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An analysis of some common animal feeds used in Sri Lanka

(Received February, 1972)

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There is little published data on the chemical composition together with energy values for animal feeds grown and produced in Sri Lanka.

The absence of laws and regulations in this country at present governing the manufacture and sale of animal feeds has resulted in the marketing of feeds of varying and haphazard chemical composition prepared without regard to specified requirements and standards.

Analytical data are presented here on some indigenous feeding stuffs.

MATERIAL AND METHODS

Fodder and pasture grasses and legumes were obtained from the pilot plots maintained by the Livestock Officer, Welisara. They were cut after 1½ months growth.

Compounded feeds and feed ingredients were obtained from local dealers at Peradeniya.

Gross energy values of feeds were evaluated on approximately 1 g. oven-dried samples using a Parr Oxygen Bomb Calorimeter.

Crude protein was determined by the Kjeldahl method; ether extract, using the Soxhlet apparatus. Crude fibre was ascertained on the residue from the ether extraction and subsequent treatment with acid and alkali. Ash content was estimated by igniting a known weight of sample in a muffle furnace at 500° C.

RESULTS

(See Table 1)

DISCUSSION

Calorific values: Calorific values are expressed on a dry matter basis, *i.e.*, per g. dry matter. Most common feeds contain around 4 kcal per g. of dry matter, while values as high as 9.37 for ash-free beef

fat and 9.33 for fat from oily seed have been reported (1). The values obtained here are not very large as the ether extracts are not unduly high or the ash contents very low. There is also little variation observed. This is due to a lack of much variation in the ether extract and the ash contents as well as to the balancing effect of a high ash content when the ether extract is also high.

Grasses & legumes : Crude protein values for grasses and legumes cut at the 1½ month stage are given in Table I, the values for the two legumes being much higher than for grasses, as expected.

Compounded feeds : 'Milkmax' and 'Morlac' are compounded feeds for dairy cattle marketed by two different firms. 'Morlac' has a higher crude protein and calorific value. The higher ash content together with the lower crude protein in 'Milkmax' has reduced its calorific value. There is little difference in the proximate analysis of these two feeds.

The analysis of the three mashes provides some interesting data. While a protein content of 18-20% is considered desirable for chick rations (2), the sample of chick mash analysed contained only 7.59%. In a growers' ration of moderate energy value, a protein content of 16% is considered suitable but the sample of growers' mash contained only 5.84% crude protein. The layers' mash with 14.75% crude protein has been compounded to the required standard.

The crude fibre content in the layers' mash exceeds the maximum stipulated of about 10 per cent while the amounts in the chick and growers' mashes are 2.30 and 3.70 per cent respectively which are within the limited capabilities of the digestive systems of these categories.

Feed ingredients : The ash content of maize meal is rather high (9.70%). Samples usually contain below 2 per cent mineral matter. Since the analysis was made on the powdered product which is marketed, there is the possibility of adulteration.

The three samples of rice bran show marked variations in composition. Rice bran III contains only 8.65 per cent crude protein compared with about 13 per cent in the other two samples. The crude fibre and ash contents of rice bran III are high, while the N.F.E. is low. This sample of rice bran probably contain much of the husk. The composition of rice brans in the market will depend on the efficiency of the hulling process. These data indicate clearly the need for taking into account the possible wide variations in the composition of the rice brans marketed at present in the compounding of rations.

The fish meal analysed appears to be an inferior product. It contains only 39.12 per cent of crude protein whereas fish meals should usually contain about 60 per cent, since they are relied on to furnish most of the crude protein of animal origin in farm rations. The composition of fish meal is known to vary according to the raw material used in its preparation, particularly the amount of heads and other waste matter. The relatively high ash content in the sample analysed would seem to indicate a large amount of heads and waste matter in the material used in this preparation.

SUMMARY

Analyses of some of the grasses and legumes, compounded feeds and feed ingredients have indicated the wide variation in the composition of compounded feeds and feed ingredients marketed at present in Sri Lanka. Compounded feeds and some of the more widely used ingredients such as rice bran and fish meal do not conform to the required standards and the marketed products are seldom suitable for the purposes for which they are intended. Only properly established standards and legislation enforcing their adoption will remedy this situation. In the absence of legislation compelling manufacturers to state the composition of their products it is only by analysis of the feed each time it its purchased that there can be any certainty about the ration meeting the necessary requirements for the proper nutrition and health of livestock.

ACKNOWLEDGMENTS

We wish to thank Dr. M. Kopalasunderam, Livestock Officer, Welisara, for providing the grasses from his pilot plot ; Mr. C. J. Ekanayake and Mrs. K. Wijetunge for the technical assistance.

REFERENCES

1. McDonald, P., Edwards, R. A. and Greenhalgh, J. F. D., (1966) : Animal Nutrition. Oliver and Boyd Ltd., Edinburgh.

2. Abrams, J. T. (1961) : Animal Nutrition and Veterinary Dietetics. W. Green & Son, Ltd., Edinburgh.

TABLE1. COMPOSITION OF FEEDS

	Dry matter (per cent)	*Crude protein*	*Crude fibre (per cent of dry matter)*	*Ether extract*	*N. F. E.*	*Ash*	*Calorific value (kilo cal. per g. dry matter)*
Grasses and Legumes							
Pusa Giant Napier (*Pennisetum purpureum* × *P. typhoidum*)	16.43	11.89	19.26	1.54	56.67	10.64	3.96
Guinea A (*Panicum maximum*)	21.28	7.69	41.48	1.46	42.30	7.07	4.08
Guinea B (*Panicum maximum*)	21.72	8.69	38.36	1.33	44.49	7.13	4.09
Setaria (*Setaria sphacelata*)	14.19	13.30	30.83	1.94	42.92	11.01	3.59
Cori grass (*Brachiaria milliformis*)	12.34	10.75	34.14	1.49	46.29	7.33	3.79
Para grass (*Brachiaria mutica*)	18.05	13.84	28.51	1.68	43.94	12.03	3.86
Signal grass (*Bachiaria brrizantha*)	16.49	11.11	30.79	1.55	48.07	8.48	4.01
Pangola (*Digitaria decumbens*)	12.00	13.14	27.14	3.05	46.94	9.73	3.60
Tropical kudzu (*Pueraria phaseolodies*)	—	19.68	30.31	1.57	37.74	10.70	4.01
Centro (*Centrosema pubescens*)	—	17.77	31.66	1.64	38.71	10.22	4.11
Compounded Feeds							
Milkmax*	89.25	14.75	14.28	6.55	50.17	14.25	3.79
"Morlac" BCC†	87.92	20.80	15.54	6.47	51.33	5.86	4.38
Chick mash	93.96	7.59	2.30	1.32	70.94	17.85	3.49
Growers' mash	95.60	5.84	3.70	1.21	50.72	38.53	2.92
Layers' mash	93.56	14.75	12.06	5.98	46.91	20.30	3.66
Feed Ingredients							
Coconut Poonac	88.31	22.18	11.36	8.80	51.88	5.78	4.18
Maize	92.28	8.86	2.10	3.20	76.14	9.70	3.22
Rice bran I	88.86	13.16	5.38	1.22	71.64	8.60	3.57
Rice bran II	87.28	13.80	2.77	1.48	70.41	11.54	3.02
Rice bran III	90.56	8.65	22.74	7.27	35.83	25.51	3.30
Rice millings	94.32	6.33	1.92	0.16	65.39	26.20	2.92
Rice polish	93.15	10.17	3.06	7.18	71.69	7.90	4.33
Millet	92.95	10.17	0.79	3.92	79.72	5.40	3.98
Fish meal	87.06	39.12	1.14	4.25	19.83	35.66	3.42
Yeast	87.62	36.32	1.86	0.50	54.00	7.32	3.90
Dhal husk	87.84	13.66	22.04	0.50	57.93	5.87	3.64

* Product of Ceylon Fats & Oils Corporation.

† Product of British Ceylon Corporation.

Mid-term drainage and nitrogen utilization by rice

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(Received : June, 1972)

INTRODUCTION

Lowland rice is generally grown under flood irrigation where the rice field is submerged during most of the time from tillering to ripening stage. Submergence, in addition to satisfying the water requirements of the crop, provides many essential nutrients for plant growth (Ponnamperuma, 1955 ; Rodrigo, 1961 ; 1962). On the other hand, it can also result in the release of appreciable concentration of toxic products such as hydrogen sulphide, ferrous iron and organic acids which affect the physiological functions of the rice roots (Ponnamperuma, 1955).

Drainage and drying out of fields for a period of time is considered to be beneficial to the crop under certain conditions. Accumulation of toxic products such as ferrous iron and organic acids can be removed by draining the water before they reach toxic levels. On the other hand, draining and maintaining oxidising conditions in acid sulphate soils (cat clays) could have deleterious effect on the plant because of the high acidity developed on oxidation.

Mid term drainage can also be practised to conserve water ; but experiments at the International Rice Research Institute, Philippines (1965) have shown shallow continuous flooding to be the most efficient system where water is limited or needs to be conserved and managed most efficiently.

Drainage is believed to increase root activity, reduce lodging and promote tillering. In some places in Northern Japan, for broadcast rice, fields are drained for 2-3 days after seed emergence to accelerate the rooting of seedlings. In the warmer regions of Japan, rice fields are drained for several days at the late tillering stage for the purpose

* Agricultural Diversification Project, Ministry of Plantation Industry, Peradeniya.

of controlling root rot. Heavy fertilization in Japan, results in decreased yields due to excess nitrogen uptake; hence drainage is practised to regulate the fertilizer response (Nojima and Tanaka, 1968).

Drainage may directly affect the efficiency of nitrogen fertilizer for lowland rice. This paper deals with studies to determine the above effect carried out in Ceylon under the sponsorship of the Joint FAO/IAEA Division of Atomic Energy in Agriculture, Vienna, Austria. Eight other countries namely, Bangla Desh, Burma, Indonesia, Taiwan, South Korea, Vietnam, India and Philippines also participated in this programme. The experiment in Ceylon was carried out at the Agricultural Research Station, Maha Illuppallama. The soil profile description, soil analysis and climatological data of the two locations are presented in Tables 1-5.

MATERIALS AND METHODS

Dry Season Experiment (*Yala 1960*)

The experiment was of a split-plot design (Figure 1) with four water management practices in the main plots and nitrogen fertilizer treatments in the sub-plots. Each treatment was replicated four times. The main and sub-plot treatments were as follows :

A.—Main Plots (*Water Management Treatments*) :

1. *Continuous Flooding* (*CF*).—Water was maintained continuously at a height of about 5 cm.

2. *Mid-term Drainage—2 days* (*MTD–2*).—Plots were fully drained at primordial initiation; stage, nitrogen fertilizer applied (where necessary), soil kept just moist† for 2 days and reflooded.

3. *Mid-term Drainage—10 days* (*MTD–10*).—Same as treatment 2 except that plots were kept just moist† for 10 days before reflooding.

4. *Mid-term Drainage Early 10 days* (*MTD–E–10*).—Plots were drained 10 days prior to primordial initiation stage and kept just moist† for 10 days, nitrogen fertilizer applied (where necessary) and reflooded.

†This condition was such that there was no deficiency of water in the soil but oxidising conditions persisted in the soil surface throughout this period.

B.—Sub-Plots (Nitrogen Fertilizers) :

1. Ammonium Sulphate (AS.)
2. Urea (U.)
3. Control (No Nitrogen) (CK).

Nitrogen at 110 kg/ha was applied in two equal doses at planting and at primordial initiation stage. All plots received 107.5 kg P_2O_5/ha as concentrated superphosphate and 62.5 kg K_2O/ha as muriate of potash before planting. The plots also received a top dressing of 31.25 kg K_2O/ha as muriate of potash at primordial initiation stage.

Each individual plot was 4 meteres × 1.25 meteres. Three week old seedlings of the variety of IR–22 were planted in 25 cm. × 25 cm. rows and each hill had three seedlings. Plots which received N–15 labelled fertilizer were divided into three areas namely, A (1.25 sq.m.), B (0.9385 sq. m.) and C (2.8125 sq.m.) (Figure 1) using wooden planks.

Area A received N^{15} labelled fertilizer at transplanting and non-labelled nitrogen at primordial initiation stage, while area B received non-labelled nitrogen at transplanting and N^{15} labelled fertilizer at primordial initiation stage. Area C received only non-iabelled nitrogen at these times of applid cations.

The N^{15} labelled fertilizers were obtained from Junta De Energia Nuclear Spain. The isotopic enrichment of urea and ammonium sulphate were 1.37 and 1.41% respectively.

Appropriate agro-chemicals consisting of weedicides, insecticides and fungicides were applied to control weeds and to protect from insects and rice blast disease.

Forty-two hills excluding border line hills were harvested from each plot, that is, 9 hills from area A, 9 hills from area B, and 24 hills from area C (Figure 1) for yield estimation and plant analysis.

Plant samples from each treatment were taken, dried at 70° C and weighed for yield estimation. The dried plant materials were ground in a mill and 5 g. or rought grain and straw from each treatment was sent to the I.A.E.A. Laboratories, Vienna, Austria for N^{15} analysis. Total nitrogen was determined by Kjeldhal method.

Wet Season Experiment (Maha 1970/71)

The wet season experiment also had a split-plot design but with two water trea ments in the main plot and nitrogen fertilizers plus varieties in the sub-plots. There were four replicates. The main and sub-plot treatments were as follows :

A.—Main Plots (Water Management Treatments) :

1. *Continuous Flooding (CF).*—Water was maintained continuously at a height of about 5 cm.

2. *Mid Term Drainage—2 days (MTD–2).*—Plots were drained at primordial initiation stage, nitrogen fertilizer applied (where necessary), soil kept just moist for 2 days and reflooded.

B.—Sub-Plots (Fertilizers Plus Varieties) :

1. Ammonium Sulphate—IR–22 (AS–IR–22)
2. Ammonium Sulphate—Bg–11–11 (AS–BG–11–11)
3. Urea—IR–22 (U–IR–22)
4. Urea—Bg–11–11 (U–Bg–11–11)
5. Control—IR–22 (C–IR–22)
6. Control—Bg–11–11 (C–Bg–11–11)

Nitrogen was split applied at the rate of 10 kg/ha in two equal doses at planting and at primordial initiation stage. Details regarding phosphorus and potassium fertilizers, plot design, harvesting and plant analysis, etc. were same as that described for the dry season experiment.

RESULTS

Dry Season Experiment (Yala 1970)

The three different mid term drainage treatments and the continuous flooding method did not significantly affect either the total dry matter, straw and grain yields or the yield components except the 1,000 grain weight where two mid term drainage treatments MTD-10 and MTD-E-10 gave significantly higher values than the other two water treatments (Table 6).

Both ammonium sulphate and urea gave significantly higher total dry matter, straw and grain yields than the no nitrogen control, but there was no significant difference between these two nitrogen fertilizers (Table 6).

The total and fertilizer nitrogen taken up by the grain and straw confirmed the trends shown by the yield data (Table 7).

The utilization of fertilizer nitrogen by grain plus straw of the variety IR-22 during the dry season was about 20%. The overall efficiency of applied nitrogen expressed in terms of kg grain/kg N was around 8.

Although water treatments and forms of nitrogen fertilizers did not significantly affect the grain yields, in terms of percentage nitrogen derived from fertilizer by grain plus straw, MTD-2 was slightly superior to the other water treatments and ammonium sulphate was somewhat better than urea (Tables 6 and 8).

The most striking result was that the percentage nitrogen derived from fertilizer was considerably more (about 3 to 10 times) from the top dressing (primordial initiation stage) than from the basal dressing. Furthermore, for the basal dressing more nitrogen was derived from urea than from ammonium sulphate while the reverse was true for the top dressing (Table 8).

Wet Season Experiment (*Maha* 1970-71)

There was no significant difference between continuous flooding and mid term drainage for 2 days in terms of total dry matter, straw and grain yields and yield components (Table 9). This was also true in terms of nitrogen removed from soil plus fertilizer (total) but in terms of nitrogen taken up from fertilizer, continuous flooding was superior to mid term drainage for 2 days (Table 10).

Ammonium sulphate gave higher yields than urea though statistically not significant, while variety Bg-11-11 was significantly superior to IR-22 in terms of total dry matter, straw and grain yields (Tables 9 and 10). These trends were also reflected in the total and fertilizer nitrogen taken up by the grain and straw (Table 10).

The overall efficiency of applied nitrogen (kg grain/kg N) with ammonium sulphate and urea were 14 and 12 respectively. On the other hand, the efficiency of applied nitrogen, calculated on the basis of percentage of added nitrogen recovered from the grain and straw of IR-22 and Bg-11-11 were 21 and 27 respectively.

The wet season experiment also clearly indicated that nitrogen derived from fertilizer from top dressing was considerably higher than from basal dressing (Table 11).

DISCUSSION

Both dry and wet season experiments have clearly shown mid term (or mid season) drainage to be not superior to continuous flooding. Bangla Desh, Burma, India, South Korea and Thailand, which also carried out these experiments obtained similar results (Rahman, 1971 ; Khin Win, 1971 ; Datta, 1971 ; Shim, 1971 ; Snitwongse, 1971). On the other hand, experiment conducted in Indonesia indicated mid term drainage—early—10 days (MTD-E-10) to be superior to all the other treatments (Abdullah, 1971).

Similar experiments at IRRI, Philippines have shown that mid term drainage does not give higher grain yields than continuous flooding (IRRI, 1963 ; 1965 ; 1967 ; 1968). In fact, fields drained for a week during panicle initiation stage resulted in a grain reduction of the variety IR-8 by 13% (IRRI, 1968). Further experiments using the varieties H-4 and IR-8 clearly demonstrated that if water was maintained at 5 cm., temporary drainage for nitrogen top dressing offers no advantage in terms of grain yield (IRRI, 1967).

Draining the fields for a period of 5 to 10 days during the growing stage of the crop was found to promote vigorous tillering (Bulanadi, 1966), while draining for several days at the late tillering stage is considered to increase root activity and reduce lodging (Nojima and Tanaka, 1968 ; IRRI, 1970). There are also reports to indicate that fields drained at both early and late tillering stage gave higher yields than continuously flooded fields ; this was attributed to the increased photosynthesis on reflooding (Nojima and Tanaka, 1968). However, in the present experiments, these beneficial affects of mid term drainage were not reflected in the tiller numbers or in the grain yields.

Of the other participants, Bangla Desh, Burma, South Korea, Taiwan and Thailand, also found that more fertilizer nitrogen was taken up from the top dressing than from the basal application (Rahman, 1971 ; Khin Win, 1971 ; Shim, 1971 ; Chu, 1971 ; Snitwongse, 1971). On the other hand, India, Indonesia and Vietnam did not observe any difference between the two times of nitrogen applications (Datta, 1971 ; Abdullah, 1971 ; Thai-Cong-Tung, 1971). It is worth mentioning that experiments at IRRI (1967) indicated that the later the application the higher the percentage of nitrogen recovery.

The results obtained at Maha Illuppallama can be interpreted to mean that the young seedlings utilize more soil nitrogen than fertilizer nitrogen for their initial growth ; at later stages, the plants utilize more fertilizer nitrogen, than soil nitrogen for their reproductive stages. Most soils under submergence provide appreciable amounts of soil ammonia from the mineralization of organic matter which the young seedlings can utilize (Ponnamperuma, 1955 ; Rodrigo, 1961). However, the results obtained in India, Indonesia and Vietnam (Datta 1971 ; Abdullah, 1971 ; Thai-Cong-Tung, 1971) indicate that initial soil ammonia released from some soils (low in organic matter) on submergence may not meet the requirements of the young seedlings.

From the foregoing it appears that mid term or mid season drainage in normal rice fields has no effect on nitrogen utilization or grain yields. However, it will be important in problem fields where toxic products such as ferrous iron have to be removed and oxidising conditions temporarily maintained.

Although rice soils on submergence release ammonia, the amount released from some soils may not be sufficient for initial growth of the plants. This could be more so with improved rice varieties which have higher nitrogen requirements.

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REFERENCES

ABDULLAH, N. (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies, Djarkarta, Indonesia.

BULANADI, J. (1968). Rice Irrigation Research, IRC Working Committee on Soils, Water and Fertilizer Practices. Eleventh Session, Peradeniya, Ceylon.

CHU, Y. (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies, Djakarta, Indonesia.

DATTA, N. P. (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies, Djakarta, Indonesia.

IRRI (1963). Annual Report, 94–95.

IRRI (1965). Annual Report, 222–224.

IRRI (1967). Annual Report, 161–164.

IRRI (1968). Annual Report, 206–212.

IRRI (1970). Annual Report, 135–136.

KHIN WIN, (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies, Djakarta, Indonesia.

NOJIMA, K. and TANAKA, I. (1968). Water requirement and Management in Rice Cultivation in Japan. IRC Working Party on Soils, Water and Fertilizer Practices Eleventh Session, Peradeniya, Ceylon.

PONNAMPERUMA, F. N. (1955). Chemistry of Submerged Soils. Ph. D. thesis, University of Cornell, Ithaca.

PONNAMPERUMA, F. N. (1963). IRRI—Annual Report, 61–82.

RAHMAN, L. (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies, Djakarta, Indonesia.

RODRIGO, D. M. (1961). The relationship between Chemical and Physico-chemica Characteristics of Paddy Soils in the Dry State and on Continued Submergence. *Tropica Agriculturist*, CXVII, 245–272.

RODRIGO, D. M. (1962). The Variation of Chemical and Physico-chemical Characteristic of Paddy Soils on Submergence—Experiment II. *Tropical Agriculturist*, CXVIII, 1–80.

SNITWONGSE, P. (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies Djakarta, Indonesia.

SHIM, S. (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies, Djakarta, Indonesia.

THAI-CONG-TUNG (1971). Report presented at the Second FAO/IAEA Research Co-ordination Annual Meeting on the Use of Nuclear Techniques in Rice Production Studies, Djakarta, Indonesia.

