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Effect of rubber seed meal on hatchability of hens' eggs

V. Buvanendran

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(Received February, 1971.)

Rubber seed meal has been shown to be a satisfactory substitute for coconut cake in broiler and layer diets in Ceylon when used at levels up to 20-25 per cent. At these levels, the weight gains in broilers or egg production traits in the case of layers were not significantly depressed when compared to control rations containing no rubber seed meal (Buvanendran and Siriwardena, 1970).

Fertility and hatchability are two major components of reproduction in poultry and are therefore very important in flocks kept for breeding purposes. It was therefore felt that an assessment of the effect of rubber seed meal on these two traits was necessary before it could be recommended for use in breeder flocks.

MATERIAL AND METHODS

Two experiments were conducted. In the first experiment three levels of rubber seed cake were given to separate groups of White Leghorns of approximately 30 birds per group. Details of the rations are shown in Table 1. After the birds had been on the experimental diets for 10 weeks, the birds were artificially inseminated on alternate days with pooled semen from 20 White Leghorn cockerels. Eggs were collected for hatching from the second day following inseminations and incubated weekly. The infertile and dead germs were removed by candling on the 7th and 14th days. These eggs as well as those that remained unhatched at the end of 22nd day were examined and the approximate time of death determined using the criteria given by Buvanendran (1967).

In the second experiment, two groups of 26 White Leghorn pullets each, were given the diets shown in Table 1 for a period of 180 days.

From the commencement of the experiment, the birds were inseminated with pooled semen and eggs collected for inculbation. Eggs were incubated weekly for the first 5 weeks of the experiment and again from the 10th to 15th week. Eggs failing to hatch were examined as before.

Table 1.—Composition of rations used in experiments 1 and 2

	Experiment 1			*Experiment 2*	
Ingredients	*Ration 1*	*Ration 2*	*Ration 3*	*Ration 1*	*Ration 2*
Ground maize	40	40	40	40	40
Coconut meal	25	15	5	25	—
Rubber seed meal	—	10	20	—	25
Rice polish	21	21	21	21	21
Fish meal	10	10	10	10	10
Shell grit	3	3	3	3	3
Bone meal	1	1	1	1	1
Salt	0 .25	0.25	0.25	0.25	0.25
Vitamin-mineral supplement	At recommended levels.				

Table 2.—Fertility, embryonic mortalities in early and late incubation and hatchability in Experiment 1

Ration	*Fertility*	*Embronic Mortality*		*Hatchability*
		Early	*Late*	
1		14.06^{a}	10.41^{a}	75.52^{a}
2		21.05^{b}	14.91^{a}	64.03^{b}
3		30.28^{c}	32.00^{b}	37.71^{c}

