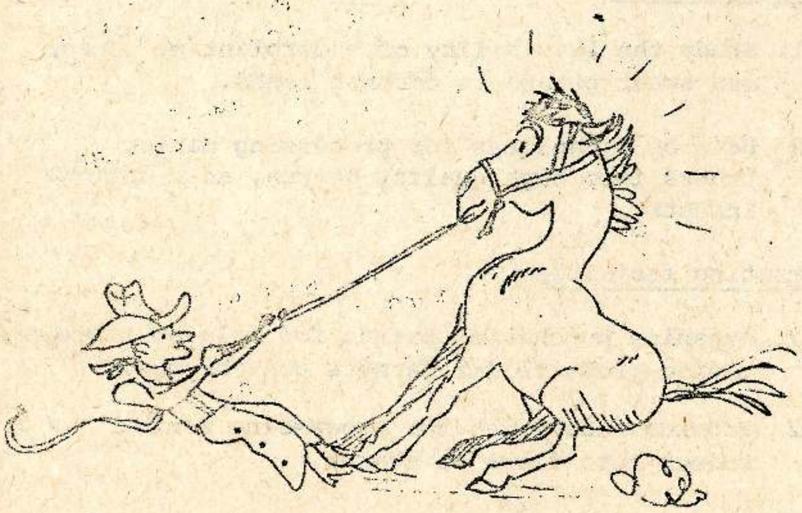
(5) Supply of Planting Materials.

5.1. Preferably each Agricultural Service Centre area should be self sufficient in its planting material requirements of root and tuber crops. After obtaining good quality planting materials from relevant sources, multiplication and distribution of planting material should be organized and co-ordinated; so that they are readily available locally.

Conclusions:

Improvements in the production and processing of manioc and sweet potato as well as other roots and tubers is an important aspect that deserves attention of the farmer, the extension worker, the researcher, as well as the policy maker and the agro-industrialist.

Although arrowroot grows well in Sri Lanka, no systematic programme has been implemented for the production and marketing of arrowroot flour. But in some countries arrowroot flour production is a flourishing industry. However, unlike arrow root, manioc could be of far greater economic significance to Sri Lankans as we can achieve a substantial saving in foreign exchange if we develop the manioc industry, effectively and without further delay.



Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

BETEL CULTIVATION IN KURUNEGALA AND GAMPAHA DISTRICTS

A Survey Report

W.M.W. Weerakoon, Research Officer
Regional Agricultural Research Centre, Makandura.

Abstract:

Betel (Piper betel) is an important cash crop mainly because, it provides an additional income. This crop is grown mainly in Gampaha and Kurunegala districts. Most of the farmers engaged in betel cultivation have more than 10 years experience in growing this crop. The betel leaves produced are either exported or sold locally

The profit margin from betel cultivation is superior to almost all the other crops conventionally grown under the mixed cropping patterns in these two districts. The size of an individual holding varies significantly. A farmer may cultivate 300 to 10,000 betel vines in his land holding. In Gampaha and Kurunegala districts for many farm families, betel cultivation is one of the main sources of income. The yield and quality differences inherent to various betel varieties commonly cultivated, as well as the variation in management practices result in a remarkable income variation. This income variation may range from 250/- to 2000/- per 1000 vines per month.

For optimum growth betel vines require a humid atmosphere with adequate soil moisture (Rain or by irrigation). Betel plant is not much damaged by insects but it is highly susceptible to fungal and bacterial infections. The average life span of a betel vine is 3-4 years under good management.

Introduction:

Betel vine belongs to the family piperaceae and genus piper. It is grown by rural farmers as a cash crop. The leaves of the vine are chewed together with betel nut (Areca catechu. L.) as a masticatory. It acts as a gentle stimulant and is partaken at all ceremonial gatherings of an auspicious nature. Betel has a very good export market. Several betel are found in Sri Lanka and they differ in, the shape of leaves, bleaching quality, softness, pungency and aroma. Pungency of leaves is due to phenolic compounds and are rich in vitamin B and C.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Methodology:

This paper reports a survey done in July 1985 on twenty farmers in Pallewela and Walpita A.I. Agricultural Instructor, (AI) ranges in Gampaha district, and Hamangalla Maharachchimulla, Yakwila, Kuliyaptiya and Kanogama A.I. ranges in Kurunegala district. The farmers were randomly selected with the assistance of respective AII and K.V.SS.