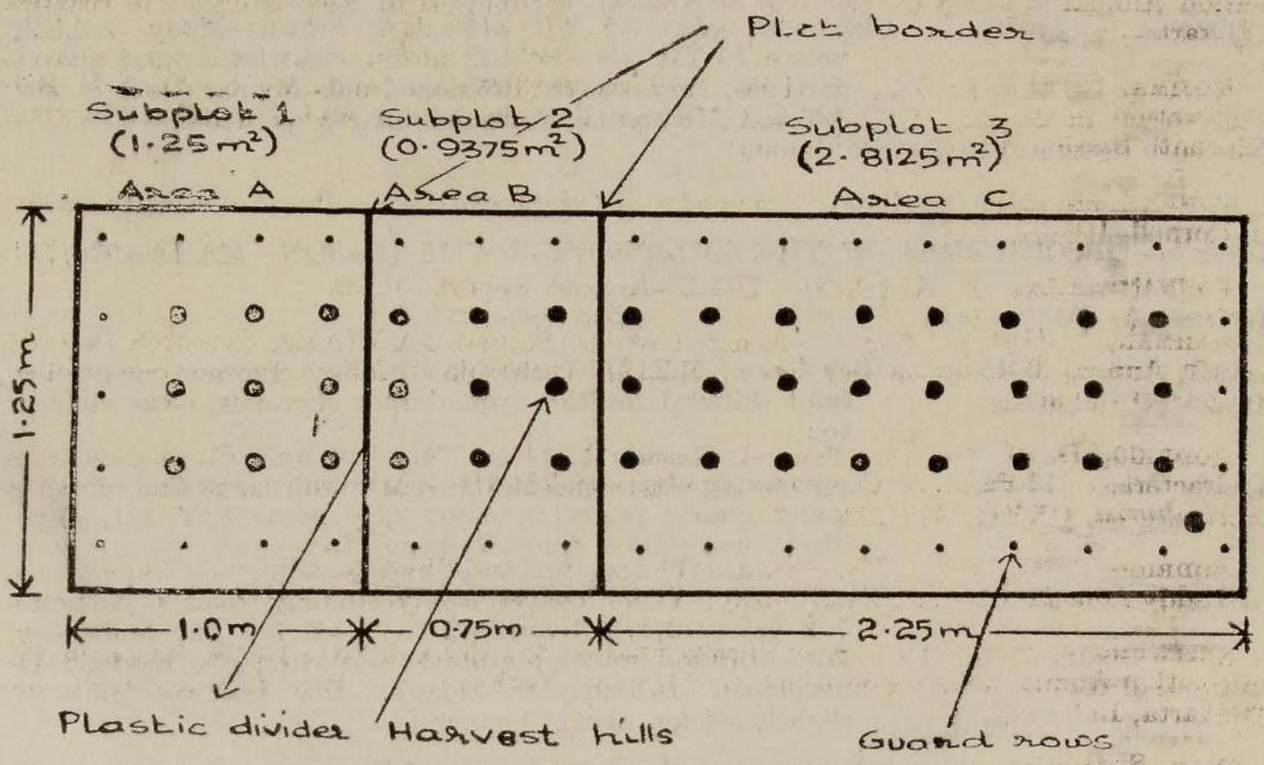

FIGURE 1 Single plot diagram showing sub-plots' A, B and C and the number of hills per plot.

Table 1.—DESCRIPTION OF THE SOIL PROFILE (DRY SEASON—YALA, 1970)

Horizon	*Depth (cm)*	*Description*
Apg ..	0–5 ..	Clay—7.5 YR 3/3—dark brown—many fine roots—clear smooth change to :
A12g ..	5–13 ..	Fine sandy clay—10 YR 2/3—brownish black—many quartz particles—Weakly developed sub-angular blocky—few diffused reddish brown mottles—clear smooth change to :
B21gg ..	13–30 ..	Sandy clay—7.5 YR 3/4 dark brown—Moderately developed sub-angular blocky, Many quartz particles, few diffused spotty *Mn* mottles, many imped pores—Few gley spots (2.5 Y 3/1) brownish black abrupt change to :
B22g ..	30–70 ..	Clay with grit—7.5 YR 3/4—dark brown—Many reddish brown 10 YR 4/8—reddish filmy. mottles around quartz particles, very weakly developed sub-angular blocky few diffused *Mn* mottling around quartz particles.

Table 2.—DESCRIPTION OF THE SOIL PROFILE WET SEASON—MAHA,1970/71

Horizon	*Depth (cm)*	*Description*
ApG ..	0–15 ..	Clay loam—5 Y 3/2 Olive black, Many common roots, few faint diffused mottles around root channels, clear change to :
A12g ..	15–22 ..	Coarse sandy clay—10 YR 3/3—dark brown, few fine rootlets many quartz particles, many gley spots 5 Y 3/1, olive black, non-sticky, smooth change to :
B1g(c) ..	22–52 ..	Sandy clay, many coarse sandy, mainly quartz particles 5 Y 3/1 to 2/1, Olive black to black, few fine roots, few faint diffused mottles around root channels, moderately developed sub-angular blocky, few micro-fragments, slightly sticky, abrupt change to :
B2 ..	52† ..	Clay with coarse sand, many quartz particles, 5 Y 3/1, Olive black, few diffused spotty and filmy reddish brown mottles, very weakly developed sub-angular blocky.

Table 3.—SOIL ANALYSIS

	Dry Season (Yala, 1970)	*Wet Season (Maha, 1970/71)*
Depth (cm)	0–15 ..	0–15
pH	6.8 ..	7.2
Organic Matter %	1.0 ..	2.3
Total N %	0.15 ..	0.16
Olsen's Available Phosphorus (kgP_2O_5/ha)	46 ..	69
Exchangeable Potassium (m.e. K/100 g)	0.13 ..	0.40
Cation Exchange Capacity (m.e./100 g) ..	13.6 ..	13.2
Mechanical Analysis		
Sand %	56.9 ..	53.7
Slit %	5.0 ..	10.0
Clay %	41.8 ..	41.8

TABLE 4.—CLIMATOLOGICAL DATA FROM NURSERY TO HARVEST
(Dry Season—Yala, 1970)

	Temperature °F		*Relative Humidity*		*Sunshine*	*Rainfall*
	Max.	*Min.*	*8.30hr.*	*14.30hr.*	*(hr./day)*	*(mm)*
June	90.2	77.4	76	63	N.A.*	1
July	90.2	75.8	75	57	7.8	17
August	91.5	76.4	73	52	8.4	0.5
September	91.2	74.9	72	52	8.1	81
October	88.0	73.1	78	51	7.3	165

N.A.*—Not available.

TABLE 5.—CLIMATOLOGICAL DATA FROM NURSERY TO HARVEST
(Wet Season Maha, 1970/71

	Temperature °F		*Relative Humidity*		*Sunshine*	*Rainfall*
	Max.	*Min.*	*8.30hr.*	*14.30hr.*	*(hr./day)*	*(mm)*
December '70	81.4	69.0	83	68	N.A.*	131
January '71	83.7	70.2	87	63	N.A.*	201
February	88.0	67.9	80	53	9.0	31
March	91.0	71.5	81	53	8.7	23
April	92.6	72.8	78	54	9.2	294
May	89.6	76.0	78	62	7.4	97

N.A.*—Not available

TABLE 6.—TOLAL DRY MATTER, STRAW AND GRAIN YIELD AND YIELD COMPONENTS (DRY SEASON—YALA, 1970)
(Mean of Four Replicates)

Treatments	*Total Dry matter (kg/ha)*	*Straw (kg/ha)*	*Grain (Filled & Ufilled) (kg/ha)*	*Grain (Filled) (kg/ha)*	*Grain (Hulled) (kg/ha)*	*Panicles (No/hill)*	*Panicle weight (g)*	*1000 grain weight (g)*
Water Management								
CF	9,375	4,030	5,281	5,062	3,757	19.1	1.74	23.10
MTD—2	8,998	3,791	5,119	4,933	3,723	18.5	1.71	23.10
MTD—10	9,058	3,922	5,096	4,945	3,684	19.9	1.68	23.40
MTD—E—10	9,377	4,025	5,308	5,117	3,839	19.3	1.77	23.30
L.S.D. 5%	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.16
C.V.	14.3	18.4	11.2	10.4	11.6	14.3	7.5	0.75
Fertilizers								
CK	7,985	3,380	4,517	4,409	3,415	16.9	1.67	23.30
U	9,895	4,292	5,528	5,321	3,952	20,3	1.73	23.30
AS	9,725	4,155	5,504	5,312	3,885	20.4	1.76	23.10
L.S.D. 5%	360	222	170	161	114	1.3	n.s.	n.s.
L.S.D. 1%	488	301	231	218	154	1.7	—	—
C.V.	5.3	23.6	4.4	4.4	4.2	9.3.	6.6	1.3

TABLE 7.—TOTAL AND FERTILIZER NITROGEN REMOVED BY GRAIN AND STRAW DRY SEASON—YALA, 1970

Treatments	*Rough Grain (kg/ha)*			*Hulled Grain (kg/ha)*		*Straw (kg/ha)*		
	Grain yield	*Total N*	*Fertilizer N*	*Grain yield*	*Total N*	*Straw yield*	*Total N*	*Fertilizer N*
Water Management								
CF	5,062	67.9	14.1	3,757	59.0	4,030	36.4	7.3
MTD—2	4,933	65.2	14.9	3,723	55.8	3,791	34.1	7.4
MTD—10	4,945	63.9	13.2	3,684	53.8	3,922	34.1	6.5
MTD–E—10	5,117	67.3	16.1	3,839	57.7	4,025	35.6	7.1
Fertilizers								
U	5,321	70.0	14.8	3,952	58.7	4,292	36.7	7.0
AS	5,312	69.5	14.4	3,885	58.0	4,155	35.7	7.2
CK	4,409	58.6	—	3,415	52.5	3,380	32.8	—

TABLE 8.—EFFECT OF TIME OF APPLICATION OF NITROGEN ON THE PERCENTAGE-N DERIVED FROM FERTILIZER (DRY SEASON—YALA, 1970)

Treatment	*Grain*	*Straw*	*Grain + Straw*	
CF				
U —a	5.2	5.1	10.3	40.7
b	15.7	14.7	30.4	
AS —a	1.9	1.4	3.3	37.3
b	17.1	16.9	34.0	
MTD—2				
U —a	4.0	3.1	7.1	40.8
b	17.1	16.6	33.7	
AS —a	2.0	1.5	3.5	44.8
b	20.7	20.6	41.3	
MTD—10				
U —a	3.9	4.0	7.9	37.3
b	15.9	13.5	29.4	
AS —a	1.9	1.7	3.6	39.2
b	17.5	18.1	35.6	
MTD-E—10				
U —a	5.7	5.4	11.1	37.0
b	13.4	12.5	25.9	
AS —a	2.4	2.0	4.4	42.8
b	19.4	19.0	38.4	

a=basal application

b=top dressing at primordial initiation stage

Mean (Water Treatment)				*Mean (Fertilizer)*	
CF	*MTD–2*	*MTD–10*	*MTD-E–10*	*U*	*AS*
39.0	42.8	38.3	39.9	38.9	41.0

TABLE 9.—TOTAL DRY MATTER, STRAW AND GRAIN YIELD AND YIELD COMPONENTS (WET SEASON—MAHA, 1970/91)

(Mean of Four Replicates)

Treatments	*Total Dry matter (kg/ha)*	*Straw (kg/ha)*	*Grain Filled & Unfilled (kg/ha)*	*Grain Filled (kg/ha)*	*Grain Hulled (kg/ha)*	*Panicles (No/hills)*	*Panicle weight (g)*	*1000 grain weight (g)*
Water Management								
CF	10,509	3,839	6,081	5,532	3,833	14.7	2.70	19.48
MTD–2	10,658	3,879	6,146	5,599	3,886	13.7	2.78	19.63
L.S.D.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s
C.V.	13.2	17.1	11.5	8.6	8.7	14.7	13.6	3.4
Varieties and Fertilizers								
AS–IR 22	10,193	3,785	5,826	5,313	3,703	17.8	2.01	22.44
AS–Bg 11–11	13,169	4,764	7,610	6,986	4,791	15.9	3.66	15.72
U–IR 22	9,705	3.593	5,541	5,033	3,517	14.9	1.92	23.05
U–Bg 11–11	12,668	4,522	7,343	6,689	4,498	14.4	3.65	16.59
O–IR 22	8,399	3,048	4,885	4,332	3,091	11.2	1.75	23.07
O–Bg 11–11	9,367	3,443	5,478	5,040	3,557	11.7	3.44	16.45
L.S.D. 5%	1,575	499	802	742	568	2.5	0.36	0.91
L.S.D. 1%	2,122	672	1,081	999	765	3.4	0.49	1.23
C.V.	10.3	8.9	9.1	9.2	10.1	12.5	9.2	3.3

TABLE 10.—TOTAL AND FERTILIRER NITROGEN REMOVED BY GRAIN AND STRAW (WET SEASON—MAHA, 1970/71

Treatments	*Rough Grain (kg/ha)*			*Hulled Grain (kg/ha)*		*Straw (kg/ha)*		
	Grain Yield	*Total N*	*Fertilizer N*	*Grain Yield*	*Total N*	*Straw Yield*	*Total N*	*Fertilizer N*
Water Management								
CF	5,532	74.4	18.4	3,833	60.2	3,839	36.5	8.5
MTD–2	5,599	76.1	15.4	3,886.	61.5	3,879	35.4	6.2
Fertilizers								
AS	6,150	87.7	18.9	4,247	70.3	4,275	46.6	9.4
U	5,861	76.7	14.8	4,008	61.1	4,058	31.4	5.3
CK	4,687	61.3	—	3,324	51.2	3,246	29.9	—
Varieties								
IR–22	4,893	66.7	15.2	3,437	54.3	3,476	33.0	6.3
Bg–11–11	6,293	83.7	18.5	4,282	67.5	4,248	38.9	8.4

TABLE 11.—EFFECT OF TIME OF APPLICATION OF NITROGEN ON THE PERCEN-TAGE —N DERIVED FROM FERTITIZER (WET SEASON—MAHA 1970/71

Treatment		*Grain*	*Straw*	*Grain+Straw*	
CF					
U–IR–22	a	4.5	4.5	9.0	44.8
	b	20.1	15.7	35.8	
U–Bg 11–11	a	2.4	3.4	5.8	45.1
	b	21.8	17.5	39.3	
AS–IR–22	a	2.8	2.7	5.5	41.3
	b	19.5	16.3	35.8	
AS–Bg 11–11	a	4.3	3.4	7.7	49.1
	b	21.2	20.2	41.4	
MTD–2					
U–IR–22	a	3.6	2.5	6.1	30.5
	b	13 0	11.4	24.4	
U–Bg 11–11	a	6.8	5.5	12.3	38.5
	b	14.4	11.8	26.2	
AS–IR–22	a	3.6	3.7	7.3	31.6
	b	12.9	11.4	24.3	
AS–Bg 11–11	a	4.2	3.5	7.7	39.0
	b	17.1	14.2	31.3	

a = basal application

b = top dressing at primordial initiation stage

Water quality of major irrigation tanks in Sri Lanka

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ABSTRACT

Water samples from fifteen major irrigation tanks in Sri Lanka were chemically analysed. Some waters contained significant qualities of potassium, calcium and magnesium. The silica content of irrigation water was low. The chloride content of some water was so high as to be considered undesirable for cigarette tobacco cultivation. The waters did not possess a sodium hazard. Some tanks contained medium salinity irrigation water.

INTRODUCTION

Most of the water in an irrigation tank is brought in during the rainy season. However, only a small portion of the tank water is obtained by direct precipitation. The bulk of it comes from the catchment area. As this water flows into the tank it brings dissolved material by contact with soil, rock and other inorganic and organic substances.

Irrigation water may benefit crops by supplying certain plant nutrients. On the other hand, a saline water or a high sodium water may be harmful. Irrigation water quality is an important parameter which may determine the sustenance of an irrigated agricultural system. This paper describes the chemical characteristics of the irrigation waters from some of the major irrigation tanks in Sri Lanka.

MATERIALS AND METHODS

The following tanks were included in this study : Iranamadu, Vavunikulam, Pavatkulam, Giant's Tank, Maha Willachchiya, Nuwarawewa, Nachchaduwa, Kalawewa, Huruluwewa, Kantalai, Minneriya, Parakrama Samudraya, Rukam, Unnichchai and Senanayake Samudraya. All these tanks are situated in the dry zone of Sri Lanka receiving an annual rainfall of about 60 to 180 cm.

Frequency of sampling

The water was sampled once a month beginning August, 1965 for a period of twelve continuous months.

Analysis

On reaching the laboratory the water was filtered and the filtrate was used for analysis. Five ml. chloroform was added to prevent fungal growth. The following determinations were made from every sample of water : pH, electrical conductivity, sodium, potassium, calcium, magnesium, chloride, sulphate, bicarbonate and silicon. The analytical methods used were identical to those described by Amarasiri (1965).

RESULTS AND DISCUSSION

Table 1 gives the chemical analysis of the water from the fifteer tanks studied. Each value represents the simple average of the twelve determinations made each month of the year.

Nutrients supplied by irrigation water

The amounts of K, Ca, Mg, SO_4 and Si supplied by irrigation water is given in Table 2. This calculation is based on a supply of four acre feet of irrigation water. Such a value may be reasonable for rice (Murakami, 1966). Once the irrigation water usage of a particular crop is known the appropriate calculation can be made for this crop.

Potassium

The results show the wide variation in the amounts of potassium supplied by the tanks. They reveal for example, that crops grown under Senanayake Samudraya water may require more potassium as fertillizer than crops grown from Giant's Tank water. The low potassium content of waters in the tanks in the eastern part of Sri Lanka may be related to the low potassium containing acidic rocks found in this region.

Calcium

Irrigation water supplies large quantities of calcium. This nutrient is also added when superphosphate is added as a P fertiliser. From these two considerations one may not anticipate calcium deficiency occurring in most parts of the dry zone of Sri Lanka.

Magnesium

Magnesium is presently not added as a fertiliser in the dry zone. A 5 ton/ha crop of rice will remove about 25 kg/ha Mg (IRRI, 1963). The results in Table 2 show that irrigation water may be able to

supply some of the Mg requirements of rice. However, the Mg content of waters from some tanks, for example, Rukam, Unnichchai and Senanayake Samudraya are so low that it may be appropriate to investigate whether magnesium might be a limiting factor in growth of plants in these areas.

Sulphate

If urea, concentrated superphosphate and muriate of potash are used as fertiliser the crops will not receive any S in the form of a fertiliser. The S in irrigation water may be helpful in supplying the S requirement of plants.

Silicon

There are several benefits to rice from this element although it is not considered an essential nutrient. Some of these benefits are mobilization nof soil phosphorus, increasing the resistance of rice plants to blast disease and making the plants less vulnerable to insects such as stem borers (De Geus, 1970). A 5 ton/ha crop of rice may remove about 900 kg/ha Si (IRRI, 1963). From the data in Table 2 it is apparent that the contribution of silicon from irrigation water is quite low compared to the amount of silicon removed. This information suggests that investigations are needed to ascertain whether silicon has to be added to some of our rice fields regularly.

Chloride content of irrigation water

A high content of chloride in tobacco leaf causes poor burning. This factor is perhaps more important for cigarette tobacco than for other kinds of tobacco. Thomson (1966) reports that irrigation water containing 12-32 ppm Cl is unsuitable for tobacco cultivation. It is evident from Table I that some of the tank waters may not be suitable for tobacco. However, the chloride content of the irrigation waters of the eastern portion of the country is low.

Sodium hazard of irrigation water

Irrigation with waters of high sodium content may lead to the formation of soils which are hard when dry and sticky when wet. Tillage is very difficult with such soils. These soils also have restricted permeability of air and water.

The United States Department of Agriculture (1954) classifies irrigation water with respect to its Sodium Absorption Ratio (SAR). SAR is obtained from the following expression, all concentrations expressed in milli equivalents per litre :

$$SAR = \frac{Na+}{\sqrt{\left[\frac{1}{2}\left(Ca^{2}+ + Mg^{2}+\right)\right]}}$$

According to the United States Department of Agriculture classification, waters having an SAR value of 0-10 are considered low sodium water. The waters of the present study have SAR values ranging from 0.4 at Minneriya to 2.1 at Giant's Tank. Sodium in the irrigation waters in this study is thus unnlikely to present a problem.

Salinity of irrigation water

Use of a saline irrigation water may lead to the formation of a saline soil. Such soils are generally unproductive and also restrictive in the type of crops which can be grown. The United States Department of Agriculture (1954) has classified irrigation waters on the basis of electrical conductivity as follows :—

Conductivity micromhos/cm at 25°C			*Class*
0	–	250	.. low salinity water
250	–	750	.. medium salinity water
750	–	2250	.. high salinity water
>2250			.. very high salinity water

If this classification is adopted for the present study, Giant's Tank, Pavatkulam, Maha Willachchiya, Nuwarawewa, Kalawewa, Huruluwewa and Nachchaduwa have medium salinity water. Such waters can be used for the cultivation of crops with moderate salt tolerance if a moderate amount of leaching occurs. If drainage is restricted salinity could become a major problem of the irrigation schemes in the dry zone of Sri Lanka.

Seasonal variation of chemical constituents of irrigation water

The dry zone of Sri Lanka can be generally considered to consist of a wet season and a dry season. Table 3 gives the values for K and electrical conductivity of the waters for the two seasons. As a result of the much higher values for K during the dry season the crops growing during the dry season may require less potassium fertiliser than during the wet season.

The salinity level is also higher during the dry season. This may suggest that the salt tolerance of crops may have to be considered in determining the crops to be grown during the dry season. It may also require paying greater attention during the dry season to drainage of low-lying lands to prevent a build up of salinity.

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REFERENCES

1. Amarasiri, S. L. (1965). A study of some rice irrigation waters in Ceylon. *Tropical Agriculturist* cxxi, 1-17.
2. De Geus, J. G. (1970). Fertilizer Guide for good grains in the tropics and sub-tropics. Conzett and Huber, Zurich.
3. IRRI. (1963). Annual Report.
4. Murakami, T.(1966) Report of the experimental results on rice water relation study. (Unpublished.)
5. Thomson, L. D. J. (1966). Irrigation water Cl—and tobacco. *Queensland Journal of Agriculture and Animal Science*. 23, 457-458.
6. U. S. Department of Agriculture, Agricultural Handbook No. 60 (1954). Diagnosis and improvement of saline and alkaline soils.