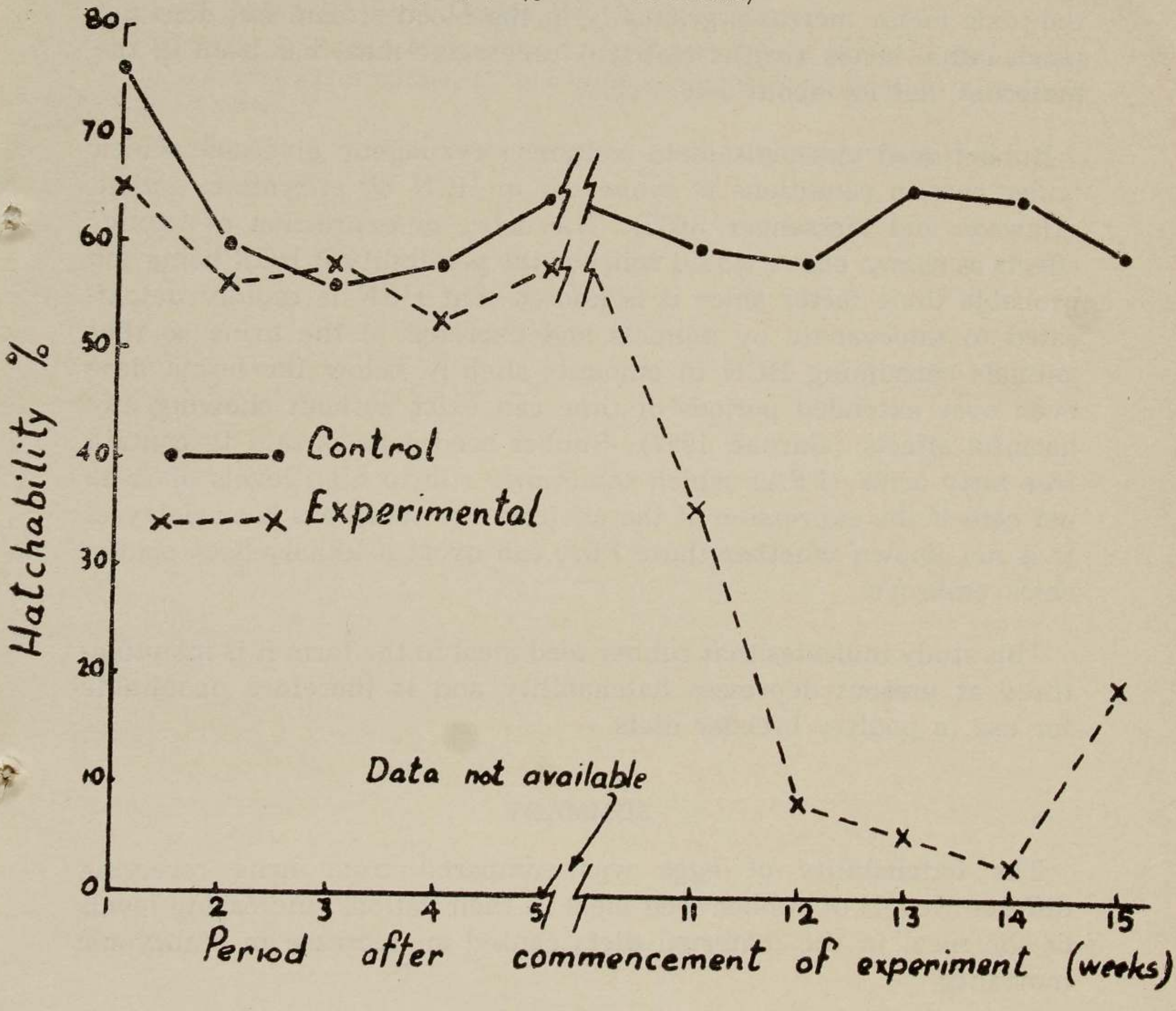
Column values not bearing the same superscript are significantly ($P < \cdot 05$) different.

RESULTS AND DISCUSSIONS

Experiment 1. The percentage fertility hatchability and embryonic mortality in the three groups with the results of statistical analysis are summarised in Table 2. The fertility was high in all three groups and treatment differences were not significant. However, the hatchability was markedly affected in the treatment groups, the hatchability decreasing with increasing levels of rubber seed meal in the ration. The average depressions in hatchability were approximately 11 and 38 per cent (as compared to the control group 1) when the levels of rubber seed meal in the feed were 10 and 20 per cent respectively. In order to examine whether the effect on hatchability was due to mortality at any particular phase of incubation embryonic mortality was classified into early (1-14 days) or late (14-22 days) depending on the age at which death occured. The results of individual hatches indicate that no consistent age specific pattern in embryonic mortality is discernible and that the proportions of early and late deaths were approximately similar in all three groups.

The second experiment was undertaken to examine whether the depression in hatchability occured immediately after the inclusion of rubber seed meal in the diet or whether there was a time lag before this effect was expressed. Figure 1 shows the hatchability of the control (group 1) and experimental groups (group 2) during the period of the experiment. It is clear that during the first 5 weeks of the experiment, there was no difference in hatchability between the two groups. However, from the tenth week, there was a depression in

Figure 1.—Experiment 2. Comparition of Hatchability in the Control of (0% rubber seed meal) and experimental group (25% rubber seed meal.)



hatchability in the experimental group which progressively worsened with time. Since there was an interruption in incubation from the 5th to 10th week, it was not possible to determine the exact period at which hatchability in the experimental group started to decline, but it would appear that the hatchability would have gradually declined sometime between the 5th and 10 week.