A pre-test of the survey was made at Pannala.

Table: 1 Distribution of Betel growing pattern in Kurunegala and Gampaha Dis-tricts.

No. of Vines	Percentage grown undear coconut	Percentage grown as a monocrop.
Less than 1000	20 %	20 %
1000 - 2000	15 %	15 %
more than 2000	30 %	-
	65 %	35

As shown in Table 1, the majority of the farmers prefer to grow betel under coconut, while a few farmers cultivate betel as a monocrop.

Most farmers prefer a well drained sandy or gravelly soils for the cultivation of betel vine. Around the betel beds farmers usually dig a deep drain to prevent the penetration of roots from the other big trees in the viscinity.

The farmers in these two districts use sunken beds with a width of 3-4½ ft, leaving a passage of 3-4 feet. between beds.

Farmers use different varities in different locations. Around 60 % of the farmers in Kurunegala and Gampaha districts use high yielding, high quality varieties such as Mahama neru, Kadalu and Galdalu where as the others grow low yielding varieties, probably due to non availability of planting material

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Local Name		Characteristics
1. Maha Maneru	-	Mature leaves are large, dark green, with a glossy upper surface. Small 5-10 cm. long spikes could be seen opposite to the leaf in plagiotrophic branches. Excellent to export. Yield - 20,000 - 40,000 leaves/ 1000 vines/2 weeks.
2. Ratadalu	-	Broad long dark green leaves. Good for export. Yield - 10,000 - 20,000 leaves/ 1000 vines/2 wks.
3. Galdalu	-	Large leaves tapering at both ends Yield - 8,000 - 15,000 leaves/ 1000 vines/ 2 wks.
4. Kaha bulath	-	Slightly smaller leaves, greenish yellow in colour. Yield - 10,000 - 15,000 leaves/ 1000 vines/ 2 wks.
5. Getathodu	-	Leaf size is small. Not acceptable to export. Yield - 15,000 - 20,000 leaves 1000 vines/2 wks.
6. Kaha Maneru	-	Medium sized yellowish green leaves Not acceptable to export. Yield - 10,000 - 15,000 leaves/ 1000 vines/ 2 wks.
7. Kaha Keeriya	-	Medium sized yellowish green leaves. Yield - 10,000 - 15,000 leaves/ 1000 vines/ 2 wks.

Kaha bulath, Kaha Maneru and Kaha Keeriya shows similar characteristics. However different names are used for these varities in different locations.

Cultivation Practices:

Planting is usually done with the rains but it supplimentary irrigation is possible. Planting could be done at any time of the year.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Bed preparation involves scraping, ploughing to a depth of about 6-9", clod breaking and levelling. **Sometimes organic debris is spread on the levelled sunken bed and burnt. Later** a second mixing and levelling of soils is done.

After preparing the beds cuttings (usually three nodal) of 12"-18" length collected from othotrophic vines are planted between planting lines is normal..Planting holes are spaced 12"-18" between the rows and 12" in the row. Two cuttings are planted per hill.

Immediately after planting the beds are covered with suitable material to avoid rapid dessication of the cuttings. Shade is an important factor and shade is provided at least up to a period of 3-4 weeks after planting. This period of 3-4 weeks of shading is adequate for sufficient root growth during the 1st phase of establishment of the crop.

Removal of shade is followed by staking and gap filling. Stakes should be at least 6-7 ft. long.

Table - 2: Cost of different kinds of stakes used by betel growers.

Common Name	Botanical Name	Average price per 100 Stakes
Veraniya	(Hedyotic fruticosa. L)	60/-
Malkera	(Ochna squarrosa. L)	100/-
Kebella	(Aporasa lindleyana Baill)	120/-
Korakaha	(Memecylou umbellatum Burm.F)	160/-
Kitul	(Caryota urenus. L)	400/-
Mahoganee	( )	25/-
Teak	(Tectoua grandis LF)	80/-
Godapara	(Dillenia retusa Thunb)	90/-
Mella	(Olax zeylanica. L)	100/-

There are two systems of planting betel.