TABLE 1.—CHEMICAL ANALYSIS OF IRRIGATION WATER

Tank	*Capacity acre feet*	*pH*	*Electrical conductivity micromhos /cm 25°C*	*Na ppm*	*K ppm*	*Ca ppm*	*Mg ppm*	*Cl ppm*	*HCO_3 ppm*	*Si ppm*	*SO_4 ppm*
Iranamadu ..	82,000..	7·7..	224..	20·65..	6·20..	13·10..	8·05..	41·10..	73·55..	1·30..	3·5
Vavunikulam ..	40,000..	7·6..	237..	17·30..	6·60..	14·90..	7·95..	35·60..	81·05..	3·30..	4·0
Pavatkulam ..	27,000..	7·9..	555..	52·40..	12·05..	26·35..	22·75..	85·40..	193.90..	5·20..	8·0
Giant's Tank ..	26,600..	8·4..	665..	66·60..	15·80..	30·20..	28·90..	132·20..	189·70..	10·60..	10·5
Maha Willachchiya ..	28,300..	7·7..	508..	47·75..	11·20..	25·30..	18·40..	111·30..	114·85..	1·70..	4·0
Nuwarawewa ..	36,000..	7·8..	506..	41·65..	10·35..	32·15..	19·35..	121·60..	106·70..	4·00..	3·5
Nachchaduwa ..	45,100..	7·9..	344..	28·10..	8·60..	21·40..	11·80..	66·70..	94·80..	1·00..	3·5
Kalawewa ..	72,700..	8·1..	436..	34·00..	8·45..	28·10..	16·75..	56·95..	167·95..	4·80..	5·5
Huruluwewa ..	55,000..	7·7..	367..	27·80..	9·20..	24·55..	13·95..	60·25..	130·85..	1·85..	3·0
Kantalai ..	90,000..	8·0..	218..	9·85..	5·05..	17·65..	10·10..	15·80..	120·45..	4·80..	4·0
Minneriya ..	110,000..	8·2..	240..	10·15..	4·20..	24·05..	13·25..	13·80..	153·70..	6·70..	3·5
Parakrama Samudraya ..	82,000..	8·2..	221..	8·50..	3·55..	22·40..	9·45..	8·65..	135·25..	9·55..	3·0
Rukam ..	16,100..	7·8..	78..	6·90..	3·50..	4·35..	2·55..	10·25..	32·20..	5·80..	5·5
Unnichchai ..	30,500..	8·0..	76..	5·00..	2·90..	4·70..	1·60..	7·05..	35·65..	4·70..	4·0
Senanayake Samudraya ..	770,000..	7·7..	80..	4·50..	2·85..	6·50..	3·10..	4·55..	52·60..	8·50..	3·5

TABLE 2.—NUTRIENTS SUPPLIED BY IRRIGATION WATER (KG/HA)

Tank	*K*	*Ca*	*Mg*	*S*	*Si*
Iranamadu ..	75·5	160·0	98·2	14·2	15·9
Vavunikulam ..	80·4	182·0	97·0	16·2	40·1
Pavatkulam ..	147·0	321·0	277·0	32·5	63·4
Giant's Tank ..	193·0	368·0	352·0	42·6	129·4
Maha Willachchiya ..	136·0	309·0	224·0	16·2	20·7
Nuwarawewa ..	126·0	393·0	235·0	14·2	48·8
Nachchaduwa ..	105·0	261·0	144·0	14·2	12·2
Kalawewa ..	103·0	343·0	204·0	22·3	58·5
Huruluwewa ..	112·0	299·0	170·0	12·2	22·5
Kantalai ..	61·5	215·0	123·0	16·2	58·5
Minneriya ..	51·2	294·0	162·0	14·2	81·7
Parakrama Samudraya ..	43·3	273·0	115·0	12·2	116·4
Rukam ..	42·6	53·0	31·1	22·3	70·7
Unnichchai ..	35·3	57·3	19·5	16·2	57·3
Senanayake Samudraya ..	34·7	79·3	37·8	14·2	103·6

TABLE 3.—SEASONAL VARIATION IN POTASSIUM CONTENT AND IN ELECTRICAL CONDUCTIVITY OF IRRIGATION WATER

Tank	*K ppm*		*Electrical conductivity micromhos/cm at 25°C*	
	Wet season *	*Dry season* †	*Wet season* *	*Dry season* †
Iranamadu ..	4·7	10·7	161	286
Vavunikulam ..	5·3	10·4	189	293
Pavatkulam ..	5·9	30·0	346	797
Giant's Tank ..	6·0	35·8	325	908
Maha Willachchiya ..	6·9	24·2	278	604
Nuwarawewa ..	7·1	21·7	320	599
Nachchaduwa ..	6·2	14·9	196	422
Kalawewa ..	5·7	17·2	278	556
Huruluwewa ..	7·6	13·5	236	388
Kantalai ..	4·4	7·0	163	286
Minneriya ..	3·5	6·7	191	312
Parakrama Samudraya ..	3·2	5·5	175	263
Rukam ..	2·6	5·4	61	96
Unnichchai ..	2·1	3·6	44	60
Senanayake Samudraya ..	2·8	3·6	72	84

* Average values for December, January and February.

† Average values for June, July and August.

Nitrogen and phosphorus fertilizers for maize *(Zea mays)* production

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INTRODUCTION

Previous experiments have indicated that maize under local conditions responds well to nitrogen and phosphorus but not to potassium (Kathirgamathaiyah and Dharmarajah, 1970 ; Hindagala, Kandasamy and Nagarajah, 1971). This lack of response to potassium is to be expected because the soils on which these experiments were conducted had exchangeable potassium values over 0.2 m.e.%. In fact, a soil fertility survey of the maize growing areas in Moneragala, Badulla and Mahiyangana also indicated that these soils have adequate levels of potassium (Nagarajah, 1970). Thus, potassium fertilizer to maize in these areas is not important although a small application is desirable to reduce lodging when high levels of nitrogen are used (Krantz and Chandler, 1951). This paper describes experiments carried out during Yala 70 and Maha 70/71 at the experimental stations in Maha Illuppallama, Sorabora and Bibile to study the effect of nitrogen and phosphorus on the yield of maize. The soil analysis of these locations for the different seasons are given in Table 1.

EXPERIMENTAL

The experiment was a NP 4×4 factorial in a randomized complete block with four replicates. The levels of N and P were 0, 40, 80 and 120 lb. N/ac as ammonium sulphate and 0, 40, 80 and 120 lb. P_2O_5/ac as concentrated superphosphate respectively. All treatments received a basal application of 40 lb. K_2O/ac in the form of muriate of potash. Nitrogen was given in two split doses, one-fourth as basal and three-fourths as top dressing at 4 weeks after sowing. Phosphorus was applied basally. The fertilizers were applied along the rows. The plot size was 10 feet $\times$ 25 feet and spacing was 10 inches in the rows and $2\frac{1}{2}$ feet between rows. The variety used was Veracruz 181 $\times$ Antiqua 2-1 and each hill had one plant. Cobs were harvested, dried and grain yields determined.

RESULTS

The main effects of N and P at Bibile, Maha Illuppallama and Sorabora may be summarized as follows (Tables 2, 3 and 4) :—

Yala 70

(i) There was a response (9.2 bu/ac) though statistically not significant, to 40 lb. N/ac level at Maha Illuppallama. Significant response (at 1% level) to 40 lb. P_2O_5/ac level was also obtained at this location.

(ii) There was no response to either N or P at Sorabora ; in fact, the higher levels of fertilizers somewhat depressed the yields.

(iii) No interaction between N and P was observed at either Maha Illuppalllama or Sorabora.

Maha 70/71

(i) There was a very good response to N at Bibile, Maha Illuppallama and Sorabora. The 80 lb. N/ac level was significantly superior (at 1% level) to both 0 and 40 lb. N/ac levels. Although the 120 lb. N/ac level gave yields higher than 80 lb. N/ac level, the response was not statistically significant. It was also found that the response to N at the three locations is fairly linear up to 80 lb. N/ac level.

(ii) There was no response to P at both Maha Illuppallama and Sorabora However, at Bibile there was some response (5.5 bu/ac) to the 40 lb. P_2O_5/ac level, though statistically not significant.

(iii) There was no N × P interaction at the three locations.

DISCUSSION

Yield responses to 40 and 80 lb. N/ac at Bibile, Maha Illuppallama and Sorabora experimental stations in Maha 70/71 were 23.8, 14.1 and 15.7 bu/ac and 35.6, 28.3 and 25.4 bu/ac respectively. On the other hand, there was no response to N during Yala 70 either at Maha Illuppallama or at Sorabora (Tables 2, 3 and 4). Earlier workers have reported responses to 40–50 lb.N/ac (Kathirgamathaiyah and Dharmarajah, 1970 ; Hindagala *et al*, 1971).

The lack of response to N during Yala 70 is not in agreement with the low N status of these soils (Table 1). Kathirgamathaiyah and Dharmarajah (1970) also failed to obtain response to N in Maha 63/64 on a Bibile soil which had a very low N content. The present authors are unable to offer any explanation for the observed inconsistency in the response of maize to N.

During Maha 69/70 maize (T–48) responded very well to P fertilizer at the Bibile Farm (Hindagala *et al*, 1971.) However, during Maha 70/71 the response to P was not striking even though a higher yielding variety (Veracruz 181 × Antigua 2–1) was used. During Maha 69/70 the soil had 16 lb. P_2O_5/ac as 'available' P while during Maha 70/71 this value had gone up to 39 lb. P_2O_5/ac (Table 1). Thus the lack of response to P during Maha 70/71 appears to be due to the P build up in this soil. Again in Maha Illuppallama the soil which had an 'available' P value of 18 lb. P_2O_5/ac responded to P fertilizer, while the

one which had 86 lb. P_2O_5/ac as 'available' P did not (Tables 1 and 3). Sorabora where no response to P was observed had a soil 'available' P value of 37 lb. P_2O_5/ac (Tables 1 and 4). These observations are in agreement with those reported earlier (Hindagala *et al*, 1971).

From the foregoing it appears that there is a soil test value for P (Olsen's method) between 18 and 37 lb. P_2O_5/ac, above which maize may probably not respond to applications of P and further investigations are needed to narrow this range.

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REFERENCES

HINDAGALA, C. B., KANDASAMY, S. and NAGARAJAH, S. (1971). Response of maize (Zea Mays) to fertilizer at Bibile and Maha Illuppallama. *Trop. Agric.* cxxvii, 197-8

KATHIRGAMATHAIYAH, S. and DHARMARAJAH, N. (1970). Fertilizer experiments with maize (Zea Mays) on a Bibile Soil. *Trop. Agric. CXXVI*, 91-94.

KRANTZ, B. A. and CHANDLER, W.V. (1951). Lodging, Leaf composition and Yield of corn as influenced by heavy application of nitrogen and potash. *Agron., J.* 4 (11), 547-552.

NAGARAJAH, S. (1970). Fertilization of Subsidiary Food Crops and Minor Export Crops. *J. Soil Sci. Soc. Ceylon* I., 146-153.

TABLE 1.—SOIL ANALYSIS

	Bibile[1]		*Maha Illuppallama*[2]		*Sorabora*[3]
	Maha 69/70	*Maha 70/71*	*Yala 70*	*Maha 70/71*	*Yala 70 & Maha 70/71*
pH	5.2	5.6	5.7	5.5	7.6
Total N%	0.09	0.10	0.17	0.12	0.09
Olsen's Available Phosphorus (lb. P_2O_5/ac)	16.0	39.0	18.0	86.0	37.0
Exchangeable Potassium (m.e. K/100 g.)	0.15	0.32	0.60	0.36	0.29
Organic Matter %	1.62	2.07	2.29	1.70	1.81
Texture	Sandy clay loam	Sandy clay loam	Clay loam	Clay loam	Sandy clay loam

[1] Locatin was the same for both Maha seasons.

[2] Locations were different for Yala and Maho.

[3] Yala and Maha experiments were on adjoining blocks.

TABLE 2.—MEAN YIELDS OF MAIZE IN BU/AC—BIBILE

Level	*Maha 70/71*	
	N	*P*
0 ..	35.0	56.4
1 ..	58.8	61.9
2 ..	70.6	60.0
3 ..	75.0	61.4
L.S.D. 5% ..	7.7	
L.S.D 1% ..	10.3	

TABLE 3.—MEAN YIELDS OF MAIZE IN BU/AC—MAHA ILLUPPALLAMA

Level	*Yala 70*		*Maha 70/71*	
	N	*P*	*N*	*P*
0 ..	43.7	36.3	36.8	53.3
1 ..	52.9	53.8	50.9	54.9
2 ..	51.9	55.9	65.1	55.5
3 ..	56.8	57.7	65.2	54.4
L.S.D. 5% ..	11.1		8.4	
L.S.D. 1% ..	14.8		11.2	

TABLE 4.—MEAN YIELDS OF MAIZE IN BU/AC—SORABORA

Level	*Yala 70*		*Maha 70/71*	
	N	*P*	*N*	*P*
0 ..	56.1	52.1	35.9	53 2
1 ..	55.5	59.0	51.6	52.3
2 ..	43.4	49.2	61.3	54.8
3 ..	54.3	49.1	65.9	54.5
L.S.D. 5% ..	n.s.		5.1	
L.S.D. 1% ..	—		6.9	

Investigations on sugarcane chlorosis in Uttar Pradesh

1—Diagnostic Symptoms of Iron Chlorosis

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INTRODUCTION

Chlorophyll is the colouring matter of the green parts of the plants. Its deficiency results in the development of an etiolation in leaves, which is termed as chlorosis or green sickness. This disease may be caused by parasitic invasion of root by soil micro-organisms like nematodes, pathological infestation of leaf tissues by viruses, physiological alteration of plant metabolism by adverse conditions, low temperature injuries, lack of adequate supply of nutrient elements concerned with chlorophyll synthesis or their imbalance in the plant's body.

Whatever may be the cause of chlorosis, it greatly retards the plants ability to absorb radiant energy and transform it into chemical forms during the process of photosynthesis. Owing to the reduction in the photosynthetic material and energy capital which, along with simple inorganic compounds obtained from the environment, build up in the plant's body all the substances and complex kinds of molecules required for cellular structures, plants fail to meet their need for normal growth processes and their productivity is markedly reduced.

In sugarcane, the radiant energy transformed into chemical forms not only provides building material and energy required for the continuance growth but also serves the important funtion of storage in the form of sugar. Chlorosis of leaves in this crop, therefore, takes a heavy toll of productivity by both a reduction in yield as well as diminution in the sugar content of juice, if it is not alleviated early.

Owing to the great importance of chlorotic disease in sugarcane, considerable attention has been paid towards it in India and a number of pathological causes have been discovered by Rafar *et al.* (1957), Sharma *et al.* (1960), Kirtikar *et al.* (1960) and Verma *et al.* (1964).

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In addition to these, chlorotic diseases of physiological origin particularly due to the malnutrition of plants have also been reported from different parts of the country. In Punjab, De *et al.* (1954) observed a chlorotic disease in sugarcane grown in light sandy soils due to deficiency of iron. In Uttar Pradesh, Singh (1961) found a chlorotic disease in sugarcane due to the lack of adequate supply of manganese to the plants. In Bengal, Dutt (1962) observed a chlorotic disease in sugarcane caused by sulphur deficiency. In South India, Sundarsan (1964) observed chlorosis in sugarcane grown in virgin land newly brought under cultivation, as well as, in calcareous soils, due to deficiencies of both iron and nitrogen.

As the chlorotic conditions caused by various factors often exhibit almost identical symptoms, their correct diagnosis and identification to the casual factor by visual observations under field conditions presents a very difficult problem. Unless a detailed and progressive account of symptoms is available and a multi-directional approach is made, detection of the real cause for chlorosis and remedial measures for its alleviation becomes difficult. Thus the long standing problem of chlorosis in sugarcane, which assumed large proportions during 1968 in different parts of Uttar Pradesh was investigated in detail and was ultimately attributed to iron deficiency. In this paper, the symptoms associated with the disease in leaves, stem and roots have been discussed in detail so that these may enable the differentiation of chlorosis caused by iron deficiency from that of other factors and lead to successful treatment by foliar application with iron compounds.

MATERIAL AND METHODS

During the year 1968, chlorosis in sugarcane was reported from the districts of Meerut, Muzaffarnagar, Bulandshahar, Rampur, Pratapgarh etc., where it had assumed serious proportions. A detailed survey was, therefore, undertaken in these districts and relevant information on soil conditions, environmental factors, cultural and manurial practices etc. was gathered. It was startling to observe that chlorosis generally appeared in upland fields having good drainage conditions in the vicinity of villages using large amounts of human excreta or fresh dung in appreciable quantity. The disease was also more prevelant in factory areas where press mud was applied as a manure annually in large quantities. The most serious attack of chlorosis was observed in the sugar cane field of Sri Lal Krishna Kant Singh of Village Daryapur, District Pratapgarh, where the young leaves were completely devoid of their normal green colour. The incidence of chlorosis was also not uniform throughout

the whole field. It was more acute in locations where fresh dung had been stored in the field for several months before being evenly distributed after decomposition. Due to the wide variation in the intensity of chlorosis in the same field, under similar conditions of culture and manuring, suitable opportunity for investigation became available and it was utilized in ascertaining the cause, the effect, the diagnostic symptoms and the curative measures for this malady.

This paper discusses in essential detail the diagnostic symptoms of the disease caused by iron deficiency.

SYMPTOMS OF IRON DEFICIENCY

Leaves.—The symptoms of iron deficiency first appeared in the young leaves as a general etiolation during the month of July when the crop was making rapid growth in elongation. As the growth continued and the new leaves emerged, the intensity of the pale colour increased in the interveinal areas parallel to the mid rib till the alternate green and pale stripes extending to the entire length of the leaf blade became fully apparant. The gradual bleaching of the interveinal areas continued in the successive leaves till the alternate green and white stripes became vihible in the newly emerged apical leaves. After the complete bleaching of the interveinal areas of the leaves, the green veins also commenced loosing their green colour and by the month of September a stage was reached when all the newly emerged leaves exhibited complete chlorosis. Thus on the same shoot, there were normal green leaves at the bottom, striped leaves possessing green veins and pale or white streaks of interveinal areas at the middle and completely bleached white leaves at the top portion of the cane. Figure 1 shows the different stages of chloric development in leaves leading ultimately to the death of tissues from the two margins, the details of which are given below.

1. Commencement of chlorosis as a general etiolation between two veins.
2. Development of alternate green and pale stripes parallel to the rib.
3. Development of alternate green and white stripes due to further loss of chlorophyll from the interveinal areas.
4. Disappearance of green stripes due to loss of chlorophyll from the veins as well.
5. Complete chlorosis in leaf tissues of both veins and interveinal areas.
6. Ultimate death of tissues from the two margins and proceeding towards the midrib.

If the chlorosis develops in the sugarcane crop as described above, it may easily be attributed to the lack of iron supply and remedied by folliar application of this nutrient element.

Stem. The affected canes on being stripped off from the leaf sheaths also exhibited anaemic condition and lack of normal colour. Figure 2 shows a normal mother shoot with thick tiller of natural colour and long internodes on the left (1) and a chlorosis affected mother shoot with thin tiller of white colour and short internodes on the right (2). It is seen that the mother shoot had been affected relatively little by the chlorosis and therefore its colour, thickness and internodal length was almost like that of the normal. The primary tiller, however, exhibited striking differences. Its colour had almost been bleached to white and thickness and internodal length reduced markedly in comparison to the normal tiller of the unaffected mothershoot. It gave clear indications that the effect of iron dificiency became acute in the later stages with the result that the tiller was relatively more affected than the mother shoot. Had the iron supply been deficient from the very beginning the mother shoot would have also become chlorotic, reduced in thickness and possessed of short internodes like the tiller.

Roots. As with the leaves and the stem, roots of plants affected with iron dificiency also exhibited characteristic symptoms which may serve as diagnostic aids of iron chlorosis. Figure 3 presents normal plant roots with numerous fibres on the left (1) and chlorosis affected plant roots devoid of fibrous structures and poor growth on the right (2). It is observed that the normal development of the fibrous structures was almost completely suppressed in the affected plants and the growth of primary roots was also reduced markedly. Owing to the lack of fibrous roots, the inter-twining habit often observed under normal conditions was not seen.

If the symptoms described above in case of leaves, stem and roots are observed in sugarcane, iron deficiency may be suspected and application of ferrous sulphate (2 per cent.) solution on the foliage may be recommended as a remedial measure.

SUMMARY AND CONCLUSIONS

A chlorotic condition had been of wide spread occurence in sugarcane in Uttar Pradesh for a long time but its causal factors remained unknown. When it assumed large proportions during the year 1968, reports poured in from the districts of Meerut, Muzaffarnagar, Bulandshabar. Rampur, Pratapgarh, etc. requesting immediate suggestions and recommendations for saving the crop from serious losses. A

survey was, therefore, immediately undertaken which revealed that the chlorosis generally appeared in upland fields having light soils and good drainage conditions in the vicinity of villages, using human excreta or fresh dung in appreciable quantity. It was also more prevelant in sugar factory areas, where press mud was used regularly for years in large amounts. Investigations to find out the real cause for this malady were undertaken in various directions and it was ultimately discovered to be due to a deficiency of iron. Characteristic symptoms were, therefore, recorded in leaves, stem and roots, a brief account of which is given below.

In the earliest stage, young leaves of the apex exhibited a general etiolation. As the growth continued and new leaves emerged, the intensity of pale colour increased in the interveinal areas till alternate green and pale stripes parallel to the mid rib became apparent. The bleaching continued in successive leaves with the result that green and white stripes became prominent. Gradually green stripes also lost their colour in succeeding leaves till a completely chlorotic condition ensued in the apical leaves. Thus on the same shoot, there happened to be green leaves at the bottom, striped leaves at the middle and completely chlorotic leaves at the apex.

The stem also exhibited a chlorotic condition which was more pronounced in the tiller than in the mothershoot. Both thickness and internodal length of the tiller were markedly reduced. The roots of affected plants failed to develop fibrous structures and their growth was reduced considerably. If symptoms as described above are observed in leaves, stem and roots of sugarcane crop, ferrous sulphate at 2 per cent. concentration sprayed on the plants should alleviate the condition.