The depression in hatchability caused by feeding of rubber seed meal is probably due to the presence of a toxic factor in the meal since the hatchability decreased with increasing levels of the meal as shown in experiment 1. However, the delayed action of this toxic factor as shown in experiment 2 where the hatchability was not affected for as long as 5 weeks after the birds had been on the rubber seed meal diet suggests that the toxic factor is either stored by the hen till threshold levels are reached and then released into the blood stream thus gaining entry into the egg, or that the concentration of the toxic factor increases gradually in the blood stream but does not reach lethal levels (to the embryo) unless the meal has been in the maternal diet for about 5-10 weeks.

Rubber seed meal is said to contain a cyanogetic glycoside which under certain conditions is converted to HCN by enzymatic action. (Dawson and Messenger, 1932). The delay in expression of 'toxic' effects as shown above would rule out the possibility if HCN being the probable toxic factor since it is known that HCN is rapidly detoxicated to thiocyanate by animals and excreted in the urine so that animals consuming HCN in amounts slightly below the lethal dose even over extended periods of time can exist without showing any harmful effects (Garner, 1957). Rubber seed cake is said to contain free fatty acids (FFA) which sometimes rise to high levels of 15-18 per cent if the expression of the oil from the seeds has been delayed. It is not known whether these FFA can exert a lethal effect on the chick embroyo.

This study indicates that rubber seed meal in the form it is manufactured at present depresses hatchability and is therefore unsuitable for use in poultry breeder diets.

SUMMARY

The hatchability of eggs was compared from hens receiving different levels of rubber seed meal in their rations. Increasing levels of the meal in the maternal diets caused an increase in embryonic mortality.

There was a delay between commencement of feeding the rubber seed cake and depression in hatchability which suggests that cyanogenetic glycosides cannot be responsible for this effect.

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The author acknowledges the technical assistance of Miss S. K. K. Mahagedera. The rubber seed meal used in these experiments was kindly gifted by Messers. Lever Brothers Ltd. ; Colombo.

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Physiological analysis of variation in growth and yield of *zea mays* due to differences in time of sowing

I — Pre-flowering period, growth characters, growth attributes and morphological components of growth

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(Received February 1971)

INTRODUCTION

THE economic yield of a field crop consists of a small fraction of total biological yield. This economic fraction is grain in crops like maize, wheat and barley. Most of the carbohydrates in grain comes from the photosynthates produced after ear emergence (Allison, 1964 ; VanEijnattan, 1963 ; Allison and Watson, 1966). Thus the carbohydrates manufactured before ear emergence are not of any direct practical importance for the yield of grain. However, how much carbohydrates would be synthesized by the plants at the time of ear emergence is important in determining the yield of grain and this amount depends on the capacity and intensity of the photosynthetic surfaces available at the time of ear emergence. The growth before ear emergence is therefore important in the sense that it provides the source (Photosynthetic surface, stem surface, leaf laminae and ear surfaces) for the manufacturing of carbohydrates accumulated in grains.

Effect of temperature on growth characters, growth attributes and morphological components of growth in maize was analysed in detail by Jain (1968) under controlled environmental conditions. But it is

The investigations are part of the work conducted at Lab. Ecologie Vegetale, University of Louvain (Belgium) for the Degree "Docteur en Sciences Agronomiques".

difficult to control the environmental conditions in the field. At the same time the results obtained under controlled conditions in laboratory cannot be relied upon till they are confirmed in the field. The only possible way of getting variation in climatological characters at the various stages of crop growth is by planting the seeds at different times. These variations are however, natural and beyond control.

Chikov (1965) reported a relationship between: (1) leaf number in maize varieties and the accumulated temperature above 10°C from sowing to ear emergence; (2) the interval between sowing and ear emergence as a function of mean soil temperature and (3) the accumulated air temperature between ear emergence and tasseling as a function of leaf number. The number of leaves, rate of emergence and longevity of hybrid maize leaves varied due to varieties but were slightly affected by dates of sowing each separated by about 10 days (Eik and Hanway, 1965). Nearly all leaves attained their full areas before the 12th leaf was completely unfolded Ross and Vlasova (1966) also recorded the increase in area of maize leaves with increase in leaf position on shoot till 8th leaf, the area of subsequent leaves decreased slowly and was minimum for the last (13th) leaf.