1. 3 row system
2. 4 row system

Table - 3: Effect of different Planting Systems on Leaf Yield.

No. of rows per bed.	Average yield/ 2 weeks (leaf No.)	% of farmers practicing .
3 row systems	17,000	60 %
4 row system	13,250	40%

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

The increase in yield in three row system with decrease in number of rows compared to 4 row system could be due to the low availability of sunlight and other inputs to the inner rows in the 4 row system than the 3 row system.

Fertilization & Irrigation:

Soon after staking about 60% of the farmers apply organic manure, mainly cowdung, or green manure and then a dry mulch of cadjan leaves to conserve moisture and to suppress weeds.

At this stage farmers take special care to train the vines and irrigate the vines daily. Normally inorganic fertilizers are incorporated into the soil 30-45 days after planting. Due to lack of fertilizer recommendations for betel vine, farmers use different quantities of different N, P, K mixtures which may vary from 1 Kg/100 vines to 5 Kg/100 vines.

Table - 5: Fertilizer cost on yield and income

Fertilizer cost per 100 vines/ month. (Rs)	No. of Farmers.	Yield per 100 vines/ pick. (2 Weeks)	Income per 100 vines (per month)
Less than 10	46.66%	1250	36/40
10 — 30	33.34 %	1460	130/-
More than 30	20.00 %	3400	180/-

Table - 5 suggests that response to fertilizer is very heavy. Also the increase in fertilizer use is highly coreleated with the size of holding and with high quality varieties.

The fertilizer application interval is 15 days for the majority of farmers.

Table - 6: Effect of fertilizer application interval on leaf yield

Fertilizer application interval (days)	% of farmers practicing	Average yield (No. of leaves/ 1000 vines/Pick)
7 Days	5.5 %	32,000
15 Days	66.8 %	17,800
above 20 days	27.7 %	12,800

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Harvest:

First harvest is done 3-4 months after planting and there after (about 90% of the farmers) harvesting the leaves is done at two weeks intervals. Some farmers-harvest leaves either in one or three week intervals.

Table - 7: The influence of time of first harvest on on the yield of betel leaves .

Time taken from planting to 1st harvest.	Average leaf yield at the peak stage/1000 vines/pick.
2½ mts.	30,000
3 mts	18,400
4 mts	14,750
4½ mts	10,500

Table 7 suggests that with good management practices at the early stages, one can go for an early first pick and a higher number of leaves at later stages of growth.

The peak harvest it from 8 months to 12 months. This is influenced by the cultivation and management practices, and also with the variety.

Table 8: Influence of Varietal difference on harvesting time and yield.

Variety	Average time taken for the 1st Pick. (Mmonths)	Time of the Peak harvest (Months).	Yield of leaves per pick (2 wks) per 1000 vines
Maha Maneru.	3.33	6.66	26,600
Ratadalu	3.66	6.16	13.300
Galdalu	2.25	7.0	10,500
Kaha bulath) Gatathodu) Kaha Maneru) Kaha Keeriya)	4.60	9.0	12,800 (But smaller leaves)

Digitized by Noolaham Foundation.
noolaham.org | aavanaham.org

Table 9: Cost of production of Betel Leaves/100 vines

	Small scale grower (1000 vines)	Medium scale grower (1000-2000 vines.)	Large scale grower (2000 vines)
Land preparation (an initial cost)	Family labour	Family labour	0.35 man days
Planting Materials	Nil	Nil	Nil
Fertilizer cost/ month.	7.25	10.90	44/-
Fertilizer application and irrigation per month.	Family labour	Family labour	One man day
Staking (an initial cost)	32/-	52/-	72/50
Harvesting and grading per month	Family labour	Family labour	0.75 man days
Average yield (No. of leaves) per month	1030	1890	2140
Average gross Income per month	40/-	110/-	160/-

It appears from the above table that there is an increase in cost of production with increasing size of the holding. Increase in fertilizer cost with the increase in size of holding is due to the higher levels of fertilizer per vine and for the higher quantities of organic fertilizers. Medium to large scale growers go for superior quality stakes because it is economical to keep betel vine for 3-4 years without restaking. The increase in income could be due to better management, better cultivation practices and better markets.