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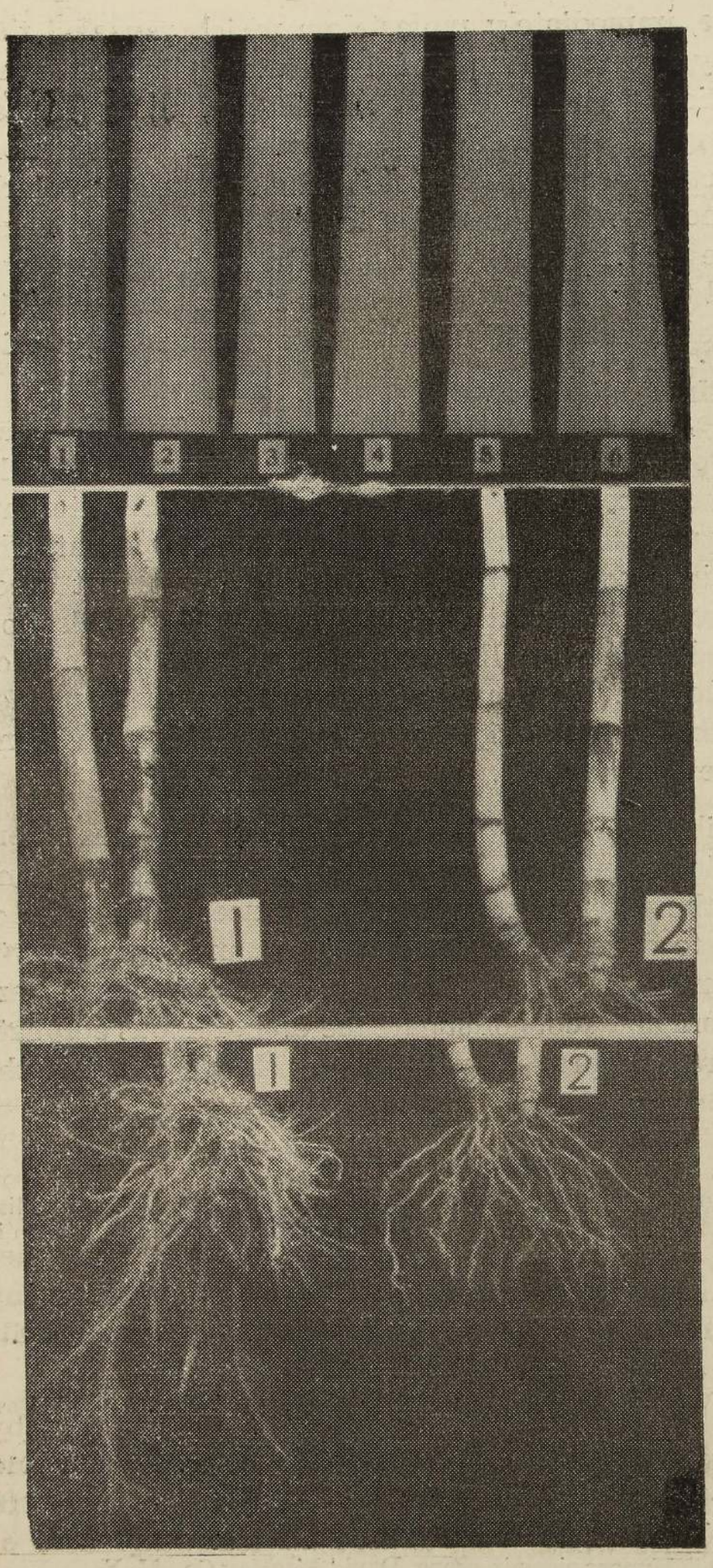
REFERENCES

1. De R. and H. Singh (1954). Proc. 2nd Bien. Conf. Sug. Res. & Dev. Work ; 862.
2. Dutt, A. K. (1962). *Empire J. Exp. Agri.* 30 : 257–262.
3. Kirtikar and H. S. Verma, (1960). Proc. 4th All Ind. Conf. Sug. Res. & Dev. Work ; 609–618.
4. Rafay, S. A. *et. al.* (1957). Proc. 3rd All Ind. Conf. Sug. Res. & Dev. Work ; 313–314.
5. Sharma, S. L. *et. al.* (1960). *Ind. J. Sug. Res. & Dev.* 4 (2) : 112–113.
6. Singh, A. (1961). *Sci. & Cul.*, 27 (2) : 102–103.
7. Sprague, H. B. (1964). Hunger signs in crops, David MacKay Co., N. Y.
8. Sundarsan, K. R. (1964). Sugarcane Herald, 6 (7) : 5–6.
9. Verma, H. S. and O. S. Rana, (1964). Proc. V, All Ind. Conf. Sug. Res. & Dev. Work ; 696–699.



Top.—Normal plant roots with numerous fibrous structures on the left (1) and chlorosis affected plant roots devoid of fibrous structures and poor growth on the right (2).

Middle.—Normal mother shoot with thick tiller of natural colour and long internodes on the left (1) and chlorosis affected shoots with thin tiller, of white colour and small internodes on the right (2).

Bottom.—Different stages of chlorisis leading to death of tissues of two margins:

1. General paling between two veins.
2. Alternats green and pale stripes.
3. Alternate green and white stripes.
4. Disappearance of green stripes.
5. Complete chlorosis.
6. Ultimate death of tissues from the two margins.

A review of micronutrients in soils with reference to Sri Lanka

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The literature on the mineral nutrition of plants and animals indicates that, for their proper development, certain nutrients—*macronutrients*— are essential in relatively large amounts, while others—*micronutrients*—are required in minute quantities.

The term "micronutrient" as used in this paper refers to all elements which are absorbed by plants in relatively minute amounts and does not necessarily indicate their essentiality for plant growth.

MICRONUTRIENTS IN TROPICAL SOILS

Geochemistry and climate largely determine the micronutrient content of soils. The effects of human interference generally produce little change; the amounts removed by crop or stock are balanced by the quantities added to soil through fertilizers or as atmospheric pollution.

Geochemically, soils derived from basic rocks are richer in micronutrients than those derived from acid rocks, because the ferromagnesian minerals that are associated with basic rocks are rich in micronutrients. During geological weathering, the micronutrients tend to be concentrated in sedimentary argillaceous rocks such as shales and slates (Mitchell, 1963). Alluvial soils and those derived from sedimentary materials like sandstones and limestones are inherently poor in micronutrients (Mitchell, 1963; Kanwar, 1964). However, Hodgson (1963) maintains that, although the carbonate rocks—e.g., limestones and dolomites—are low in B, Co, Zn, Cu, Mo etc. their weathering results in a concentration of micronutrients and the residual soils derived from them are not commonly deficient.

Climate affects the micronutrient content of a soil directly by determining the degree of weathering of the parent rock and indirectly by influencing the type and extent of vegetation. In general, in areas of intense weathering and heavy leaching, much of the minerals released on weathering are washed away and the soils are deficient in micronutrients.

A luxuriant vegetation of deep-rooted deciduous trees helps to maintain a high level of micronutrients in the upper layers as a result of nutrient 're-cycling'. Further, the organic material added by such vegetation will retard the washing away of micronutrients by retaining them in the form of organometallic complexes. It is well known, however, that under certain conditions some micronutrients are mobilized by organic material while under other conditions they are fixed (Vinogradov, 1959). The effect of organic material on the distribution, association and mobility of soil micronutrients is complicated and is not yet fully understood.

In the humid tropics, weathering reaches its maximum intensity, the minerals decomposing almost completely and the soluble weathered products being carried away by the large volume of water from the very high-intensity rainfall. Thus, such tropical soils tend to be deficient in available micronutrients. However, it is incorrect to generalize about the micronutrient status of tropical soils as a whole. In the humid Tropics, the situation is complicated by local pedological factors like drainage, topography, type of vegetation and the nature of the parent material. In dry tropical regions, the micronutrient content can vary more widely.

A survey of the voluminous literature (Schutte & Amdurer, 1960; Datta, 1964) on micronutrients reveals that deficiencies occur in widely separated areas throughout the Tropics, under varied soil conditions. Alkali, overlimed, strongly acid, highly leached, eroded, sandy and peaty soils have often created nutritional disorders in crops and these could be traced to deficiency of one or more of the micronutrients.

MICRONUTRIENTS IN THE SOILS OF SRI LANKA

The obvious role which micronutrients play in plant and animal nutrition and the possibilities of deficiencies and/or toxicities necessitate their intensive study. Such studies, unlike those of the major nutrients, have not received sufficient emphasis in Ceylon and the information available is scanty, sporadic and uncoordinated (Table 1). Little has been reported so far of attempts to systematically survey the fertility levels of Ceylon soils with regard to their micronutrient contents.

One reason for the little interest shown in this field of study is that reports from cultivators of widespread micronutrient deficiency problems have been few. This cannot reflect the actual situation in the field. Farmers may not be familiar with micronutrient deficiency

symptons exhibited by plants. On the other hand, the amounts of micronutrients present in the soil may not be low enough to produce deficiency symptoms but not sufficiently high enough either to give optimum yields.

Traditionally, farmers have used organic fertilizers, rich in micronutrients. In recent times, these have been increasingly replaced with inorganic fertilizers. Moreover, in order to reduce transportation and handling costs, inorganic fertilizers are manufactured in concentrated forms relatively poor in micronutrients. Thus even the amount of micronutrients applied involuntarily through the main inorganic fertilizers is reduced to a minimum.

To increase food production, new areas are being brought under cultivation. As a result of removing the natural forest vegetation, the biological recycling of the nutrients, which plays an important role in replenishing the top soil, is inhibited, and the organic matter which prevents the nutrients from being leached, is lost by poor soil conservation measures adopted after jungle clearing.

With increasing use of NPK fertilizers and higher yields, larger quantities of the other nutrients are required for crop growth. This might lead to a deficiency of micronutrients and physiological nutrient imbalances may possibly arise because of a lower uptake of micronutrients. As a result, the full benefit of high applications of NPK fertilizers may not be realized.

Past investigations

Manganese deficiency has been reported in tea (Tolhurst, 1954) and corrected by the application of mangenese sulphate. Some tea soils showed extremely low levels of manganese in Deeside and Hapugastenne Estates in Maskeliya (Kalpage, 1967). Very low total and 'available' manganese values were found (Kalpage and Silva, 1969) in the Deniya, Boralu, Agalawatte, and Homagama series of rubber soils. In these areas, even though manganese deficiency has not been observed, soil manganese levels are probably below optimum. Koch (1946) considered that, with the exception of the very sandy soils he studied, manganese was not a limiting factor for plant growth.

Boron deficiency in tea has been reported in Uva District where the soils are mostly derived from quartzitic rocks, poor in accessory minerals (Tolhurst, 1954). Soils in Dimbula also showed boron deficiency. Deficiency symptoms were first noticeable in shade trees and in tea near the end of the pruning cycle and later symptoms were

seen in shoots soon after pruning. Symptoms similar to that of boron toxicity in *Hevea* have been reported in Panawatte Group on a replanting and in two other estates, Illuktenne Group and Homodola estate (Jeevaratnam, 1967).

Zinc deficiency was increasingly common in nurseries and to a lesser extent in young clearings in Tea (Tolhurt, 1962). Zinc deficiency symptoms, more striking at lower elevations, were first observed near Lunugalla estate in Ratnapura. In fact, in some areas the zinc levels in the soil were so low that even applications of 50 to 300 lb/acre of zinc sulphate did not show any toxic effects. Disease symptoms similar to those attributed to zinc deficiency were noticed in young *Hevea* plants in three estates, namely Nakiyadeniya estate in Galle District, Kumarawatte Group in Moneragala, and an estate in Kalutara District (Jeevaratnam, 1959 ; 1960). Surface soils from the rubber growing districts in Ceylon, had high levels of ' available ' zinc, and an excessive uptake was likely in the illdrained Deniya series (Pavanasasivam and Kalpage, 1969). Zinc deficiency in cocoa, causing ' sickle-leaf ' disease, is well established in Ceylon. A very low level of zinc in the leaves of affected cocoa plants was reported by Vermaat (1956).

Iron deficiency symptoms were frequent in tea, especially in rapidly growing clonal plants under a wide variety of conditions (Tolhurst, 1959 ; 1961). Ferrous sulphate sprays were effective in treating chlorotic plants. ' Bronzing ' disease of rice was associated with a high ferrous iron concentration in soils (Ponnamperuma, 1955). Liming of acid soils was effective in correcting this disorder (Ponnamperuma, 1958 b). One type of bronzing, appearing 1-2 weeks after transplanting, was found in sandy soils adjacent to lateritic highland ; the other, appearing 1-2 months after transplanting, occured in peaty or boggy soils (Ota and Yamada, 1962). Physiological diseases similar to ' bronzing ' were observed along the western coast and in certain sandy as well as boggy soils (Baba, 1958).

Molybdenum deficiency symptoms were reported at St. Coombs' Estate on both seedling and clonal tea recovering from pruning late in the year (Tolhurst, 1965).

Ponnamperuma (1960 b) suggested that one of the causes for the increased yields of rice on liming acid lateritic soils was the enhanced availability of silica and molybdenum. Silica applications on rice had a cumulative effect ; yield increases were not significant in the first season but the level of significance became greater with each season (Rodrigo, 1964).

Further studies might well indicate more widespread micronutrient deficiencies and/or toxicities.

Future work

An understanding of the many factors involved in the correlation of plant uptake of micronutrients with soil content is far from complete. An elucidation of the complexity and effects of these factors will enable an estimation to be made of the 'available' micronutrients in soils.

Total micronutrient content of a soil is not an index of availability. Even in the most acute instances of deficiency there may be sufficient of the total nutrient in the soil to provide adequately for the crop if it was readily available. Although a good pasture herbage removed not more than 5×10—4 ppm of cobalt, yet deficient herbages were found in soils containing several parts per million of total cobalt (Mitchell *et. al.*, 1957).

The availability of micronutrients is modified by varying soil conditions including pH, amount of clay, calcium carbonate content, nature and amount of organic matter, drainage conditions and soil amendments used. No single extractant is universally applicable to estimate the 'available content' of all nutrients and, even for a particular nutrient, the suitability of extractant varies with crops and with soil types. This is evidenced by the fact that an extractant which is proved to be the best for a particular nutrient for any single crop grown on a certain soil type often fails to give significant correlations with crop uptake for other crops or for the same crop grown on different soils.

Among the problems which need investigation and study in Ceylon are :

(1) Suitable sampling techniques to ensure that soil samples for micronutrient studies are representative of the area under consideration and free of contamination. Sampling techniques suggested for most other soil determinations (e.g. Joachim, 1937 ; Cline, 1944 ; Petersen and Calvin, 1965), have not proved satisfactory in view of the wide variations observed even among closely situated profiles (Jackson, 1958).

(2) Correlations between micronutrients, extracted by various extractants, and plant uptake.

(3) Critical levels of toxicities and deficiencies in soils and plants. Foliar analysis is being successfully used in various countries for making fertilizer recommendations for perennial tree crops like rubber (Guha, 1969) and coconuts (Fremond, Ziller and Lamotte, 1966). Correlations and critical levels need to be studied for various types of soils and for different crops.

(4) Visual diagnosis of deficiency and toxicity symptoms in locally grown crops.

(5) Assay of the total and 'available' forms of various micronutrients in soils.

(6) Suitable locally available 'indicator' plants which would reflect deficiencies and toxicities efficiently and quickly, are easy to establish, quick growing and would provide enough organic material for chemical analysis.

(7) Remedial measures in the field wherever deficiencies or toxicities are observed.

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LITERATURE

1. Baba, I. (1958). Methods of diagnosing 'Akiochi', iron, and hydrogen sulphide toxicity in the wet-zone rice fields of Ceylon. *Trop. Agriculturist, 114*, 231–236.

2. Barham, C. B. F. (1963). Report of the Soils Department. *Ann. Rep. Rubb. Res. Inst. Ceylon.*

3. Bhavanandan, V. P. (1968). The Report of the Agricultural Chemist. *Ann. Rep. Tea Res. Inst. Ceylon.*

4. Bhavanandan, V. P. and Manipura, W. B. (1969). Fertilizer responses of tea in the upcountry districts. *Tea Quart, 40*, 135–144.

5. Cline, M. G. (1944). Principle of soil sampling. *Soil Sci. 58*, 275–288.

6. Dattam, N. P. (1964). Review of trace element studies in India. *J. Indian Soc. Soil Sci. 12*, 449–466.

7. Eden, T. (1933). The Report of the Agricultural Chemist. *Bull. Tea Res. Inst. Ceylon, 11*, 49.

8. Ferdinandez, D. E. F. (1970). Report of the officer in charge, Agrostology Division. Ceylon Coconut Q. *21*, 41.

9. Fremond, Y., Ziller, R. and Lamothe, M. N. (1966). *The Coconut Palm.* International Potash Institute Publication. pp. 103–109.

10. Guha, M. M. (1969). Recent advances in fertilizer usage for rubber in Malaya. *J. Rubb. Res. Inst. Malaya, 21*, 207–216.

11. Harrassowitz, H. (1930). Soils of the tropical region. Abstracted in *Trace-element contents of soils* Commonwealth Agricultural Bureaux Publication. Ed: Swain, D. J.

12. Hasselo, H. N. (1965). The N, P, K, Ca, Mg, Na, Mn, Fe, Cu, B, Zn, Mo, and Al contents of tea leaves of increasing age. *Tea Q. 36*, 122.

13. Hodgson, J. F. (1963). Chemistry of the micronutrient elements in soils. *Adv. Agron. 15*, 119–160.

14. Inada, K. (1966). Studies on the 'bronzing' disease of rice plant in Ceylon. II. Cause of the occurrence of 'bronzing'. *Trop. Agriculturist, 122*, 31–46.

15. Iyer, C. R. H. and Rajagopalan, R. (1936). Determination of Mn in Soils *J. Indian Inst. Sci. 19A*, 57–66.

16. Jackson, M. L. (1958). *Soil Chemical Analysis.* Prentice-Hall Publication. p. 12.

17. Jeevaratnam, A. J. (1958). Zinc deficiency of young *Hevea brasiliensis*. Proc. Ceylon Association for the Advancement of Science (Sect. B.)

18. Jeevaratnam, A. J. (1959 & 1960). Report of the Soils Department. *Ann. Rept. Rubb. Res. Inst. Ceylon.*

19. Jeevaratnam, A. J. (1967). A note on boron toxicity in replantings. *Rubb. Res. Inst. Ceylon Quart, J. 2*, 22–23.

20. Joachim, A. W. R. (1937). Soil sampling. *Trop. Agriculturist, 88*, 213–215.

21. Joachim, A. W. R., Kandiah, S. and Panditheseкera, D. G. (1933). Studies on paddy cultivation. 2–The effect of manures on the composition of the paddy crop and soil. *Trop. Agriculturist, 81*, 11–35.

22. Kalpage, F. S. C. P. (1967). Manganese in soils and tea under *Grevillea* shade. *Trop. Agriculturist, 44*, 209–214.

23. Kalpage, F. S. C. P. and Silva, C. G. (1968). Studies on the manganese status of the rubber soils of Ceylon. *Rubb. Res. Inst. Ceylon Quart. J. 44*, 8–15.

24. Kanwar, J. S. (1964). Research on trace elements in the Punjab–present and future. *J. Indian Soc. Soil Sci. 12*, 221–224.

25. Kathirgamathyah, S. and Ceasar, K. (1964). Fertilizer response studies on potato. *Trop. Agriculturist, 120*, 87–124.

26. Koch, D. E. V. (1946). Manganse content of some Ceylon soils. *Trop. Agriculturist, 102*, 219–223.

27. Kulasegaram, S. (1968). The Report of the Agricultural Chemist. *Ann. Rep. Tea Res. Inst. Ceylon.*

28. Mitchell, R. L. *et. al.* (1957). Trace elemant uptake in relation to soil content. *J. Sci. Food Agric. Suppl. 8*, 551.

29. Mitchell, R. L. (1963). Soil aspects of trace element problems in plants and animals. *J. R. Agric. Soc. 124*, 75–86.

30. Nicholas, D. P. D. (1961). Minor mineral nutrients. *Ann. Rev. Plant Physiol, 13*, 63–90.

31. Ota, Y. and Yamada, N. (1962). Physiological study on bronzing of rice plant in Ceylon. *Proc. Crop. Sci. Soc. Japan, 31*, 90–97.

32. Paltridge, T. B. (1959). Studies of the nutrient status and affinity of some coconut soils in Ceylon. *Emp. J. exp. Agric. 27*, 35–54.

33. Pavanasasivam, V. and Kalpage, F. S. C. P. (1969). Dithizone extractable zinc in Ceylon soils. *Trop. Agriculturist, 125*, 1–6.

34. Peterson, R. G. and Calvin, L. D. (1965). *Methods of soil analysis.* American Society of Agronomy Publication pp. 54–71. Ed: C. A. Black.

35. Pethiyagoda, U. and Krishnapillai, S. (1971). Studies on the mineral nutrition of tea. 3–Experimentally induced minor-nutrient deficiency symptoms. Tea Q. *42*, 19–29.

36. Pethiyagoda, U., Krishnapillai, S. and Nagarajah, S. (1969). Studies on the mineral nutrition of tea 1. Techniques of growing tea plants in sand culture. *Tea Q. 40*, 145–152.

37. Ponnamperuma, F. N. (1958a). Response of potato to fertilizers, manure, lime, and trace elements. *Trop. Agriculturist, 114*, 99–111.

38. Ponnamperuma, F. N. (1958b). Lime as a remedy for physiological disease of rice associated with excess iron. IRC Newsletter 7, 10–13.

39. Ponnamperuma, F. N. (1960a). Fertilizer trials in cultivators' fields in Ceylon. *Trop. Agriculturist, 116*, 253–266.

40. PONNAMPERUMA, F. N. (1960b). Lime as an amendment for the acid lateritic rice soils of Ceylon. *Trop. Agriculturist, 116,* 243–252.

41. PONNAMPERUMA, F. N., BRADFIELD, R. and PEECH, M. (1955). Physiological disease of rice attributable to iron toxicity. *Nature, 175,* 265.

42. RODRIGO, D. M. (1964). Response of rice to silica. Proc. Ceylon Association for the advancement of science (Sec. B).

43. SANTHIRASEGARAM, K. and FERDINANDEZ, D. E. F. (1964). Studies on the nutrient status of some coconut soils of Ceylon. 2–The cinnamon sand of Horakelly estate. *Ceylon. Coconut Q. 15,* 115–124.