Briggs *et al* (1920) studied maize plants sown at different dates under the same conditions and concluded that NAR was positively related with mean day temperature (or mean daily maximum) and negatively related to mean might temperature (or mean daily minimum). Gregory (1926) also concluded that NAR was completely controlled by the factors of temperature and radiation. Thorne (1960) reported a linear decrease in values of NAR, RGR (relative growth rate) and RLGR (relative leaf growth rate) with increase in age of sugar-beet, potato and barley plants. Gibbon (1966) recorded a maximum NAR of maize between 6 and 8 weeks after sowing as 0.446 g dm^{-2} wk^{-1} (0.637 mg cm^{-2} day^{-1}) for no nitrogen plots and 0.530 g dm^{-2} wk^{-1} (0.756 mg cm^{-2} day^{-1}) for nitrogen plots.

MATERIALS AND METHODS

The experiment was conducted in summer season under temperate climatic conditions of Heverlee (Belgium) situated at 50°52′ N latitude, 4°4′ E longitude and 25 m altitude. The soil was basically sand with an organic carbon content of 1.5 percent and pH 6.6. The climatological data indicated in Fig. 1 were recorded from the following sources :—

(1) Temperature and relative humidity: Automatic hygro-thermographs installed in the middle of the field on a basement 10 cm above the ground level. Mean values of temperature were caliberated by measuring the area of thermographs by "*Planimeter*".

(2) Rainfall data were collected from the rain gauge installed at a distance of 30 m from the field.

(3) The data on total radiation, sunshine hours and wind velocity were taken from the bulletin de Institute Royal Meteoro-logique de Belgique a Ucle (25 km from the field).

The seeds of maize variety Inra hybrid 244 were sown at five different dates, i.e., 4th, 13th and 23rd May and 2nd and 13th June. A spacing of 50 cm between rows and 25 cm within rows was maintained in the plots of 6 × 2 m.

Sampling : Four plants from each plot were sampled at an approximate interval of 10 days from four different replications. However, four more plants from each plot were measured intact in the field for the precise estimation of growth attributes (Jain, 1970a). Thus the estimated values are the mean of 32 plants (4 × 2 × 4) for the first three stages and 16 (2 × 2 × 4) for the last two stages of growth.

The methods employed for estimating different aspects of growth (Jain, 1970a) and the characters, attributes and morphological conponents studied have already been reported (Jain, 1968). However, for ready reference they are summarised as follows :—

1 : *Growth characters :*

(*a*) Stem—Surface area(πdh dry weight πr^2hxk

(*b*) Leaves—Leaf area = KLW ; dry weight = Leaf area x dry wt per unit area (leaf area)

2 : *Growth attributes or physiological components of growth 9*

(*a*) Net assimilation rate NAR (E)

$$= \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\text{Log}^e L_2 - \text{Log}^e L_1}{L_2 - L_1}$$

(*b*) Relative growth rate (RGR)

$$= \frac{\text{LogWe}_2 - \text{Log}^e W_1}{t_2 - t_1}$$

(*c*) Relative leaf growth rate (RL)

$$= \frac{\text{Log}^e L_2 - \text{Log}^e L_1}{t_2 - t_1}$$

3 : *Morphological components of growth :*

(*a*) Leaf area ratio (LAR) = Leaf area/plant weight
(*b*) Leaf wt. ratio (LWR) = Leaf wt./plant weight
(*c*) Specific leaf area (SLA) = Leaf area/leaf weight

LAR = LWR × SLA

RESULTS

The growth studies were analysed in three different aspects, namely ; (I) The Growth Characters, (II) The Growth Attributes and (III) The Morphological Components of Growth.

(I) GROWTH CHARACTERS

The growth of shoot was analysed separately for stem and leaves.

Stem : The stem growth was measured in terms of surface area (πdh) and its dry weight was estimated from its volume (πr2h). The results are given in table 1.

Table 1 : Mean surface area and dry weight of stem for five consecutive stages of growth at an interval of 10 days :

Mean values at the various stage of growth		Different dates of planting				
Stage	Character	D1 4th May	D2 13th May	D3 23rd May	D4 2nd June	D5 13th June
1st	Surface area cm^{-2}	16.7	36.6	55.4	39.0	31.8
	Dry weight mg.	235	523	991	562	434
2nd	Surface area	97.6	144.7	146.3	99.4	61.5
	Dry weight	1864	4229	4256	2255	1027
3rd	Surface area	313.4	411.0	324.4	230.8	156.5
	Dry weight	8583	14390	11226	6893	4512
4th	Surface area	562.4	707.4	526.6	403.5	384.3
	Dry weight	20085	28664	23178	15793	15973
5th	Surface area	1088	996	1029	711	733
	Dry weight	50561	44160	48671	32040	30190

It is evident from table 1 that the growth of stem in early sown plants of maize (D_1, D_2 and D_3) was better than late sown (D_4 andD_5) plants. But even in early sown plants the earliest (D_1) was not much better than later (D_4). The surface area as well as the weight of the stem was higher in D_2 and D_3 plants almost at all the five stages of crop growth.