Markets will vary with the size of holdings. Small to medium scale growers has to go to the weekly 'pola', while large scale growers sells at the farm it sells for a fixed price.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Pest and Diseases:

No serious pests have been observed in the betel crop except leaf eating and sucking insects. These insects are nocturnal.. Damage by these insects is not severe due to their low population.

Betel vine is highly susceptible to bacterial leaf spot disease caused by Bacterium betel. When the farmers observe this disease, they immediately uproot the vine and burn it.

Collar rot disease is caused by a fungus known as Rhizoctonia spp. (possibly Rhizoctonia bataticola). This is a major disease during wet weather. When the disease is severe, it may wipe out the whole crop.

References:

* Indian farming 1981 April - control of pest and diseases of betel vine.
* Indian agric. 1975 Vol.19 - phytochemical studies on Bangla variety of betel leaf (piper betel linn)
* Tropical crops - Dycoty ledons - J.W.Purseglove p. 436 - 440.
* The Sri Lanka Förester 1974 vol.XI.

SUBSIDY SUPPORT FOR PASTURE DEVELOPMENT

E. A. Dias

Subject Matter Specialist/Lecturer in Animal Husbandry

School of Agriculture - Kundasale.

Milk production in this country is around 450,000 litres per day. But the national requirement is approximately 850,000 litres per day. Therefore to fulfil the daily consumption needs, large amounts of milk and milk products are imported into the country. In 1983, 430 million rupees were spent to import milk and milk products.

To increase milk yield of cows, they have to be fed and looked after well. Feeding large quantities of concentrates to milch cows is expensive, and uneconomical. The use of fodder from improved pasture varieties as a major portion of the feed will lower the cost of production of milk. Therefore, the Government attempts to encourage farmers to grow

Digitized by Noolaham Foundation.
noolaham.org | aavanaham.org

improved grass varieties that have a high nutritive value. To achieve this the government grants a subsidy for planting improved grasses.

The Department of Animal Production and Health offers the following subsidies to farmers, to help them to grow improved grasses.

	Total Payment/ Acre	Initial Payment 1 month after establishment includes land preparation & planting.	Final Payment 6 months after Planting & satisfactory establishment.
	Rs.	Rs.	Rs.
I. For establishment of Pasture & Fodder on Lands in which Plantation crops have to be uprooted in mid and up-country.	2000.00	1,000.00	1,000.00
2. Other lands in mid-country & up-country areas where no plantation crops have to be uprooted.	1500.00	900.00	600.00
3. For establishment of pasture and fodder on any other land not including 1 and 2. (Includes land with less than 30 coconut trees/Acre.	1500.00	900.00	600.00

The above subsidy is given to persons who satisfy the following requirements:-

1. Only a land owner or a lessee over 10 years is eligible for a subsidy. Half an acre is the minimum land where the subsidy is eligible.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

2. The land should be planted with improved pasture variety (or varities) recommended by the Department of Animal Production and Health.

3. Lands already under pasture will not be paid the subsidy.

A coconut land is defined as a land carrying over 30 coconut trees per acre and it is the minimum extent eligible for receiving a pasture subsidy, offered by the Coconut Development Board Coconut lands of 1/2 an acre or more in extent, situated in areas with an evenly distributed rainfall over 60" per year, in the following districts are eligible for the pasture subsidy. Colombo, Gampaha, Kalutara, Galle, Matara, Kegalle, Kandy, Matale, Badulla, Puttalam, Kurunegala and Ratnapura. A subsidy of Rs.800/- is paid in two annual instalments of Rs.400/- each.

Other than planting of grass, the planting of Ipil Ipil is also eligible for a subsidy. This is also granted by the Animal Production and Health Department. The subsidy payment is Rs.1500/- per acre.