44. SANTHIRASEGARAM, K., RAJARATNAM, D. T. and FERDINANDEZ, D. E. F. (1962). Studies on the nutreint status of some coconut soils of Ceylon. 1–Lateritic soils at Bandirippuwa estate. *Ceylon Coconut Q. 13,* 41-54.

45. SANTHIRASEGARAM, K., RAJARATNAM, D. T. and FERDINANDEZ, D. E. F. (1965a). Studies on the nutrient status of some coconut soils of Ceylon. 5–The lateritic gravel on Mattegoda estate. *Trop. Agriculturist, 121,* 43–54.

46. SANTHIRASEGARAM, K., RAJARATNAM, D. T. and FERDINANDEZ, D. E. F. (1956b). Studies on the nutrient status of some coconut soils of Ceylon. 6–The loamy soils from Vanathivillu. *Trop. Agriculturist, 121,* 105–116.

47. SANTHIRASEGARAM, K., RAJARATNAM, D. T. and FERDINANDEZ, D. E. F. (1966). Studies on the nutrient status of some coconut soils of Ceylon. 7–The alluvial sandy soils at Pothukulama. *Ceylon Coconut Q, 17,* 42–55.

48. SANTHIRASEGARAM, K., RAJARATNAM, D. T. and FERDINANDEZ, D. E. F. (1967) Studies on the nutrient status of some coconut soils in Ceylon. 8–Lateritic gravel at Gonapinuwela. *Ceylon Coconut Q. 18,* 38–63.

49. SCHUTTE, K. H. and AMDURER, S. (1960). Some causes and effects of trace elements deficiencies in South African soils. *Trans. 7th Internat. Congr. Soil Sci. 3,* 20–26.

50. TANAKA, A. and YOSHIDA, S. (1970). *Nutritional disorders of the rice plant in Asia.* IRRI Publication. pp. 36–38.

51. TANAKA, A., MULLERIYAWA, R. R. and YASU, T. (1968). Possibility of hydrogen sulphide induced iron toxicity of the rice plant. *Soil Sci. Plant Nutr. 14,* 1–6.

52. TOLHURST, J. A. H. (1954). Magnesium and manganese deficiencies in the nutrition of the tea bush. *Tea Q. 25,* 84–86.

53. TOLHURST, J. A. H. (1959). The Report of the Agricultural Chemist. *Ann. Rep. Tea Res. Inst. Ceylon.*

54. TOLHURST, J. A. H. (1961). The Report of the Agricultural Chemist. *Ann. Rep, Tea Res. Inst. Ceylon.*

55. TOLHURST, J. A. H. (1962). Zinc deficiency of tea in Ceylon. *Tea Q. 33,* 134–137.

56. TOLHURST, J. A. H. (1963). Manganese deficiency symptoms of tea. *Tea Q. 34* 148–149.

57. TOLHURST, J. A. H. (1965). The Report of the Agricultural Chemist. *Ann. Rep. Tea Res. Inst. Ceylon.*

58. VERMAAT, J. G. (1956). Report to the Govt. of Ceylon on soil and paddy problems. *Sessional paper, 19,* 30.

59. VINAGARDOV, A. P. (1959). *The geochemistry of rare and dispersed chemical elements in soils,* 2nd Ed., Consultants Bureau, Inc., New York.

60. WEERARATNE, C. S. (1968). Absorption of manganese by rice under flooded and unflooded conditions. *Plant and soil 30,* 121–125.

61. YAMADA, N. (1959). Some aspects of the physiology of "bronzing" *IRC Newsletter 8,* 11–16.

TABLE 1.—MICRONUTRIENT ASSAYS IN SRI LANKA SOILS

Element	*Form*	*Values (ppm)*	*Reference*
Titanium	Total	7400 (surface soil) 4000–5450 (sub-soils) (Av. 4900)	Harrassowitz, 1930
Manganese	Total	170–12110 (Av. 1470)	Eden, 1933
Manganese	Total	510–690 (600)	Iyer & Rajagopalan 1936
Manganese	Total	24–1204 (Av. 500)	Koch, 1946
Manganese	Total Available	15–889 10–43.6	Kalpage, 1967
Manganese	Total Available Exchangeable	10–2290 0·8–106 0·6–133·2	Kalpage & Silva, 1968
Zinc	Available	2·5-56·4	Pavanasasivam & Kalpage, 1969

TABLE 2.—OTHER MICRONUTRIENT STUDIES IN SRI LANKA

Element	*Crop*	*Type of study*	*Reference*
Aluminium	Tea	Interaction	Kulasegaram, 1968
	Rice	'Bronzing'	Ota and Yamada, 1962
	Rice	Plant uptake	Tanaka and Yoshida, 1970
Boron	Tea	Deficiency	Barham, 1963
	Tea	Deficiency	Tolhurst, 1961
	Tea	Deficiency symptoms	Pethiyagoda, *et. al.*, 1969, 1971
	Rubber	Toxicity	Jeevaratnam, 1967
	Coconut	Deficiency	Paltridge, 1959
	Coconut	Fertilizer trial	Santhirasegaram, *et. al.*, 1965a ; 1966.
	Potato	Fertilizer trial	Ponnamperuma, 1958a
	Potato	Fertilizer trial	Kathirgamathyah, *et. al* 1964
	Rice	Fertilizer trial	Ponnamperuma, 1960a
Chlorine	Tea	Deficiency symptoms	Pethiyagoda, *et. al.* 1969; 1971
Copper	Tea	Deficiency symptoms	Pethiyagoda, *et. al.*, 1969; 1971
	Coconut	Deficiency	Paltridge, 1959
	Coconut	Fertilizer trial	Santhirasegaram, *et. al.*, 1962, 1965a ; 1965b ; 1966 ; 1967
	Potato	Fertilizer trial	Ponnamperuma, 1958a
	Potato	Fertilizer trial	Kathirgamathyah, *et. al.*, 1964
	Rice	Fertilizer trial	Ponnamperuma, 1960a
	Paspalum Commersonii	Fertilizer trial	Santhirasegaram, *et. al.*, 1964
	Paspalum Commersonii	Fertilizer trial	Ferdinandez, 1970
Iron	Tea	Deficiency	Tolhurst, 1959 ; 1961
	Coconut	Fertilizer trial	Santhirasegaram, *et. al.*, 1962 ; 1965a ; 1965b ; 1966 ; 1967
	Rice	'Bronzing'	Ponnamperuma, *et. al.*, 1955
	Rice	Plant uptake	Ponnamperuma, 1958b ; 1960a ; 1960b

TABLE 2.—OTHER MICRONUTRIENT STUDIES IN SRI LANKA

Element	*Crop*	*Type of study*	*Reference*
	Rice	'Bronzing'	Yamada, 1959
	Rice	'Bronzing'	Ota and Yamada, 1962
	Rice	'Bronzing'	Inada, 1966
	Rice	'Bronzing'	Tanaka, *et. al.*, 1968
	Rice	'Bronzing'	Tanaka and Yoshida, 1970
	Paspalum Commersonii	Fertilizer trial	Santhirasegaram, 1964
	Paspalum Commersonii	Fertilizer trial	Ferdinandez, 1970
Manganese	Tea	Fertilizer trial	Tolhurst, 1954
	Tea	Deficiency	Tolhurst, 1954 ; 1961 ; 1963
	Tea	Leaf analysis	Hasello, 1965
	Tea	Correlations	Bhavanandan, 1968
	Tea	Deficiency symptoms	Pethiyagoda, *et. al.*, 1969; 1971
	Coconut	Fertilizer trial	Santhirasegaram, *et. al.*, 1962 ; 1965a ; 1965b ; 1966 ; 1967
	Potato	Fertilizer trial	Kathirgamathyah, *et. al.*, 1964
	Rice	Plant uptake	Weeraratne, 1968
	Rice	Plant uptake	Tanaka and Yoshida, 1970
	Paspalum Commersonii	Fertilizer trial	Santhirasegaram, *et. al.*, 1964
	Paspalum Commersonii	Fertilizer trial	Ferdinandez, 1970
Molybdenum	Tea	Deficiency	Tolhurst, 1965
	Tea	Deficiency sympotms	Pethiyagoda, *et. al.* 1969; 1971
	Coconut	Fertilizer trial	Santhrasegaram, *et. al.* 1962 ; 1964 ; 1965a ; 1965b ; 1966 ; 1967
	Potato	Fertilizer trial	Ponnamperuma, 1958a
	Potato	Fertilizer trial	Kathirgamathyah, *et. al.* 1964
	Rice	Fertilizer trial	Ponnamperuma, 1960a
	Paspalum Commersonii	Fertilizer trial	Ferdinandez, 1970
Silica	Rice	Plant uptake	Joachim, *et. al.*, 1933
	Rice	Physiology	Yamada, 1959
	Rice	Fertilizer trial	Ponnamperuma, 1960a ; 1960b
	Rice	Fertilizer trial	Rodrigo, 1964
	Rice	Plant uptake	Tanaka and Yoshida, 1970
Zinc	Tea	Deficiency	Tolhurst, 1961 ; 1962 ; 1963
	Tea	Fertilizer trial	Fernando, 1966
	Tea	Fertilizer trial	Bhavanandan, *et. al.*, 1969
	Tea	Deficiency symptoms	Pethiyagoda, *et. al.*,1969; 1971
	Rubber	Deficiency	Jeevaratnam, 1958 ; 1959 ; 1969
	Coconut	Fertilizer trial	Santhirasegaram, *et. al.*, 1962; 1965a ; 1965b ; 1966 ; 1967
	Cocoa	Deficiency	Vermaat, 1959
	Potato	Fertilizer trial	Ponnamperuma, 1958a
	Potato	Fertilizer trial	Kathirgamathyah, *et. al.* 1964
	Paspalum Commersonii	Fertilizer trial	Santhirasegaram, *et. al.*, 1964
	Paspalum Commersonii	Fertilizer trial	Ferdinandez, 1970

Studies on the inflorescence of strawberry

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Cultivation of strawberry has been taken up in India only in the past few decades. Many exotic cultivars have also been introduced and their performance study is in progress. Strawberry clones differ to a great extent in kind of inflorescene they produce and so also in number of inflorescences. In order to assess the possibility of using of inflorescences. In order to assess the possibility of using inflorescence studies were carried out at the Horticultural Research Station of the Indian Agricultural Research Institute, New Delhi during 1961-64.

EXPERIMENTAL PROCEDURES

Twenty-two clones of strawberry were included in the present studies. The nature of inflorescence was observed. Total number of inflorescences per plant were studied and two categories were made arbitrarily.

Many—average number of inflorescences 2.50 and above per plant.

Few—average number of inflorescences less than 2.50 per plant.

The flowers produced per plant were also recorded and following groups were made :

Numerous—average number of flowers 25.0 and above per plant.

Few—average number of flowers less than 25.0 per plant.

RESULTS

A young runner plant of strawberry (excepting *Fragaria indica*) consisted of a short primary axis bearing leaves and leaf initials in spiral succession and terminated by a vegetative growing point. With

the advent of winter season this terminal growing point ordinarily transformed into a flower bud which gave rise to a 'first order' inflorescene. The extension growth of the crown was continued by the youngest uppermost axillary bud. The secondary crown extension axis so formed later terminated in a 'second order' inflorescence. Any further extension growth again arose from the axillary bud immediately below the 'second order' inflorescence. This formed a tertiary crown extension axis which in turn ended in a 'third order' inflorescence and so on. Thus, each inflorescence was terminal and growth habit sympodial.

Nature and character of inflorescence

The inflorescence of strawberry was of cymose type excepting *F. india* in which case flowers were brone singly in leaf axils. At each node of an inflorescence a bract replaced the leaf of vegetative stem while the bud in the axil of each bract developed into a branch of inflorescence. The bract of a branch at the first node of inflorescence was commonly as large as one of the leaflets of a true leaf. In some cases a bract consisted of 3 leaflets and resembled a true leaf except in the position and length of petiole. The bracts at second, third and later nodes progressively diminished in size.

A flower terminating the main axis of inflorescence was called primary ; those terminating the branches were secondary, tertiary and so on. The plant material under study showed much variation in the form of inflorescence. In some cases a primary flower was lacking. The peduncle and pedicel length varied within the clone. There was apparently a constant negative correlation between the two, i.e., as the length increased resulting in a constant ratio between fruit stalk length and leaf petiole length.

Average number of inflorescences produced by a plant and total number of flowers per plant are presented in Table 1. It is clear from the data that clones differed in their potentialities of producing number of inflorescences and flowers.

TABLE 1.–NUMBER OF INFLORESCENCES AND FLOWERS PER PLANT IN STRAWBERRY

Clone	1961—1962		1962—1963	
	Inflorescence (average)	*Flowers (average)*	*Inflorescence (average)*	*Flowers (average)*
Cavalier	—	—	2.12	18.50
Ch. 24	—	—	1.33	16.90
Ch. 33	—	—	1.71	20.20
Ch. 35	—	—	2.64	23.00
Ch. 37	—	—	1.23	14.40
Ch. 40	—	—	2.20	19.30
Dilpasand	3.27	44.50	2.98	37.20
J. F. 2	1.91	22.13	1.97	18.41
J.F. 18	2.46	27.05	2.43	26.36
Kalimpong Local	—	—	4.61	72.30
Kashmir Local	2.31	24.10	2.46	30.24
Katrain Sour Local	4.30	54.00	4.21	46.22
Katrain Sweet Local	3.31	46.20	2.97	42.00
Pusa Early Dwarf	3.02	29.75	3.14	31.23
Red Coat	—	—	1.62	15.50
Royal Sovereign	3.21	43.70	3.00	41.50
Shasta	2.56	21.20	2.17	23.40
Swiss	—	—	2.63	28.12
V. L. 9	1.96	18.30	2.20	19.60
V. L. 13	1.95	19.10	1.98	20.70
Fragaria indica	—	—	Solitary flowers numerous	
Fragaria vesca	—	—	2.30	41.20

It was interesting to note that wild forms in general produced more inflorescences and flowers per plant than cultivated clones. Among the cultivars Katrain Sour Local gave highest records and Ch. 37 the lowest. A little seasonal variation was also noticed for these characters in two crop seasons i.e. 1961-62 and 1962-63.

Flower and fruit size

The size of flower was influenced by its position on the inflorescence (Table 2). Primary flower was biggest in size. The size decreased on secondary position and still decreased on tertiary position and so on.

TABLE 2.—SIZE OF FLOWERS ON DIFFERENT POSITIONS OF AN INFLORESCENCE IN CULTIVAR 'PUSA EARLY DWARF'

Flower Part	*Primary*	*Secondary*	*Tertiary*	*Quadrinary*
Sepals (Nos.)	15.61	12.53	11.04	10.96
Petals (Nos.)	8.12	6.26	5.22	5.01
Stamens (Nos.)	35.06	27.63	24.21	22.26

Similarly, the inflorescence position influenced the size of fruit (Table 3). The data reveal that there was a high correlation between the fruit position and its size. The fruits of primary position were

bigger and heavier than those of secondary and later positions. The fruit size was rather small on tertiary and quardrinary positions and there was a high number of nubbins (imperfectly developed fruits, rather irregular in shape with very few achenes).

TABLE 3.—SIZE OF FRUIT BORNE ON DIFFERENT POSITIONS OF INFLORESCENCE IN CULTIUAR 'PUSA EARLY DWARF'

Position	*Av. Weight (gm.)*
Primary	8.212
Secondary	7.159
Tertiary	4.623
Quadrinary	1.810

DISCUSSION

The clones studied had cymose type of inflorescence with diversity of form (excepting *F. indica* in which flowers were borne singly in leaf axils). This is in conformity with the work of Bailey (1953), Valleau (1918), Darrow (1929) and Robertson *et al.* (1954). The clones differed in their potentialities of producing number of inflorescences per plant. Therefore, it appears to be a clonal character supporting the findings of earlier workers (Darrow, 1929 and Robertson *et al.*, 1954). The arrangement of flower and order of blooming on an inflorescence of a clone was in the manner reported by Valleau (1918) and Haskell *et al.* (1954) i.e., flowers of primary positions bloom first followed by flowers of later positions. Besides, inflorescence characters were influenced by environment because differences were apparent and appealing in two crop seasons of 1961-62 and 1962-63. Similar work has also been reported by Darrow (1927). As mentioned earlier a typical inflorescence of strawberry was of cymose type with regular branching. But in cultivated clones especially, this branching was some what variable. A century ago, Lambertye forwarded such an observation which was subsequently supported by Darrow (1927), that the size of inflorescence tended to increase with increased vigor of the plant in a cultivar. The present work also supports the views of earlier workers. The primary flowers produced larger sized fruits than other flowers in strawberry. This way be a direct effect of fruits position on inflorescence or due to increased size of flower. Valleau (1918) has noted that primary flowers produce 'King' fruits by virtue of higher carpel number and other floral parts.

SUMMARY

In strawberry, excepting *Fragaria inndica,* inflorescence is a terminal cymose. In *F. indica* flowers are borne singly in leaf axils. Number of inflorescences and flowers per plant varied from clone to clone. Primary flowers bloom first, produce largest size flowers and fruits.

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REFERENCES

Bailey, L. H. (1953). *Standard cyclopedia of Horticulture* 2 : 2071–73. (MacMillan Co., N. Y.)

Darrow, G. M. (1927). Sterility and fertility in strawberry. *Jour. Agr. Res. 34 :* 393–411.

Darrow, G. M. (1929). Inflorescence types of strawberry varieties. *Amer. Jour. Bot. 16 :* 571–85.

Haskell, G. and H. Williams, (1954). Biometrical variation in flowers of polyploid series of strawberries. *Jour. Genet. 52 :* 620–30.

Robertson, M. and C. A. Wood (1954). Studies on the development of strawberry. *J. Hort. Sci. 29 :* 104–11.

Valleau, W. D. (1918). Sterility in garden strawberry. *Jour. Agr. Res. 12 :* 613–99.

Optimum level and critical period of irrigation for sugarcane grown in areas of water deficit

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INTRODUCTION

In Uttar Pradesh, resources for irrigation are very scanty. About two thirds of the cultivated area still remains unirrigated. The crops generally depend on natural precipitation and underground soil water. Lack of adequate irrigation is, therefore, one of the main reasons for poor yields of all crops, particularly in sugarcane which is planted in the relatively dry season and has a large demand for water in the early stage of its life cycle due to the stresses caused by low temperature, low humidity, intense solar radiation and high wind velocity of the summer months.

Anon., (1940) claims that in Punjab, an irrigation requirement of about 50 acre inches is needed for optimum yields of sugarcane in addition to the usual rainfall. Rege and Basu (1944) report that optimum irrigation requirement for January planted sugarcane in Padegaon, Bombay is about 95 acre inches. Rege and Rao (1954) observe that 115 acre inches of water are required for sugarcane in the Deccan canal tract. Verma (1962) claims that in Uttar Pradesh, 61.77 acre inches of water are needed to raise a normal crop of spring planted sugarcane. Singh and Negi (1969) observe that 5 irrigations of about 80 thousand gallons/acre each must be given at frequent intervals till the onset of rains in addition to usual rainfall.

As regards the frequency of irrigation in various areas, Rege and Basu (1944) observe that 10 days interval is the best for sugarcane at Padegaon. Irrigation at 12 days interval during the growth phase and 15 days interval during maturity also proved as good as 10 days interval. Anon., (1951) reports that irrigation at 12 days interval increased the yield of sugarcane but it proved uneconomical when compared to the interval of 18 days at Anakapalle. Anon. (1951) claims that intervals of 6, 12 and 18 days between two irrigations gave similar results at Gudiyattam. Khan and Pattanayake (1956) report that irrigation at 20 days interval proved optimum for a good

sugarcane crop at Delhi. Khan and Mohapatra (1957) claim that intervals of 10, 15 and 20 days between two irrigations did not exhibit marked variation in their effect on yield. An interval of 20 days was, therefore, considered as optimum. Bhoj and Singh (1960) claim that irrigation at 15 days interval is sufficient for spring planted sugarcane at Shahjahanpur. Verma (1962), however, claims that irrigation at 20 days interval from April onwards till the onset of monsoon is necessary for an average crop of sugarcane.

Considerable work has thus been done to determine the irrigation requirement of sugarcane and interval of its application where ample irrigation facilities are available. But there is no information about water deficit areas, which pose a rather different problem. To meet this need the present investigations were undertaken to determine the optimum level and critical period of irrigation for sugarcane grown in areas of water scarcity so that an economic schedule of irrigation may be evolved for practical purposes and profitable ends.

EXPERIMENTAL PROCEDURE

An experiment was conducted during the crop season 1964-65, 1966-67 and 1967-68 on sugarcane variety, Co. 1158, in sandy loam soils of the Experimental Farm of Sugarcane Research Station, Shahjahanpur. Uttar Pradesh, which has an average pH of 6.6 and water holding capacity of 42.66 percent. The mechanical and chemical composition of a representative soil sample taken from surface to a depth of 22.5 cm is furnished below.

Mechanical		*Chemical*	
Coarse sand	1.34%	Organic carbon	0.34%
Fine sand	55.52%	Nitrogen	0.03%
Silt	23.47%	P_2O_5	0.09%
Clay	17.40%	K_2O	0.10%

The experimental layouts were in the randomized block design with 4 replications and 7 irrigation treatments, the schedule of which is given below.

SCHEDULE OF IRRIGATION TREATMENTS

S. N.	*Treatments*	*Dates of irrigations*			*Total No. of irrigations*
1	I_1	April, 20	—	—	One
2	I_2	—	May, 15	—	One
3	I_3	—	—	June, 10	One
4	I_4	April, 20	May, 15	—	Two
5	I_5	April, 20	—	June, 10	Two
6	I_6	—	May, 15	June, 10	Two
7	I_7	April, 20	May, 15	June, 10	Three

The net plot size was 1/112 ha during 1964-65 and 1/150 ha during 1966-67 and 1967-68. The rainfall data for these years from January to December are presented in table I.

The fields were prepared after *palewa* by ploughing and planking and 3 budded sets of sugarcane were planted in rows made 90 cm. apart, at the rate of one set per 30 cm. of the row length during the month of February in the first two seasons and March in the last. Manuring was done with nitrogenous fertilizers at the rate of 134 Kg N per hectare. All the nitrogen was applied in one dose in the case of one irrigation treatment and two doses in case of two and three irrigation treatments. The fertiliser applications were made at the time of the first irrigation and at the first and second irrigations respectively. After each irrigation, hoeing and weeding were done as usual when the soil came into proper working condition. The sugarcane crop was harvested during the month of February in the first two seasons and March in the last. The yield data of stripped cane thus obtained plotwise were analysed statistically for each year and finally the pooled data for all the years was worked out to derive valid conclusions. The treatment differences were judged at 5 per cent. probability level, and results for each year are discussed separately and on the basis of pooled data for all the years. Final conclusions were drawn on the basis of pooled results.