Leaves : Similar to the growth of stem, the growth of leaves was better in early than late sown plants (Fig. 2). The leaf area was highest for middle sown (D_3) plants folowed by D_2 and was lowest for D_1 at the first stage of growth. But the leaf area was highest for D_2 followed by D_1 plantings during the last two stages of growth. Maximum increase in leaf area per day were recorded during the 2nd to 4th stages of growth (31 to 51 days after germination) in all treatment plots. But there was a gradual increase in weight per unit area of leaf with increase in age of the plants.

The growth of individual leaves on main shoot of the plant at the various stages of growth are given in Fig. 3, 4 and 5.

Each leaf starts with a rapid growth followed by a gradual decrease in rate of growth, ultimately reaching to its complete cessation after attaining its maximum size. The maximum area of each leaf is attained at a definite physiological stage and after a few days the leaf starts drying and ultimately falls off.

The differences in leaf area of various leaves were much more for the upper 10 to 13 than the lower nine leaves. These differences can be explained on the basis of (1) time of leaf blade initiation (2) the rate of growth and (3) the maximum area attained by each leaf at last sampling.

The growth of 10th and 11th blade in D_1, D_2 and D_3 started after 31 days after germination, whereas, there was no visibility of blade 10th and 11th in D_5 and 11th in D_4 treatments at this stage. The differences were still wider for the 12th and 13th leaves. The area attained by 13th leaf in D_2 was about five times of D_4 and 10 times of D_5 at the time of last sampling.

The maximum area attained by leaf 7-13 were higher for D_2 and D_1 and least for D_5 treatments. Maximum leaf area attained by 9th leaf was highest in the early plantings (D_1 and D_2) as against leaf 8th for the three late plantings. Thus the early sown plants (D_1 and D_2) produced larger number of leaves and higher leaf areas per plant.

(II) GROWTH ATTRIBUTES

The results of growth attributes are given in table 2.

Table 2 : Mean values of net assimilation (Ea) relative growth (R) and relative leaf growth rates (RL) in relation to time of plantings and age of the plants.

Growth attribute and unit of expression	*(a) In relation to date of planting*							
	D1	*D2*	*D3*	*D4*	*D5*	*D5 SEm*	*LSD*	
1. Ea mg cm^{-2} day^{-1}	0.715	0.628	0.596	0.637	0.559	±0.092	—	—
2. R mg mg^{-2} day^{-1}	p.121	0.097	0.079	0.103	0.089	±0.0173	—	—
3. RL $cm^{-2}cm^{-2}$ day^{-1}	0.092	0.067	0.057	0.095	0.057	±0.0218	—	—

Growth attributes	*(b) In relation to age of the plants**						
	A1	A2	A3	A4	SEm	LDS	1
Ea mg cm^{-2} day^{-1}	0.720	0.578	0.577	0.633	±0.083	—	—
R gm mg^{-2} day^{-1}	0.175	0.099	0.077	0.057	±0.155	0.034	.047
RL cm^{-2} cm^{-2} day^{-1}	0.161	0.076	0.038	0.018	±0.019	.042	.058

* Interval between observations = 10 days

1 : *In relation to time of planting* :

There was a continuous decrease in the rate of assimilation with delay in planting except for D_4 where it was higher than D_2 and D_3 plantings. The mean rate of assimilation in D_1 was 25 per cent higher than D_5, but the differences were statistically not significant.

Similar to the rate of assimilation, there was also a gradual decrease in relative growth and relative leaf growth rates with delay in planting from D_1 (4th May) to D_3 (23rd May). However, the values of relative growth rates for D_4 (2nd June) were comparatively higher than D_3 and that of D_5 were comparable to D_3. No significant difference in values of all these growth attributes was however recorded due to the effect of time of planting.