For application forms and further particulars about the subsidies offered by the Department of Animal Production & Health, please contact the Veterinary Surgeon of the area; details about the subsidies offered by the Coconut Development particulars could be had from their regional offices.

A NOTE ON WATER MELON

H. Samaratunga, Research Officer
Regional Agricultural Research Station,
Maha Illuppallama.

Water Melon (Citrallus lanatus) can be grown during both seasons, Maha and Yala. But it is ideal for Yala cultication due to better fruit quality. Melon fruits produced during the Maha season are watery and less sweet.

A humus rich soil with a good drainage, and a pH value between 6.0 - 7.3 is suitable for melon cultivation.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Melons need a considerable amount of fertilizer, hence you should give enough manure or other types of organic matter. Since melons have a shallow root system, fertilizer should be applied shallow in the soil. Standard values of fertilizer (pure nutrient in kg/ha) required by the Melon crop is as follows:-

Nitrogen	-	80-100 Kg/ha
P_2O_5	-	60-120 Kg/ha
K_2O	-	100-200 Kg/ha

For melon cultivation the average atmospheric temperature should not be less than 20°C. Ideal spacing is 100 cm between rows) x 50 cm(in the row). For wind protection maize or sorghum can be planted along the boarder.

Direct seed in planting holes of 45 x 45 x 45 cm, filled with top soil and cattle manure or organic manure. 3 - 4 seeds are to be sown in every planting hole, not too close to each other and after developing the second leaf the plants should be carefully thinned to a single plant per hill. Poor germination can be balanced at this occasion by immediate re-sowing or by transplanting (with plants raised in poly bags). Raising plants in poly-bags and later field planting has been considered as a successful method.

During the entire growth period the soil should be kept loose by repeated hoeing, particularly after heavy showers or irrigation. As soon as the vines cover up the field, hoeing is stopped. Excess evaporation of soil moisture during drought can be overcome by mulching with paddy straw. Mulching suppresses the weed growth.

Preventive measures must be taken against injurious pests and diseases. The most common pests are fruit fly, Aulacophora beetle and Welworm and the most common diseases are downey and powdery mildew, angular leaf spot, anthracnose and cucumber mosaic virus (CMV). Most water melon varieties are resistant and some are tolerant to C.M.V.

Water melon also has a very good yield potential provided that the management practices are done properly in time. Water melon has now been considered as a potential export crop.

Many varieties have been tested at the Research Stations of the Department of Agriculture. The most popular as well as recommended Water melon variety is SUGAR BABY.

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

In water melon, fruit size, shape (Round to oval) and also fruit weight (4-13 kg) varies according to the variety (Red to Yellow).

The crop mature in 75 days from sowing (this may-vary according to the prevailing weather conditions) Number of fruits per vine varies depending on the variety, weather, and the level of management.

Water melon is an easy crop to grow. However, its potential for export depends on the fruit size, shape, appearance and taste. Therefore, careful harvesting at proper maturity is very important, A direct recommendation cannot be made about the time of harvest. For example in case of SUGAR BABY formation of an ash (film) layer on the fruit is an indication of its maturity.

Continued from Page 34.

NEW RICE RECOMMENDATIONS

BG 573 - 4½ month, Samba variety.

BG 94-1 (Red) - 3½ month, red rice variety.

BW 288 - 3½ month, red rice variety suitable for low country wet zone.

Characteristic -	BG 573	BG 94-1 (Red)	BW 288
Seedling vigour	Moderate	Good	Good
Days from transplanting to 50% flowering.	100	76	79
Days from broadcasting to 50% flowering.	90	70	69
Resistance to gall midge.	Resistant	Resistant	-
Tolerance to brown plant hopper.	Moderate	-	-
Resistance to iron toxicity.	-	-	Moderate
Resistance to Sheath blight.	-	-	Moderate

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Digitized by Noolaham Foundation.
noolaham.org | noolaham.media

Cover Printed at the
Agricultural Department Press, Peradeniya, Sri Lanka - 218 (650) 4/86
Digitized by Noolaham Foundation.
noolaham.org | noolaham.media