TABLE 1.—RAINFALL OF DIFFERENT CROPPING SEASONS

Months	*1964–65*		*1966–67*		*1967–68*		*Mean of 10 year*	
	Rainfall (mm)	*Rainy days*	*Rainfall (mm)*	*Rainy days*	*Rainfall (mm)*	*Rainy days*	*Rainfall (mm)*	*Rainys days*
January	0.0	0	13.5	2	1.3	1	25.4	2
February	1.0	1	22.4	3	0.0	0	9.6	2
March	0.5	1	0.0	0	48.2	5	21.8	2
April	0.0	0	0.0	0	5.1	1	3.0	1
May	23.6	3	13.5	3	42.6	2	7.8	1
June	27.7	3	181.4	12	84.1	6	80.6	5
July	341.1	15	139.1	9	197.8	15	251.9	14
August	132.0	11	290.7	18	380.7	22	308.0	17
September	273.2	16	32.8	4	173.6	13	189.6	10
October	3.8	1	27.7	5	0.0	0	134.3	3
November	0.0	0	15.2	1	8.1	1	5.0	1
December	15.8	3	1.8	2	35.3	5	4.8	1

THE FINDINGS

The yield data of sugarcane for the different years, as well as the pooled data are presented in table II.

TABLE 2.—YIELD OF SUGARCAN IN M. T/HA

S.N.	*Treatments*	*Seasons*			*Pooled*
		1964–65	*1966–67*	*1967–68*	
1	I_1	53.82	35.27	58.82	49.30
2	I_2	41.63	35.54	59.01	45.39
3	I_3	54.47	32.14	60.38	48.99
4	I_4	59.06	50.35	65.39	58.27
5	I_5	63.35	55.17	75.84	64.78
6	I_6	61.42	52.57	69.30	61.10
7	I_7	66.05	63.30	81.74	70.35
S. E.		3.46	4.40	5.28	2.14
C. D. at 5%		10.28	13.08	15.69	6.11

It is evident from the above table that 3 irrigations as given in treatment 1_7 during the months of April, May and June invariably gave the highest yield and proved significantly superior to all treatments except 2 irrigations of April and June and May and June, as given in treatments 1_5 and 1_6 respectively, in all the seasons of trial. In the pooled results, however, the 2 irrigations of April and June alone proved statistically similar to 3 irrigation treatment and gave significantly higher yields than all the other treatments comprising one and two irrigations. Among the single and double irrigation treatments, somewhat variable results were obtained in different seasons. While in the initial year of trial, all treatments comprising one and two irrigations except that of the single irrigation in May (1_2) were on par statistically, in the second year, all the treatments comprising one irrigation were significantly inferior to the two irrigation treatments. In the third year, on the other hand, all the treatments comprising a single irrigation were statiscally similar to two irrigations of April and May and May and June. In the pooled result of all the three years, however, all the treatments comprising a single irrigation were significantly inferior to two irrigations. There

was no significant variation between different times of one irrigation *viz.*, April 20th, May 15th and June 10th but the two irrigations of April 20th and June 10th were significantly superior to those of April 20th and May 15th.

The seasonal variations in yield appeared to be caused by variations in the weather conditions especially rainfall. When the maximum rainfall was received during the germination phase in 1967-68, highest yield was obtained during this season. On the other hand, minimum rainfall of 1966-67, during the germination phase resulted in the lowest yield. There was thus a close relationship between rainfall and the sugarcane yield.

DISCUSSION

The sugarcane crop showed favourable response to increasing levels of irrigation in general, and the maximum yield was obtained with three irrigations applied in the months of April, May and June. But there was no statistically significant difference over 2 irrigation treatment of April and June in all the years of trial as well as to the data pooled. It thus gave a definite indication that the additional irrigation in May di dnot result in any significant yield increase and may therefore, be easily dispensed with, in the event of water deficit The wide frequency of 50 days between two irrigations applied at critical periods proved equally good to narrow frequency of 25 days fixed arbitrarily and thus indicated the importance of critical periods of water application to the sugarcane crop. The adoption of irrigation practice based on critical periods of water requirement may enable considerable economy in water use and make possible the irrigation of larger areas than are actually irrigated presently with the limited irrigation resources. The recommendations made by Rege and Basu (1944), Anon. (1951), Khan and Pattanayak (1956), Khan and Mohapatra (1957), Bhoj and Singh (1960) and Verma (1962) to irrigate sugarcane crop in various areas at short periods of 10 to 20 days did not find support in these studies.

The highest yields of 1967-68 and lowest yields of 1966-67 were associated with the highest and lowest rainfall received during the germination phase. It evidently shows that irrigation of the sugarcane crop during this phase in the event of failure of rain or its deficiency is absolutely necessary for obtaining high yields. Likewise, the great importance of irrigation during the tillering period in June was brought out. In areas of water deficit, therefore, irrigation of the crop

during the germination and tillering periods in the month of April and June respectively is imperative, for these appear to constitute the critical periods of crop water requirement. The rainfall received during the growth phase has also shown profound influence on the yield of sugarcane. Higher rainfall of 1964-65 and 1967-68 of this period as compared to that of 1966-67 resulted in the higher yields of sugarcane and indicate that in the event of rain failure or scanty rains during the monsoon, an irrigation may be required to meet the crop's need. The positive relationship of sugarcane yield with the rainfall of the growth phase as observed earlier by Singh and Ahmad (1969) has been also corroborated by these results.

SUMMARY AND CONCLUSIONS

An experiment was conducted for three years to determine the optimum level and critical periods of irrigation for sugarcane grown in areas of water deficit. The treatments consisted of 3 dates of irrigation *viz.* one, two and three which were given in the months of April, May or June, singly and in different combinations. Thus, there were 7 treatments of irrigation, viz. April, May, June, April plus May April plus June, May plus June and April plus May plus June. These were tried in a randomised block design with 44 replications with the sugarcane, variety Co. 1158.

The crop responded favourably to increasing levels of irrigation and 3 irrigation gave the maximum yield but was not significantly superior to that obtained by two irrigations applied at critical periods in the months of April and June. It showed that in water deficit areas the water applied in the month of May can be omitted without adversely influencing the yield. The results also show that rainfall had a considerable influence on sugarcane yields and an increase in precipitation was associated with increases in yield. Irrigation needs, therefore, to be applied in the event of rain failure or scanty rainfall during germination and growth phases. The need for a minimum of two irrigations for sugarcane in the premonsoon period was established. These should be applied in the months of April and June for efficient and economic production of this crop.

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REFERENCES

1. Anon. (1940). *Ann. Rept. Sug. Scheme, Punjab.*

2. Anon. (1950–51). *Ann. Rept. Sug. Res. Scheme, Anakapalle.*

3. Anon. (1950–51). *Ann. Rept. Sug. Res. Scheme, Gudiyattam.*

4. Bhoj, R. L. and Singh, R. K. (1960). *Proc. 4th All Ind. Conf. Sug. Res. & Dev. Workers,* 117–30.

5. Khan, A. R. and Pattanayak, N. (1956). *Proc. Ninth Cong. Inter. Soc. Sug. Tech. India,* 311–17.

6. Khan, A. R. and Mohapatra, N. (1957). *Proc. 3rd All Ind. Conf. Sug. Res. & Dev. Workers,* 164–70.

7. Rege, R. D. and Basu, J. K. (1944). *Final Rept. Sug. Res., Bombay-Deccan,* 1932–44.

8. Rege, R. D. and Rao, B. V. S. (1954). *Ind. Sug.,* 4 (1).

9. Singh, U. S. and Ahmad, N. (1969). *Proc. Nat. Acad. Sci.* B, 39 (4).

10. Singh, U. S. and Negi, V. S. (1969). *Ind. Sug.,* 18 (11).

11. Verma, H. P. (1962). *Ind. J. Sug. Res. & Dev.,* 6 (2) : 76–79.

Fungicidal control of bean rust disease

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SUMMARY

Five proprietary products were tested in a fundicide screening trial against the rust disease of bean. Only Manzate D was found to be effective in achieving economic control of the disease. This product is recommended for use against bean rust at a dosage of 4 Kg in 1,000 l per ha, on a 7–10 day schedule. More frequent spraying may become necessary in the pre–blossom and blossom stages when very humid weather conditions are prevalent. Spray applications are not necessary later than 7–10 days after flowering.

INTRODUCTION

Bean is one of the most economically important vegetable crops grown in the up country districts in Ceylon. About 3,800 hectares in the Nuwara Eliya and the Badulla Districts alone are brought under bean cultivation annually. Surveys carried out recently indicated that the bean rust disease, caused by the fungus *Uromyces phaseoli typica* Arth., is present in all the up country bean growing areas, during both maha and yala seasons. The disease was found to be particularly severe, and hence economically important, in the Welimada, Bandarawela, Badulla and Padiyapelella areas.

Control of bean rust is generally achieved by a combination of several methods such as long crop rotations, resistant varieties and chemicals. The use of resistant varieties necessitates the operation of a continuous breeding programme particularly in the case of rust disease. The operation of such a breeding programme for bean rust is obviously uneconomical because beans are grown in this country mainly for local consumption and not for seed production on a large scale. Although long crop rotations are a very effective method of controlling bean rust (*Chupp and Sherf,* 1958) it could hardly be expected to be practised rigidly by the average cultivator. Therefore the most promising method under local conditions is the use of chemicals.

Copper fungicides are generally known to be ineffective in controlling rust disease. However, Cortado (1969) found that colloidal copper checked the visual symptoms of bean rust to an appreciable extent, but there was no significant increase in yield of treated plants. Sulphur-based fungicides, though effective in controlling the disease suffer from the disadvantage that they damage flowers and young

pods during warm weather (Oxenham, 1956), Systemetic fungicides containing oxanthiin derivatives have been found to be very effective against bean rust (Von Schmeling and Kulks, 1966 ; Vaugham and Siemer, 1967). However, like most other systemic fungicides they are too expensive for the Sri Lanka farmer. Dithiocarbamates on the other hand are less expensive and have been found by several workers to be effective in controlling this disease.

Owing to the present importance of the bean rust disease this study was undertaken to select a suitable fungicide for its control.

EXPERIMENTAL METHODS

Five proprietary fungicides were tested in this trial using the dwarf bean variety "Top Crop" (Table 1). The trial was carried out at the Bindunuwewa Farm, Bandarawela, during the Maha 1971-72, season.

A randomized complete block design, with four replicates, was used for the trial. The treatment plots within a replicate block were separated by paths 50 cm wide. The plants were spaced 50 cm between rows and 10 cm within a row in a plot area of 200 cm x 300 cm. Out of the four rows per plot only the inner three rows, consisting of 90-93 plants, were considered for the purpose of taking rust infection assessments and yield.

A fertilizer mixture containing 1 : 5 : 2 of urea, conc. superphosphate and muriate of potash, respectively, was applied uniformly to all plots, at the rate of 500 Kg/per ha. Brassicol 75 WP (containing 75 per cent. pentachloronitrobenzene) at the rate of 50 g weell mixed with about 500 g of sand, was applied uniformly over 100 m^2, and worked well into the soil, two weeks before planting, to prevent damping off.

The fungicides were sprayed, using a high volume knapsack sprayer, on a 10 day schedule at concentrations recommended by the manufacturer (Table 2). The first spraying was carried out two weeks after the appearance of the primary leaves. There were no symptoms of rust at the time of the first application. The degree of rust infection was assessed subjectively, considering both the intensity of infection in a leaf and the percentage of leaves infected per plant. Twenty plants, taken at random from each plot were considered in taking the average rust infection in a plot. These assessments were taken 3, 7, and 9 weeks after the appearance of the primary leaves. The pods were harvested twice, 9 and 10 weeks after planting.

RESULTS

Rust infection assessments and yield data are presented in Table 2. Infection percentages shown are those taken 9 weeks after the appearance of the primary leaves.

Of the five fugicides tested only Manzate D gave a result significantly better (5% level) than the control, on the basis of yield. Brestan 60 ranked second and the improvement was very nearly significant. There was good linear correlation between yield data and rust infection assessments.

Economics of Control

The yield increases as a result of rust control with Manzate D and Brestan 60 were found to be 32.6 per cent. and 19.2 per cent., respectively, over the control (Table 2). It is therefore necessary to determine whether the extra costs incurred by the cultivator in controlling the disease, using these fungicides, would increase his income to an extent which could be considered as more profitable. Cost of control, including fungicides and labour, with Manzate D and Brestan 60 are shown in Table 3.

Average yield per ha obtained by a cultivator . .	. .	4,000Kg
Average cost of production/ha . .	. . *Rs.*	2,000 00
Average income/ha	. . *Rs.*	4,200 00
Nett profit/ha	. . *Rs.*	2,200 00
Average yield/ha with Manzate D . .	. .	5,300Kg
Cost of production/ha with Manzate D . .	. . *Rs.*	2,450 00
Average income/ha with Manzate D . .	. . *Rs.*	5,565 00
Nett profit/ha with Manzate D . .	. . *Rs.*	3,115 00
% increase in profit with Manzate D . .	. .	41.6
Similarly nett profit/ha with Brestan 60 . .	. . *Rs.*	2,460 00
% increase in profit with Brestan 60 . .	. .	12 00

DISCUSSION AND CONCLUSIONS

Studies by Harter et al (1935) on the biology of *U. phaseolt typica* indicate that the rust disease of bean is favoured more by cloudy and humid weather, when dew remains on the leaves until late in the morning, than by very wet weather with washing rains. They found the optimum temperatures for germination and infection by the uredospore to be about 14—18° C, and concluded that under these temperature conditions outbreaks of rust are possible when the relative humidity remains at or above 95 per cent. for any period of 8

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consecutive hours or more. Such conditions are frequently found in most of the bean growing areas in the up country districts in Ceylon, particularly from about December to March, and therefore may account for the relatively high incidence of the disease in these areas. Although *U phaseoli typica* is an autoecious macrrocyclic rust fungus, fortunately only the uredospore stage has been observed in abundance in Sri Lanka.

Of the five fungicides screened in our trials only Manzate D gave a significant increase in yield over the control. Brestan 60 also showed an appreciable increase in yield though the difference over the control was not significant. Nevertheless, it is interesting to note that both these fungicides contain manch with the concentration of this active ingredient in the spray fluid of Manzate D being twelve times that in the spray fluid of Brestan 60. In screening trials several other workers too have found maneb to be superior to sulphur and copper based fungicides in controlling bean rust (Conover, 1957 ; Bekhit *et al*, 1970). In their trials however applications of maneb have been made twice as frequently as in our trial. This is perhaps one of the reasons why they have been able to achieve a 100 per cent. increase in yield, as a result of control, compared to the 32.6 per cent increase in our trial.

Apart from the choice of the fungicide itself another factor that should be considered in controlling the disease is the stage of the crop at which the application of fungicides would give the most economical control. Oxenham (1956) observed that appreciable yield reductions due to bean rust occur only when the disease becomes established in the crop before flowering. This is probably related to the finding of Sempio and Marte (1968) that in the early stages of development of the crop there is an arrest of root growth as a result of withdrawal of nitrogen from the root by the bean rust fungus. In comparison with results generally obtained by other workers the yield increase observed in the present trial, following sprayings with Manzate D, is not in proportion to the high degree of control of rust achieved with this fungicide. As stated under experimental methods, there were no rust symptoms observed at all in the trial at 3 weeks after planting, when the first spraying was carried out, and they began to appear only about 5--6 weeks after planting. According to Oxenham (1956) then, it is possible that the very low degree of rust infection observed during the pre-blossom stage of the crop had little effect in reducing the yield and that control achieved in the post blossom stage of the crop, when infection was severe, similarly had little effect in increasing the yield.

Considering such factors as efficacy of the fungicides, economics of control and toxicology the use of Manzate D is recommended for the control of bean rust disease. It should be applied at the rate of 4 Kg 1000 l/ha on a 7-10 day schedule. More frequent spraying may become necessary during the pre-blossom and blossom stages, particularly when very humid weather prevails. Spray applications need not be given later than 7-10 days after flowering. Manzate D should not be sprayed later than 7 days before harvest.

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REFERENCES

Bekhit, M. R., Rizk, Z., Mansour, K., Abd-el-monim, A., Kamel, B., & Boshra, S., (1970). Study of the efiect of spraying with some fungicides at different dates and different intervals on the control of choclate spot and rust of field beans. *Agric. Res. Rev., Cairo, 48*, 38–63.

Chupp, C. & Sherf, A. F. (1960). *Vegetable Diseases and their Control,* Constable and Company Limited, London, 693 pp.

Cortado, R. V. (1969). Tests of copper fungicides for the control of bean rust. *Phillip J. Pl. Ind. 34*, 1–6.

Conover, R. A. (1957). Control of pole bean rust with maneb sulphur dust. *Proc. Fla. hort. Soc. 69*, 247–250.

Harter, L. L., Andrus, C. F. & Zaumeyer, W. J. (1935). Studies on bean rust caused by *Uromyces phasoeli typica J. Agric. Res. 1*, 737–759.

Oxenham, B. L. (1956). Bean rust control. *Qd. Agric. J. 82*, 319–320.

Sempio, O. & Marte, M. (1968). Influenza dell-infezione sullo svillupo degil organi di Fagioli suscethbili e resisteuti alla ruggine, con riferimenti al metabolismo azotato della radice. *Phytopath, Z, 69*, 285–299. (Abstract No. 309, *Review of applied Mycology, 48*, (1969).

Vaughan, E. K. & S. R. Siemer, (1967). Systemic chemical therapeutants for control of bean rust. *Phytopatholog, 57*, 103 (Abstr.)

Von Schmeling, B. & Kulka, M. (1966). Systemic fungicidal activity of 1, 4 oxanthiin derivatives. *Science N. Y. 152*, 659–660.

Table 1.—FVNGICIDES TESTED

Fungicide	*Active Ingredient*	*A.I* (%)
Antracol ..	Zinc propylene bis-dithiocarbamate (propineb) ..	70
Brestan 60 ..	Triphenyl tin acetate × + anganese ethylene bis dithiocarbamate (maneb)	60+20
Elosal ..	Elemental sulphur	80
Manzate D ..	Complex of zinc salts and maneb (mancozeb) ..	80
Morestan ..	6–methyl–quinoxaline–2, 3–dithiolcyclocarbamate	25

Table 2.—EFFECT TO FUNGICIDES ON THE CONTROL OF BEAN RUST

Fungicide	*Rate Kg/ 1,000l/ha*	*Mean % rust infection*	*Mean yield metric tons/ha*	*% increase in yield over control*
Antracol ..	.. 4.0	.. 26.5	.. 7.30	.. 8.6
Brestan 60	.. 1.3	.. 7.5	.. 8.01	.. 19.2
Elosal ..	.. 4.0	.. 27.5	.. 7.49	.. 11.4
Manzate D	.. 4.0	.. 8.0	.. 8.91	.. 32.6
Morestan ..	.. 0.7	.. 62.8	.. 6.32	.. —
Control ..	.. —	.. 64.5	.. 6.72	.. —
	L.S.D. (P=0.05)..	—	.. 1.32	.. —

Table 3.—COST OF CONTROL PER HECTARE WITH MANZATED AND BRESTAN 60

Fungicide	*No. of sprays*	*Total Wt. of fungicide required in Kg.*	*Cost of fungicide Rs.*	*Cost of labour Rs.*	*Total Cost per ha Rs.*
Manzate D ..	.. 5 ..	20	..352 0	.. 90 0	..442 0
Brestan 60	.. 5 ..	6.5	..458 0	.. 90 0	..548 0

Preliminary survey of polyembryony in mango varieties in Sri Lanka

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INTRODUCTION

A large proportion of the mango trees found in our rural home gardens is from self-sown seeds, i.e. seeds which have been disseminated by animals, birds and man. These self-sown mango plants of the popular varieties have shown a remarkable degree of uniformity, resembling vegetatively propagated clones. The high degree of uniformity in vegetative characters, performance and quality of fruits of these varieties have been attributed to the high incidence of polyembryony and production of apogamous sucellar seedlings.

Polyembryony is the formation of more than one embryo in a seed. This phenomenon was recorded by Schacht in 1859. Subsequently, Strassburzer, Englar, Oliver (Belling 1908) independently observed polyembryony in mango.

In polyembryonic seeds one embryo is produced as a result of fertilization and several adventitious embryos arise from the cells of the nucellus. These adventitious embryos are known to originate from the epidermal cells of the nucellus situated close to the micropylar end on the side opposite to the funicle[Juliano (1934), Maheswari et. al. 1955)]. The plants that arise from these nucellar embryos have independent root systems. Hence they are easily distinguished from seedlings with branched or multiple stems.

Varieties which manifest this phenomenon of polyembryony produce several seedlings (Number ranging from 2-8 and at times even more) from one seed. Those seeds however are not extraordinarily large as a consequence. The mass of storage tissue of cotyledons in such seeds would therefore have to nourish several seedlings. Stress on food reserves of the endosperm brought about by several developing seedlings therefore could result in weak plants compared to the single seedling from a monoembryonic seed.

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It is claimed that polyembryonic varieties of mango give uniform stock plants. Hayes (1953) states that asexual or nucellar embryos from polyembroyonic seeds are generally more vigorous than the embryos produced as a result of fertilization. He further states that sexually produced seedlings may not even appear above ground. Campbell (1961) reports that polyembroynic varieties produce more fruits than monoembroynic varieties. He attributes this greater productivity of polyembryonic varieties to the development of asexual embryos even under conditions unfavourable to pollination and fertilization. These embroys supply the growth substances necessary for the development of fruits, and prevent fruit drop. In monoembroyic varieties, when pollination and fertilization have failed sexual embryos are not produced. As they do not appear to produce asexual embryos too, fruits do not develop due to lack of growth substances. This causes a poor fruits set and thereby results in low yields. Hayes (1953), states that important commercial varieties of mango grown in India are monoembryonic. Singh (1960) also reports that a large number of mango varieties in India are monoembryonic, but considers a few to exhibit polyembryony. Sen and Mallik (1940), from a survey conducted in the west coast of India report that out of 400 varieties examined only 10 are polyembryonic. They observed that even in these polyembroynic varieties there was a fair percentage of monoembryonic seed. Whether these monoembryonic seed produce sexual or nucellar seedlings has not been established.