2 :*In relation to age of the plants* :

There was a continuous decrease in the values of all growth attributes with increase in age of the plants. But the differences were statistically significant for relative growth rates (R and RL) and not for the net assimilation rate (Ea). Thus the decreased in values of relative growth rates was mainly caused through decreased rate of leaf growth (capacity of the plants) with little variation in the net assimilation rate (intensity—assimilation per unit area) of the photosynthetic surfaces.

3 : *Correlation and regression studies* :

As the temperature was the most important factor for variation in all these growth attributes correlation studies were made between the mean temperatures (Plainmetric estimation of the thermographs) above 10°C and the values of different growth attributes. The results are given in table 3.

Table 3 : Values coefficient of correlation (r) and regression (b) of growth attributes on mean temperatures above 10°C.

S. No.	*Characters studied*	*Value of r*	*Value of b*
1.	RL and temperature above 10°C (degree days) ..	0.641** ..	0.0324
2.	R and temperature	0.798** ..	0.0287
3.	Ea and temperature	0.803** ..	0.0835

**Significant at 1% level

All the three growth attributes were significantly related to mean temperature above 10oC. An increase in temperature above 10°C per day increased the leaf growth rate by 0.024 cm^{-2} cm^{-2} day^{-1}, the mean growth rate (dry wt.) by 0.028 mg mg^{-1} day^{-1} and net assimilation rate by 0.0835 mg cm^{-2} day^{-1}.

(III) MORPHOLOGICAL COMPONENTS OF GROWTH

The morphological components of growth consists of leaf area ratio, leaf weight ratio and the specific leaf area were estimated at the five consecutive stage growth from the five different treatment plots. The results are given in table 4.

Table 4: Mean values of leaf area ratio (LAR) leaf weight ratio (LWR) and specific leaf area (SLA) of plants in different treatment plots:

Morphological components	*(a) In relation to time of planting*				
	D1	D2	D3	D4	D5
	4th May	*13th May*	*23rd May*	*2nd June*	*13th June*
LAR cm^2/mg.	0.155	0.143	0.118	0.151	0.163
LWR mg/mg.	0.533	0.507	0.526	0.548	0.540
SLA cm^2/mg.	0.278	0.256	0.221	0.267	0.285
	(b) In relation to age of the plants				
	A1	A2	A3	A4	A5
	11	21	31	41	51
	(Approximate days after germination)				
LAR cm^2/mg	0.223	0.191	0.143	0.099	0.066
LWR Mg/mg	0.661	0.621	0.568	0.463	0.341
SLA cm^2/mg	0.338	0.301	0.252	0.214	0.195

There was a gradual decrease in the values of LAR and SLA with delay in planting from 4th May to 23rd May. However, the values of subsequent plantings were larger for all the three components (LAR, LWR and SLA) for the last two plantings (D_4 and D_5).

The values of LAR, LWR and SLA were decreasing with increase in age of the plants. The effect of age appeared to be much more conspicuous than the effect of time of planting. The proportionate decrease in LAR was larger than in values of LWR and SLA.

DISCUSSION

Growth characters:

The growth of plants sown at different times can be explained on the basis of the total radiation received by different plants at the various stages of growth. Total temperature, radiation and sunshine hours received by D_1 (4th May) planting during the period of 21-31 days were maximum (Fig. 1). This exactly coincides with the growth of D_1 plants which was minimum during the initial stages of growth followed by a rapid rise in rate of gorwth (21-3- days) as compared to plants in all other treatment plots. The growth of D_2 (13th May) and D_3 (23rd May) plants during the periods of 21-31 and 31-41 days was also superior to the late plantings of D_4 (2nd June) and D_5 (13th June). This may again be attributed to the minimum temperature and radiation received by late sown plants (Fig. 1). Chikov (1965) also reported the closer relationship between mean tempertures above 10°C and the growth of leaves in maize.

But contrary to the direct relationship of growth with the amount of radiation and heat energy received in these plants, the growth of plants was slow in late sown plants (D_6) even during the period of 41-61 days after germination when the radiation and heat energy received by these plants was maximum. This can be explained on the basis of two facts :

(1) The period of maximum was between the age of 31 to 51 days. The higher radiation and heat energy received by late sown plants (D_5) was too late to compensate the loses caused due to their deficiency during the early stages of crop growth.