The indigenous species of mango, *Manigfera zeylanica* Hookf. ('Etamba') and the variety of mango, known as 'sour mango' or 'Wal amba' (S) of the species *Manigfera indica* L., were reported to be monoembroyic by Richards (1943). The other varieties of the species *Manigfera indica* L. 'Fibre mango' (Kohu amba—S) Bombay mango (Betti Amba. S) investigated by him were found to be polyembryonic. Richards reports that in polyembryonic varieties such as 'Kohu amba' the growth of sexual seedlings is suppressed by the asexual or nucellar seedlings.

Manigfera zeylanica Hook. f. ('Etamba') was discarded from use as a root stock because it produces long unbranched tap roots. Seedlings of this species cannot stand the shock of root pruning and potting as heavy casualties occur during these operations. 'Wal amba' inspite of it being monoembryonic is still used as a root stock. The seedlings of this variety being monoembryonic in origin show wide variability in vegetative characters and heavy casualties occur during transplanting. The seedlings of this variety show wide variability in vegetative characters and vigour.

In view of the following observations :—

(1) Polyembryonic varieties bear more fruits than monoembryonic varieties (Campbell 1961).

(2) The asexual or nucellar seedlings produced by polyembryonic varieties are more uniform in growth and performance as root stocks.

(3) Nucellar seedlings produce fruits of the same high quality as the mother trees.

The need for a survey of the extent of polyembryony in the mango varieties found in Ceylon was realized. This survey was undertaken to distinguish the monoembryonic from the polyembryonic varieties of mango in Ceylon, and to estimate the extent of polyembryony.

METHODS AND MATERIALS

In this survey samples from 13 varieties grown in Government farms at Kundasale, Peradeniya and Maha Illuppallama were used. A minimum number of 50 fruits was used for each sample except in the case of ' Dampara ' and ' Vellai Colomban ', from which only 35, and 48 fruits respectively were available.

The seeds were extracted from ripe fruits harvested at full maturity shelled and planted in seed beds and wooden boxes. When the seeds were shelled the varieties Vellai Colomban, Chembatan, and Ambalavi were found to be heavily infested with seed weevils.

The data collected at Maha Illuppallama, were from nurseries which were planted before the commencement of this study.

Counts were taken as the seeds germinated. At the final count, made at full maturity of the first set of leaves, the Cotyledons were dissected with seedlings they nourished.

The data collected are given in Table 1.

DISCUSSION

Germination of the varieties Vellai Colomban, Ambalavi and Chembatan was poor compared to Donachi alphonso and Parrot. This can be attributed to the heavy infestation of seed weevils in these varieties.

It is evident from these data that some varieties such as Willard, ' Wal amba ' ' Pandithasekara mango ', Ambalavi and Chembatan produce 100 per cent. monoembryonic seed like the most popular Indian

varieties. In the variety Neelam 92 per cent. of the seeds were monoembryonic. The other varieties under observation, viz. Peterpassand, 'Kohuamba', Donachi Alphonso, Karutha-Colomban, Parrot, Vellai Colomban and Dampara also produce a certain percentage of monoembryonic seed ranging from 2.7-45.8 per cent.

The varieties, Peterpassand, 'Kohuamba', Donachi alphonso, Parrot, Karutha Colomban and Dampara showed a high incidence of polyembryony ranging from 74.3 to 97.3 per cent. Vellai Colomban and Neelam showed 54.2 and 9.4 per cent. polyembryony respectively.

The single seedling from monoembryonic seed could arise either sexually or asexually. The genotype of these seedlings could only be established by laborious progeny testing. However, the nucellar seedlings could be distinguished from the sexual seedlings by the differences in their vigour and vegetative characters.

The apogamous or nucellar seedlings from polyembryonic seeds are uniform in growth and performance as root stocks (Hayes 1953). As illustrated in Table 1, polyembryonic seed could produce on an average, more than 2 seedlings from each seed sown. The only exception is Vellai Colomban, possibly due to the heavy infestation of insects. Thus it seems that from the practical nurseryman's point of view polyembryonic varieties of mango are more economical for use as root stocks.

Monoembryonic seed with all the food material available for development of a single seedling should produce strong vigorous seedlings. Seedlings of Willard, 'Wal amba' and Ambalavi were found to be well developed, while Chembatan and Pandithasekara with the small seed produced less vigorous seedlings. This observation is contrary to the popular view that seedlings (particularly sexual seedlings) produced by monoembryonic seeds are less vigorous. If this view is to be accepted it is necessary to ascertain whether the vigorous seedlings originating from monoembryonic seed are sexual or asexual.

When this point is clarified and characters for identification of nucellar or apogamous seedlings are established, it would greatly facilitate the selection of true to type clones from among polyembryonic varieties. Such varieties could be propagated from nucellar or apogamous seedlings and the progeny would have the same genotype as the mother tree. It is therefore necessary to find out mother trees with high productivity and incidence of polyembryony, combined with high fruit quality and other desirable characters. Propagation of

such mother trees would then become simple and inexpensive. Seven varieties out of the thirteen studied in this survey showed that they could be used in the manner outlined as they produce polyembryonic seed.

The nucellar or apogamous seedlings with their tap root system would be suitable for transplanting, and establishment in the drier parts of the country. They are also likely to be more drought resistant than grafts. These characters therefore could be used in the establishment of mango plantations in the dry zone of Ceylon.

There are, however, two disadvantages in the use of nucellar seedlings. They are, first the extended and unproductive juvenile phase of the plant, and secondly, the large size which would obviously introduce management problems such as pruning, pest and disease control and harvesting.

SUMMARY

A very high percentage of certain varieties of self-sown mango in Ceylon have been observed to be true to type. This phenomenon could be attributed to the high incidence of polyembryony in these varieties.

This investigation showed that Willard, Ambalavi and Chembatan, three of the popular varieties presently grown are monoembryonic, while the others are polyembryonic.

The varieties with a high incidence of polyembryony could be used to estabished orchards, with plants which are true to type, without resorting to vegetative propagation.

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REFERENCES

BELLING, J. (1908). *Ann. Report. of Ha. Agric. Expt. Stn.* 1908. The report of the Assistant in Horticulture.

CAMPBELL, C. W. (1961). *H. St. Hortic. Soc.* pps. 363–65. Comparison of yield of poly-embryonic mango.

HAYES, W. B. (1953). Fruit growing in India, Allahabad, Kitabistan.

JULIANO, J. B. (1937). *Phillip. Agric. 28*, (1937) 749. Embryos of Carabao Mango (*Mangifera indica, L.*)

MAHESWARI, P. SACHAR, R. C. CHOPRA, R. N., (1955). *Proc. Indian Sci. Congr. Baroda* (1955). Embryologicar studies in mango. (*M. indica, L.*)

RICHARDS, A. V. (1943). *Trop. Agriculturist*, 1943, *99*, 134–9. Stock scion trials with mango. 1.

SEN, P K , and MALLIK, P. C. (1940). *Ind. Agr. Sci. 10*, (1940), 750–60. The embryo of the Indian mango (*M. indica L.*)

SINGH, L. B. (1960). The mango, World Crop series, Leonard Hill.

TABLE 1

Variety	*No. of seeds swon*	*No. of seeds germi-nated*	*% Germi-nation*	*Total No. of seed-lings*	*Mean No. of plants per seed germi-nated*	*Mean No. of plants per seed sown*	*% of Mono-emb-ryonic seed*	*% seed with 2 seed-lings*	*% seed with 3 seed-lings*	*% seed with 4 seed-lings*	*% seed with 5 seed-lings*	*% seed with 6 seed lings*	*% seed with 7 seed-lings*	*% seed with 8 seed-lings*	*Poly-emb-ryonic seed*
Peterpassand (1)	50	42	84	124	2.95	2.48	11.9	28.6	30.9	14.3	9.5	4.7	—	—	88.1
Peterpassand (2)	50	36	72	135	3.75	2.70	2.7	11.1	27.7	33.3	19.4	2.7	2.7	—	97.3
Kohuamba M. I.	—	50	—	134	2.68	2.68	16	34	32	6	8	4	—	—	84
Kohuamba R.C.N.	50	35	70	87	2.48	1.74	25.7	25.7	28.5	14.2	5.7	—	—	—	74.3
Donachi alphonso	53	53	100	143	2.69	2.69	15	28.3	30.1	24.5	1.8	—	—	—	85
Willard M. I.	—	50	—	50	1	1	100	—	—	—	—	—	—	—	—
Walamba M. I.	—	50	—	50	1	1	100	—	—	—	—	—	—	—	—
Karutha Colomban	50	42	84	90	2.14	1.80	23.8	42.8	28.5	4.7	—	—	—	—	74.2
Pandithasekera	50	32	64	32	1	1	100	—	—	—	—	—	—	—	—
Parrot	50	50	100	172	3.44	3.44	6	18	36	20	10	8	—	2	94
Nellam	50	48	96	52	1.08	1.04	91.6	—	—	—	—	—	—	—	—
Vellai Colomban	48	24	50	45	1.87	0.93	45.8	16.7	8.4	—	—	—	—	—	8.4
Ambalavi	50	27	54	27	1	0.54	100	—	—	—	—	—	—	—	54.2
Dampara	35	20	57	47	2.35	0.71	25	40	15	15	5	—	—	—	—
Chembatan	50	25	50	25	1	0.50	100	—	—	—	—	—	—	—	75

Meteorological Report

Summaries for January - June, 1972

January : Generally dry northeast monsoon weather conditions prevailed during this month. On the 1st there was scattered light to moderate rain, but on the 2nd, evening thundershowers were experienced over parts of the southwest quarter, heavy rain being reported from Deniyaya. During the rest of the month, generally fair weather was experienced from the 3rd to the 8th and from the 12th to the 16th. On the remaining days, scattered light to moderate rain was experienced. Thunder was reported from the South and the Southwest on most days from the 22nd to the end of the month.

The larger monthly totals of rainfall (totals over 15 inches) were experienced over the northeastern slopes of the central hills, particularly in the Gammaduwa area. Rainfall over the adjacent area, over parts of the Nuwara Eliya and Badulla Districts and over parts of the southwest quarter ranged from 5 to 15 inches. Over the Northern, Northcentral, Northwestern and Eastern Provinces, rainfall was below 5 inches. Several stations in the Northern and Northwestern Provinces experienced absolute drought conditions. The highest monthly totals were 18.53 inches (47.1 cm.) at Doorooma-della Estate (Gammaduwa) and 15.97 inches (40.6 cm) at Keenakelle Estate (Badulla).

Rainfall was below average over the Island, except for a few isolated stations in the southwest quarter, where the rainfall was a little above average. The biggest deficits were 12.19 inches (31.0 cm.) at Mahadova Estate (Madulsima), 12.14 inches (30.8 cm) at Navatkiri Aar (Batticaloa) and 12.02 inches (30.5 cm) at Vaganeri. The highest excesses were 3.96 inches (10.1. cm.) at Anningkande Estate (Deniyaya) and 3.43 inches (8.7 cm) at Panilkanda Estate (Deniyaya.)

There was only one daily fall over 55 inches (12.7 cm), this being 6.07 inches (15.4 cm) at Panikande Estate (Deniyaya) on the 2nd, 33 stations reported nil rainfall.

Day temperatures were below average in the North, above average at Ratnapura, and Nuwara Eliya and above average elsewhere. Night temperatures were a little above average at Nuwara Eliya and below average elsewhere. The highest temperature recorded was 94.9°F (34.9°C) at Ratnapura on the 17th. The lowest at a coastal station was 63.7°F (17.6°C) at Ratmalana on the 6th and for the whole Island 37.4°F (3.0°C) at Nuwara Eliya on the 6th and 16th. Ground frost was reported from Nuwara Eliya on the 5th and 6th. Day humidity ranged from 75 to 85% over the central hills and from 60 to 75% elsewhere. Night humidity ranged from 75 to 95. Mean cloud

amounts were a little below average, while mean air pressures were a little above average. Wind milleages were generally above average, the direction being mainly northerly to northeasterly.

February : The airstream over the Island was dry for almost the entire month and severe drought conditions prevailed over the Northern, North-central and Northwestern Provinces, in the Southeast and over parts of the southwest quarter. Over the rest of the Island too, spells of dry weather prevailed. Except for scattered showers on the 18th and 19th, and isolated showers or thundershowers on a few other days, no rain was experienced.

The larger monthly totals of rainfall (totals over 4 inches) were experienced at isolated stations in the Southwest. Rainfall over the Island was mainly below 2 inches, with a large number of stations recording no rain at all. The highest monthly totals were 5.14 inches (131 mm) at Maliboda Group (Deraniyagala), 4.76 inches (121 mm) at Bandara Eliya Estate (Haputale) and 4.64 inches (118 mm) at Gilimalay Estate (Ratnapura).

Rainfall was below average over the entire Island, not even a single station experiencing rainfall above average. The biggest deficits were 11.86 inches (301 mm) at Dooroomadella Group (Gammaduwa) 10.16 inches (258 mm) at Kobonella Estate (Urugala) and 8.95 inches (227 mm) at Amparai.

There were no daily falls over 5 inches, while 159 stations reported nil rainfall.

Day temperatures were generally above average. Night temperatures were well below average, being appreciably so at Kankesanturai, Badulla and Diyatalawa. The highest temperature recorded was 96.1°F (35.6°C) at Ratnapura on the 9th. The lowest at a coastal station was 58.8°F (14.9°C) at Puttalam on the 25th and for the whole Island 38.4°F (3.6°C) at Nuwara Eliya on the 4th. Ground frost was experienced at Nuwara Eliya on the 3rd and 8th. Day humidity ranged from about 55 to 60% over the northcentral region of the Island and from about 60 to 70% elsewhere. Night humidity ranged mainly from about 80 to 95%. Mean cloud amounts and mean air pressures were a little below average. Wind mileages were generally below average, the general direction being variable in the West and northerly to east northeasterly elsewhere.

March : The drought conditions of February continued till about the middle of the month, except for a few isolated falls on the 5th and fairly widespread rain on the 6th. On the 15th, scattered light to moderate rain was experienced over parts of the southwest quarter and the Northcentral Province. On the 16th, only isolated rain was experienced, but on the next two days scattered showers were experienced in the southwest quarter. On the 19th, some fairly heavy thundershowers were experienced in the Southwest, Kalutara report-

ing a fall of 4.56 inches (116 mm). There was less thunder activity from the 20th to the 25th, but on the last few days of the month fairly active thundery conditions were again evident.

The larger monthly totals of rainfall (totals over 10 inches) were experienced at a few scattered stations in the southwest quarter and in Uva. Rainfall over the southwestern mid-country ranged from 5 to 10 inches, decreasing to less than 5 inches along the southwest coastal belt. Rainfall over the Northern, Northwestern, Northcentral, Central and Eastern Provinces was mainly below 2 inches, several stations in the Northern Province recording no rain at all. The highest monthly totals were 17.03 inches (433 mm) at Meeriabedda Estate (Koslanda), 13.16 inches (334 mm) at Koslanda and 12.75 inches (324 mm) at Beausojour Estate (Nakiyadeniya).

Rainfall over the Island was below average, except at a few isolated stations in the southwest quarter and Uva. The biggest deficits were 9.24 inches (235 mm) at Eheliyagoda, 8.40 inches (213 mm) at Sunderland Estate (Eheliyagoda) and 8.15 inches (207 mm) at Labugama. The highest excesses were 5.48 inches (139 mm) at Meeriabedde Estate, 3.14 inches (80 mm) at Dompe and 2.83 inches (72 mm) at Beausejour Estate.

There were no daily falls over 5 inches (127 mm), while 39 stations reported nil rainfall.

Day temperatures were above average, being appreciably so at Nuwara Eliya and Kurunegala. Night temperatures were well below average at Kankesanturai and a little below average elsewhere. The highest temperature recorded was 99.9°F (37.7°C) at Kurunegala on the 12th. The lowest at a coastal station was 65.0°F (18.3°C) at Kankesanturai on the 2nd and for the whole Island 38.7°F (3.7°C) at Nuwara Eliya on the 4th. Ground frost was experienced at Nuwara Eliya on the 8th and 9th and from the 21st to the 24th. Day humidity ranged from 45 to 60% over the northcentral and central regions of the Island and from 60 to 70% elsewhere. Night humidity was about 70% at Nuwara Eliya and between 80 and 95 in other places. Mean cloud amounts were a little below average, while mean air pressures were slightly above average. Wind mileages were somewhat above average at Puttalam and about average elsewhere. Wind directions were east-northeasterly in the North and East and variable elsewhere.

April : Normal intermonsoon weather conditions prevalied during April. At the beginning of the month, the Inter-tropical Convergence Zone (ITCZ) moved over the Island and fairly active thundery conditions were experienced till the 5th. On the next two days, there was less thunder activity, but from the 8th, the ITCZ became active under the influence of a trough which moved across the Island and thundershowers were fairly widely experienced. These conditions continued till the 21st, even after the trough moved into the Bay

of Bengal on the 13th. From the 22nd to the 27th there was less thunder activity. On the 28th, a trough formed over the southwestern part of the Island and there was increased thunder activity which continued till the end of the month.

The larger monthly totals of rainfall (totals over 20 inches) were experienced at a few stations in the southwest quarter and in Uva Rainfall over the southwestern mid-country and southwestern lowlands ranged from 10 to 20 inches, decreasing to 2 to 10 inches along the southwestern coastal belt. Rainfall over the central hills ranged mainly from 5 to 15 inches Rainfall over the northcentral region of the Island ranged mainly from 2 to 10 inches, while over the Northern and Eastern Provinces, rainfall was mainly below 5 inches, some stations recording no rain at all. The highest monthly totals were 24.21 inches (615 mm) at Avissawella, 23.02 inches (585 mm) at Hakgala and 21.66 inches (550 mm) at Dabar Estate (Deraniyagala).

Rainfall was above average over parts of the southwest quarter, over a small area of Uva near the central hills and at scattered stations in the Northcentral and Northwestern Provinces. Rainfall was generally below average elsewhere. The highest excesses were 14.88 inches (378 mm.) at Hakgala, 9.26 inches (235 mm) at Avissawella and 7.76 inches (197 mm) at Rasagalla Estate (Balangoda). The highest deficits were 6.82 inches (173 mm) at St. Leonards Estate (Elpitiya), 6.67 inches (169 mm) at Annfield Estate (Dickoya) and 6.50 inches (165 mm) at Galle.

There was only one daily fall over 5 inches, this being 5.30 inches (135mm) at Alagalla on the 11th. Ten stations reported nil rainfall.

Day temperatures were above average at all stations, while night temperatures were mainly about average. The highest temperature recorded was 99.0° F (37.2° C) at Anuradhapura on the 4th. The lowest at a coastal station was 71.0° F (21.7° C) at Ratmalana on the 1st and 27th, and for the whole Island 46.3° F (7.9° C) at Nuwara Eliya on the 6th. Day humidity ranged from 70 to 75% over the southern part of the southwest quarter and from 60 to 70% elsewhere. Night humidity ranged mainly from 80 to 95% Mean cloud amounts were generally about average, while mean air pressures were a little above average. Wind mileages were mostly below average, the direction being varialbe.

May : Intermonsoon conditions prevailed at the beginning of the month. On the 3rd, a trough of low pressure in the Bay of Bengal induced a southwesterly flow and thundershowers were fairly widespread till the 5th. Balapitiya recorded 7.88 inches (200 mm) on the 3rd. On the 7th, a cyclonic circulation developed over the Island and moved slowly over India. The westerlies strengthened up to 30,000 feet (9 km.), From the 8th to 16th moderate to heavy rain was fairly widespread and there were several gusts

of 30-40 m.p.h (48-64 kml. p.h.) wind along the southwest coast. There were over 50 falls of over 5 inches (127 mm.) during this period. After the 16th rainfall was light and confined mainly to the southwest quarter. Except for the 26th and 27th, the southwesterly wind stream did not extend beyond 7,000 feet (2 km).

The larger monthly totals of rainfall over 25 inches (635mm) were experienced over most parts of Kalutara and Ratnapura Districts and the windward slopes of the central hills. Elsewhere in the southwest quarter and parts of Puttalam District rainfall ranged from 10-25 inches (254-635mm). Rainfail over the rest of the Island was below 10 inches (254mm). Rainfall under 2 inches (51 mm.) was mainly confined to the coastal areas of Batticaloa District. The highest monthly totals were 40.03 inches (1017 mm) at Theydon Bois Group (Nawalapitiya) 38.87 inches (987 mm) at Alupolla Group (Ratnapura) and 36.64 inches (931 mm) at Padupola.

Rainfall was below average over parts of Hambantota, Badulla and Batticaloa Districts and a few isolated stations in the southwest quarter. Rainfall was above average elsewhere. The highest excesses were 13.99 inches (355 mm) at Theydon Bois Group (Nawalapitiya) 12.97 inches (329mm) at Nalanda and 12.34 inches (313 mm.) at Wester Seaton Farm (Negombo). The biggest deficits were 3.90 inches (99 mm.) at Gourakele Estate (Badulla), 3.85 inches (98 mm) at Hunumulla and 3.58 inches (91 mm) at Kinellan Estate (Ella).

There were 64 daily falls over 5 inches (127 mm). Only one station (Illakantai Tank) reported nil rainfall.

Temperatures were below average except night temperature at Nuwara Eliya which was above normal. The highest temperature recorded was 96.0°F (35.6°C) at Trincomalee on the 23rd and 30th. The lowest at a costal station was 69.6°F (20.9°C) at Colombo on the 9th and for the whole island 48.9°F (9.4°C) at Nuwara Eliya on the 23rd. Day humidity ranged from 65 to 70% in the east and 70 to 85% elsewhere. Night humidity ranged from 89 to 95% Mean cloud amounts were mostly above average, while mean air pressures were a little above average. Wind mileages were above average in the south and north and below average elsewhere, the direction being southwesterly.

June : Weak monsoon conditions prevailed during the first half of the month. Rainfall up to the 16th was mainly confined to the southwest quarter. The westerly wind stream deepened beyond 7,000 feet (2 Km.) only on the 16th and from the 22nd to 31st the depth was over 20,000 feet (6 Km.) There were 6 daily falls over 5 inches (125 mm) on the 2nd. On the 16th a trough of low pressure deepened over India and Sri Lanka and rainfall was fairly widespread on the 17th and 18th. There were 36 daily falls over 5 inches (125 mm) for the period 16th to the 18th. There was light rain on the 19th and 20th. Due to a trough of low pressure in southwest Bay of Bengal rainfall was fairly widespread on the 21st and 22nd. Weather was mainly fair from

the 23rd to the 25th. There was light to moderate rain in the southwest from the 26th till the end of the month due to a depression in West-central Bay of Bengal.

The larger monthly totals (over 30 inches—750 mm) were confined to a small area within Matugama, Neboda and Ingiriya. In parts of Galle, Kalutara, Colombo, Ratnapura, Kegalle and Kandy District rainfall ranged from 10 to 30 inches (250-750 mm). Elsewhere in the southwest quarter and parts of Badulla District rainfall ranged from 2 to 10 inches (50-250 mm). Rainfall over the rest of the Island was below 5 inches (125 mm). The highest monthly totals were 33.40 inches (848 mm) at Sirikandura Estate (Matugama). 32.46 inches (824 mm) at Frocestor Group (Govinna) and 30.48 inches (774 mm) at Gikiyanakanda Estate (Neboda).

Rainfall was above normal over most parts of Uva, Eastern and Northern Provinces and parts of Galle, Kalutara, Ratnapura and Kegalle Districts. Elsewhere rainfall was below normal. The highest excessess were 16.80 (427 mm) at Sirikandura Estate (Matugama), 12.57 inches (327 mm) at Gikiyanakande Estate (Neboda) and 12.29 inches (312 mm) at Halwatura Estate (Ingiriya). The biggest deficits were 20.55 inches (522 mm) at Carolina Group (Watawala), 17.86 inches (454 mm) at Norton Bridge and 16.05 inches (408 mm) at Luccombe Estate (Maskeliya).

There were 46 daily falls over 5 inches (125 mm), the highest being 9.30 inches (236 mm) at Gikiyanakande Estate (Neboda) on the 2nd. 39 Stations recorded nil rainfall.

Temperatures were mostly above average except night temperatures at Diyatalawa, Nuwara Eliya and Ratnapura which were below average. The highest temperature recorded was 98.8° F (37.1° C) at Batticaloa on the 9th. The lowest at a coastal station was 70.1 °F (21.2 °C) at Batticaloa on the 22nd and for the whole Island 50.1° F (10.1° C) at Nuwara Eliya on the 17th. Day humidity ranged from 70 to 80% in the southwest quarter and north-western and nothern coastal areas and 60 to 70% elsewhere. Night humidity ranged from 75-80% in the East and 80-95% elsewhere. Mean cloud amounts were mostly below average and mean air pressures were below average. Wind mileages were above average in the South and North and below average elsewhere, the direction being southwesterly.

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Colombo 7, 22nd July, 1972.

January, 1972

Station	Temperature F°				Humidity		Cloud Amount	Rainfall			
	Mean Max.	Off-set	Mean Min.	Off-set	Day	Night		Amount Inches	Off-set	Rain days	Off-set
Anuradhapura ..	84·3..	+0·8..	68·4..	−0.8..	71..	95..	2·7..	0·48..	−4·37..	6..	−6
Badulla ..	75·9..	−0·3..	63·0..	−1.0..	80..	91..	5·5..	4·77..	−4·25..	16..	+1
Batticaloa ..	81·4..	−0·1..	73·5..	−0.2..	73..	84..	4·5..	2·61..	−8·38..	17..	−1
Colombo ..	87·6..	+1·0..	71·5..	−0.4..	68..	88..	3·6..	0·61..	−2·85..	3..	−5
Diyatalawa ..	71·3..	−0·5..	56·7..	−0.9..	83..	94..	5·7..	2·33..	−3·67..	15..	−2
Galle ..	83·7..	−0·1..	72·1..	−0.1..	75..	90..	4·2..	3·17..	−1·28..	9..	−2
Hambantota ..	84·8..	−0·2..	72·7..	−0.1..	69..	83..	3·6..	0·30..	−3·67..	4..	−5
Jaffna ..	82·2..	−0·9..	71·2..	−1.0..	66..	85..	3·9..	0·28..	−3·52..	5..	−3
Kandy ..	82·8..	+0·6..	64·1..	−0.9..	66..	86..	3·4..	0·69..	−3·97..	9..	+1
Kankesanturai ..	82·0..	−1·1..	73·1..	−1.9..	77..	86..	4·0..	0·13..	−3·08..	5..	−1
Katunayake ..	89·4..	— ..	70·5..	— ..	60..	85..	2·8..	0·10..	— ..	2..	—
Kurunegala ..	87·4..	+0·9..	68·6..	−1.2..	65..	92..	3·0..	0·27..	−3·59..	3..	+6
Maha Illuppallama ..	85·0..	+1·0..	68·1..	−0.9..	66..	87..	3·3..	0·98..	— ..	5..	—
Mannar ..	82·8..	−0·4..	74·1..	−0.3..	70..	78..	3·0..	0·02..	−3·42..	1..	−7
Nuwara Eliya ..	69·7..	−1·9..	48·6..	+1.0..	76..	80..	4·2..	3·72..	−1·99..	11..	−2
Puttalam ..	86·9..	−1·2..	68·2..	−2.0..	67..	92..	3·2..	0·49..	−2·39—	4..	−5
Ratmalana ..	87·5..	−0·2..	69·8..	−1.8..	66..	90..	3·6..	1·52..	— ..	6..	—
Ratnapura ..	91·6..	−2·1..	70·0..	−1.2..	70..	93..	4·8..	4·92..	−1·04..	11..	—
Trincomalee ..	804·..	−0·2..	75·4..	+0.1..	72..	75..	4·8..	1·19..	−7·10..	8..	−5
Vavuniya ..	84·3..	— ..	67·7..	— ..	71..	95..	3·3..	0·12..	−5·33..	5..	−5

February, 1972

Station	Temperature F°				Humidity		Cloud Amount	Rainfall			
	Mean Max.	Off-set	Mean Min.	Off-set	Day	Night		Amount Inches	Off-set	Rain days	Off-set
Anuradhapura ..	89·1..	+1·9..	67·7..	−1·6..	59..	92..	3·2..	0 ..	−2·11..	0..	+6
Badulla ..	80·1..	+1·2..	59·1..	−4·2..	64..	88..	3·0..	0·01..	−4·74..	1..	−9
Batticaloa ..	83·1..	+0·3..	71·4..	−2·4..	69..	85..	4·2..	2·40..	−4·62..	2..	−8
Colombo ..	87·0..	0 ..	70·9..	−1·3..	69..	90..	2·9..	0 ..	−3·78..	0..	−7
Diyatalawa ..	75·8..	+0·8..	52·9..	−4·3..	63..	81..	4·7..	1·30..	−2·07..	2..	−8
Galle ..	85·1..	0 ..	72·4..	−1·3..	70..	85..	4·2..	0·47..	−4·09..	3..	−6
Hambantota ..	86·2..	+0·4..	71·8..	−1·2..	65..	81..	3·5..	0 ..	−2·30..	0..	−5
Jaffna ..	86·1..	+0.5..	71·7..	−0·7..	62..	85..	3·1..	0 ..	−1·45..	0..	−3
Kandy ..	86·8..	+1.6..	61·4..	−2·9..	54..	89..	3·6..	0 ..	−3·27..	0..	−5
Kankesanturai ..	86·1..	+1.0..	69·6..	−4·4..	67..	90..	3·4..	0 ..	−1·34..	0..	−2
Katunayake ..	89·8..	— ..	69·1..	— ..	63..	90..	3·2..	0 ..	— ..	0..	—
Kurunegala ..	92·2..	+2.3..	67·3..	−2·3..	53..	92..	3·1..	0 ..	−2·35..	0..	−6
Maha Illuppallama ..	89·5..	+1·6..	66·4..	−1·9..	67..	87..	4·0..	0 ..	— ..	0..	—
Mannar ..	86·4..	+0·5..	71·7..	−2·3..	65..	88..	2·8..	0 ..	−1·32..	0..	+3
Nuwara Eliya ..	72·4..	+2·7..	44·1..	−1·7..	59..	71..	3·1..	0·06..	−2.96..	1..	−8
Puttalam ..	89·4..	+1·1..	67·9..	−2·5..	64..	92..	3·2..	0 ..	−1.80..	0..	−5
Ratmalana ..	86·4..	−1·0..	69·4..	−2·3..	67..	93..	3·2..	0·05..	— ..	1..	—
Ratnapura ..	93·3..	+1·7..	69·8..	−1·5..	63..	93..	4·8..	2·41..	−4·70..	6 ..	−
Trincomalee ..	83·8..	+1·3..	73·3..	−2·5..	66..	81..	4·2..	0·61..	−3·14..	2..	−6
Vavuniya ..	88·7..	— ..	65·9..	— ..	62..	95..	3·8..	0·05..	−2·06..	1..	−4 −3

March, 1972

Station	Temperature F°				Humidity		Cloud Amount	Rainfall			
	Mean Max.	Off-set	Mean Min.	Off-sst	Day	Night		Amount Inches	Off-set	Rain days	Off-set
Anuradhapura ..	93·8..	+2·1..	70·7..	−0·8..	53..	90..	2·2..	0·04..	−3·85..	2..	−5
Badulla ..	84·6..	+2·1..	62·2..	−2·1..	59..	86..	2·6..	1·49..	−2·84..	5..	−6
Batticaloa ..	85·3..	+0·1..	73·6..	−1·5..	69..	84..	3·0..	1·47..	−1·87..	2..	−6
Colombo ..	89·3..	+1·5..	73·6..	−0·4..	67..	90..	2·5..	2·69..	−1·94..	9..	−2
Diyatalawa ..	78·5..	+0·6..	55·3..	−2·9..	61..	91..	3·8..	2·77..	−2·01..	9..	−3
Galle ..	87·6..	+1·3..	74·3..	−0·7..	67..	84..	3·6..	2·14..	−2·14..	4..	−7
Hambantota ..	87·6..	+0·6..	74·2..	−0·2..	66..	81..	2·6..	0·18..	−2·43..	3..	−4
Jaffna ..	89·3..	+0·5..	73·9..	−1·9..	60..	84..	1·6..	0 ..	−1·18..	0..	−3
Kandy ..	90·5..	+2·5..	64·7..	−2·2..	52..	86..	2·6..	1·06..	−3·67..	5..	−3
Kankesanturai ..	89·0..	+0.3..	70·7..	−4·2..	65..	93..	2·0..	0 ..	−0·97..	0..	−2
Katunayake ..	91·1..	— ..	72·2..	— ..	62..	88..	2·2..	3·41..	— ..	5..	—
Kurunegala ..	96·5..	+3·7..	70·9..	−1·1..	52..	87..	2·7..	3·61..	−3·09..	5..	−5
Maha Illuppallama ..	93·6..	+1·4..	69·3..	−1·2..	51..	85..	2·0..	0·70..	— ..	3..	—
Mannar ..	89·9..	+0·8..	73·2..	−2·2..	63..	86..	1·4..	0 ..	−1·75..	0..	−4
Nuwara Eliya ..	76·2..	+5·0..	45·9..	−0·4..	54..	69..	2·9..	0·80..	−3·00..	4..	−7
Puttalam ..	92·4..	+2·3..	71·4..	−1·6..	62..	90..	2·2..	1·22..	−1·77..	4..	−3
Ratmalana ..	88·7..	+0·3..	71·6..	−2·3..	66..	90..	3·0..	4·22..	— ..	7..	—
Ratnapura ..	95·0..	+2·8..	71·2..	−1·3..	61..	93..	4·0..	6·83..	−2·76..	13..	−5
Trincomalee ..	86·5..	+0·7..	75·6..	−1·1..	65..	79..	2·3..	0·11..	−1·79..	3..	−2
Vavuniya ..	92·9..	— ..	68·7..	— ..	44..	92..	2·2..	0·01..	−2·45..	1..	−4

April, 1972

Station	Temperature F°				Humidity		Cloud Amount	Rainfall			
	Mean Max.	Off-set	Mean Min.	Off-set	Day	Night		Amount Inches	Off-set	Rain days	Off-set
Anuradhapura ..	95·2..	+3·3..	74·6..	+0·2..	62..	90..	3·8..	5·46..	−1·90..	14..	+1
Badulla ..	86·4..	+2·0..	66·5..	+0·2..	68..	92..	4·8..	6·44..	−1·30..	15..	−2
Batticaloa ..	89·3..	+1·4..	77·3..	+0·5..	68..	84..	4·6..	0·69..	−2·16..	3..	−4
Colombo ..	89·1..	+1·2..	75·7..	−0·1..	73..	91..	5·4..	6·17..	−4·06..	16..	−2
Diyatalawa ..	77·7..	−0·6..	60·2..	−0·5..	76..	94..	5·6..	4·92..	−3·35..	16..	−2
Galle ..	87·2..	+1·1..	76·3..	−0·4..	74..	86..	5·2..	3·44..	−6·50..	12..	−4
Hambantota ..	88·0..	+0·3..	76·7..	+0·3..	72..	84..	4·6..	4·42..	+0·13..	6..	−4
Jaffna ..	91·5..	+1·8..	81·1..	−0·8..	66..	79..	3·8..	0·93..	−1·83..	4..	−3
Kandy ..	88·3..	+0·6..	69·6..	−0·3..	68..	87..	5·5..	7·91..	+0·50..	17..	+5
Kankesanturai ..	92·9..	+1·4..	77·4..	+1·1..	68..	93..	3·3..	1·16..	−0·97..	3..	−1
Katunayake ..	91·1..	— ..	74·9..	— ..	69..	88..	5·0..	4·33..	— ..	12..	—
Kurunegala ..	93·1..	+2·0..	74·5..	−0·1..	69..	93..	5·4..	16·18..	+5·82..	21..	+5
Maha Illuppallama ..	94·0..	+2·1..	73·8..	+0·1..	58..	86..	4·2..	6·66..	— ..	20..	—
Mannar ..	91·8..	+1·6..	77·5..	−0·6..	70..	84..	3·9..	2·48..	−1·00..	6..	−2
Nuwara Eliya ..	73·2..	+1·8..	51·3..	+1·3..	76..	91..	5·4..	6·85..	+0·80..	19..	+3
Puttalam ..	92·1..	+2·6..	75·5..	+0·6..	69..	91..	4·4..	5·99..	+0·57..	12..	−2
Ratmalana ..	89·2..	+0·7..	74·0..	−1·6..	70..	90..	5·6..	4·73..	— ..	13..	—
Ratnapura ..	92·6..	+1·3..	73·0..	−0·7..	76..	95..	6·1..	12·55..	−0·56..	25..	+4
Truncomalee ..	90·8..	+0·2..	78·4..	−0·6..	67..	82..	4·0..	0·21..	−2·81..	2..	+5
Vavuniya ..	95·0..	— ..	71·3..	— ..	60..	90..	2·5..	5·30..	−0·34..	14..	−9

May, 1972

Station	Temperatvre. F°				Humidity		Cloud Amount	Rainfall			
	Mean Max.	Off set	Mean Min.	Off set	Day	Night		Amount Inches	Off set	Rain days	Off set
Anuradhapura ..	87.0..	-3.9..	75.0..	-1.3..	77..	93..	5.3..	6.92..	+3.0..	12..	+ 4
Badulla ..	85.6..	0 ..	66.2..	-0.3..	68..	89..	4.7..	3.99..	—0.51..	15..	+
Batticaloa ..	89.7..	-0.7..	77.1..	-0.8..	69..	82..	5.1..	3.16..	+1.93..	9..	+ 4
Colombo ..	86.8..	-0.2..	77.3..	-0.3..	80..	89..	6.0..	18.38..	+4.50..	26..	+ 3
Diyatalawa ..	76.7..	-2.0..	62.1..	-0.3..	77..	89..	5.7..	6.91..	+1.28..	15..	+ 1
Galle ..	84.8..	-0.2..	77.7..	-0.4..	79..	84..	6.0..	11.93..	+0.03..	21..	0
Hambantota ..	85.3..	-1.7..	77.2..	-0.5..	72..	86..	5.2..	6.44..	+1.68..	17..	+ 5
Jaffna ..	86.4..	-1.9..	80.5..	-1.2..	80..	85..	5.3..	5.93..	+3.46..	7..	+ 3
Kandy ..	83.3..	-2.4..	69.7..	-0.9..	73..	87..	5.9..	16.22..	+8.74..	16..	+ 5
Kankesanturai ..	88.8..	-2.8..	79.4..	-1.6..	76..	87..	5.4..	5.48..	+3.62..	9..	+ 5
Katunayake ..	87.3..	— ..	76.2..	— ..	77..	88..	6.1..	19.70..	— ..	24..	—
Kurunegala ..	87.5..	-1.6..	75.4..	-0.7..	77..	91..	5.8..	21.13..	+13.39	15..	- 1
Maha Illuppallama ..	87.5..	-2.6..	75.2..	-0.6..	70..	86..	5.9..	6.41..	— ..	13..	—
Mannar ..	86.9..	-2.5..	79.6..	-1.2..	80..	85..	5.6..	9.06..	+7.12..	10..	+ 6
Nuwara Eliya ..	68.0..	-2.4..	55.3..	-1.6..	85..	91..	5.8..	12.92..	+3.60..	19..	+ 2
Puttalam ..	87.4..	-1.2..	77.7..	-1.1..	79..	89..	6.2..	11.31..	+7.42..	14..	+ 4
Ratmalana ..	86.9..	-0.6..	76.0..	-1.7..	77..	88..	6.4..	17.99..	— ..	20..	—
Ratnapura ..	87.9..	-1.2..	74.0..	-0.9..	80..	95..	5.8..	25.31..	+5.85..	21..	- 3
Trincomalee ..	90.8..	-1.7..	77.5..	-1.4..	66..	80..	5.3..	4.69..	+2.02..	9..	+ 3
Vavuniya ..	88.4..	— ..	75.2..	— ..	74..	91..	6.0..	6.81..	+2.44..	12..	+ 5

June, 1972

Station	Temp. F°				Humidity		Cloud Amount	Rainfall			
	Mean Max.	Off set	Mean Min.	Off set	Day	Night		Amount Inches	Off set	Rain days	Off set
Anuradhapura ..	90.8..	+0.8..	76.7..	+0.3..	68..	91..	5.4..	0.55..	+0.02..	2..	— 2
Badulla ..	88.0..	+2.4..	66.4..	+0.9..	62..	89..	5.2..	2.10..	+1.15..	5..	— 1
Batticaloa ..	91.8..	—0.6..	78.4..	+0.6..	66..	80..	5.3..	2.47..	+1.74..	4..	+ 1
Colombo ..	87.9..	+2.6..	79.0..	+1.6..	77..	86..	6.1..	5.77..	—2.56..	21..	— 1
Diyalatawa ..	79.5..	+2.0..	62.3..	—1.1..	68..	89..	5.8..	2.1 ..	+0.37..	7..	— 1
Galle ..	84.9..	+1.4..	78.0..	+0.8—	78..	84..	6.2..	8.39..	—0.28..	20..	— 2
Hambantota ..	87.6..	+1.2..	78.2..	+1.2..	74..	82..	5.6..	0.12..	—2.06..	1..	—11
Jaffna ..	87.6..	+0.8..	81.8..	+0.8—	77..	81..	6.0..	1.92..	+1.28..	1..	0
Kandy ..	85.0..	+3.0..	70.6..	0 ..	68..	87..	6.2..	2.72..	—4.55..	12..	— 6
Kankesanturai ..	90.8..	—0.2..	80.8..	—0.1..	71..	85..	4.9..	1.44..	+0.88..	1..	0
Katunayake ..	88.7..	— ..	77.3..	— ..	74..	89..	6.0..	3.44..	— ..	17..	—
Kurunegala ..	89.8..	+3.3..	77.0..	+1.3..	72..	88..	6.2..	6.19..	— ..	11..	—10
Maha Illuppallama ..	91.8..	+2.4..	77.1..	+1.1..	62..	82..	5.8..	0.04..	— ..	1..	—
Mannar ..	88.0..	0 ..	81.5..	+0.8..	76..	81..	5.9..	0.01..	—0.18..	1..	0
Nuwara Eliya ..	68.5..	+2.9..	55.6..	—0.3..	81..	91..	6.3..	3.23..	—7.25..	13..	—11
Puttalam ..	89.9..	+3.2..	80.1..	+0.8..	76..	87..	6.0..	0.04..	—0.87..	3..	— 3
Ratmalana ..	87.8..	+2.1..	77.6..	0 ..	76..	86..	6.4..	9.09..	— ..	20..	—
Ratnapura ..	89.4..	+2.6..	74.6..	—0.2..	77..	95..	6.4..	12.87..	—5.34..	25..	— 1
Trincomalee ..	93.7..	+1.1..	79.4..	+0.2..	60..	76..	5.3..	3.72..	+2.99..	6..	+ 4
Vavuniya ..	92.0..	— ..	76.6..	— ..	64..	88..	6.0..	2.07..	+1.60..	2..	+ 1

ERRATA

In the article entitled "Performance of four varieties of guava (*Psidium guajava*, L.) in the intermediate zone of Ceylon," published in *Tropical Agriculturist*, Vol. CXXVII, July to December 1971, the following corrections should be noted :—

Page 175, line 10 : For *loan* read *loss*

Page 175, line 23 : For *lower* read *higher*

Page 177, Table 1, Column 1 : For *Safaedad* read *Safaeda* and for *Allahaba* read *Allahabad*

Page 177, Table 1, Column 8 : For *3315·20* read *331·20* and for *1243·61* read *124·61*

In the Departmental Note entitled "Mass production of pineapple planting material" appearing in *Tropical Agriculturist*, Vol. CXXVII, July to December 1971, the following corrections should be noted :—

For *planting* and *plantings* read *plantlings* and *plantling*

Page 200, line 15 : For *buds* read *butts*

Page 200, line 35 : For *stem* read *stems*

Page 201, line 12 : For *Crown* read *crowns*

Page 201, line 14 : For *out* read *cut*

Page 201, line 15 : For *sterlized* read *sterilized*

Page 201, line 22 : For *linde* read *lined*