(2) The plants might have responded to the energy received and the rate of photosynthesis have increased to certain extent, but the amount of photosynthetic surface intercepted with solar energy was relatively smaller than in other plants and the total amount of dry matter synthesized even during these stages of growth in D_6 treatment plots might be poorer than other treatment plots. Thus the light and heat energy received during the early stages of maize growth was comparatively more important because of its cumulative response for a larger period of plants life cycle than the energy received during the later part of the season.

The growth of individual leaves follows the same trend in the field as under the controlled temperature conditions (Jain, 1968). The area of each leaf increases first rapidly then slowly, the leaf attained its maximum size and finally starts drying after maintaining the maximum size for sometime. The differences in growth of leaves in the field and the controlled environmental conditions were recorded in respect of : (1) the rate of leaf appearance was comparatively slower in the field than under the controlled temperature conditions and (2) the total leaf area particularly the width of leaves was more in the field than under controlled conditions. Low soil temperatures and wider spacings in the field might be responsible for these differences. Decrease in values of L/W of epidermal cells due to low temperatures was also reported by Jain (1970b). The higher leaf area (maximum) attained by each leaf in the field as compared to the controlled conditions in the cells may be attributes to the larger spacing (50 × 25 cm.) in the field than in the cells (20 × 20 cm.). Thus the higher light and heat energy received by early sown plants gave a better start during the initial stages of growth which could not be compensated by the late sown plants even if there was a rich supply of light and heat energy during the later part of the season.

Eik and Hanway (1965), however, recorded only slight differences in the number of leaves, rate of emergence and longevity of leaves by growing at different dates each separated by 10 days. This may be because of greater climate differences in the present treatments than the experiment of Eik and Hanway (1965). Moreover, all these differences appeared simply due to the higher ontogenetic development of plants initiated due to the superior conditions of light and heat in the early sown plants. Watson (1965) and Blackman (1956) also observed the effect of temperature on leaf formation. Jain (1968) and Thorne *et al* (1967) while working on maize and sugar-beet respectively under controlled conditions also suggested that plants respond better to the light and temperature during the early stages of crop growth.

Growth attributes :

The mean growth rate of dry matter (R) and leaf area (RL) were not statistically different for different treatment plots, but the variation due to age of the plants was statistically significant. Decrease in the rate of growth attributes (NAR, R and RL) with increase in age of the plants is now almost an established fact and have been reported by Throne (1960) for sugar beet, potato and barley and by Jain (1968) for maize. The maximum average value of relative growth rate was recorded as 0.175 mg mg^{-1} day^{-1} at the age of 11-21 days (table 2) which resembles with the maximum value reported by Hammond and Kirkham (1949) in maize as 0.159 g $g^{-1}day^{-1}$. The maximum rate of assimilation reported by Gibbon (1966) between 6 and 8 weeks after sowing as 0.446 and 0.530 g dm^{2} wk^{-1} (0.637 and 0.756 mg cm^{-2} day^{-1}) were in complete agreement with the values of NAR in the present investigations (0.633) mg cm^{-2} day_{-1} during 41-51 days after germination (table 2).

Morphological components of growth:

Contrary to the growth characters and growth attributes, the value of the morphological components of growth, i.e., LAR, LWR and SLA were highest for D_2 followed by D_1 and D_4 treatments (table 4). As there was a continuous decrease in all these characters with increase in age of the plants, the opposite effect on the time of sowing on the morphological components of growth can again be attributed to the slow ontogenetic development of late sown plants. The differences in growth of plants sown at different dates also attributed to the differences in rate of ontogenetic development of plants while discussing the growth of leaves in this paper.

SUMMARY

The growth of maize plants was analysed in the field in relation to the date of planting. The differences in growth of stem and leaves were related to the variation in light and heat energy received by plants sown at different dates. The results were compared with the results recorded under controlled conditions.

It was inferred that under temperate conditions where the radiation and heat energy is limiting factor for growth, the energy received during the early stages of crop growth (21-41) days after germination) was more beneficial than the later part of the season. The period 21-41 days also coincides with the periods of maximum growth of leaves. The data confirm the results recorded under controlled environmental conditions. It is suggested that maize should be sown in these area only a few weeks (3-5) before the maximum intensity of sun.

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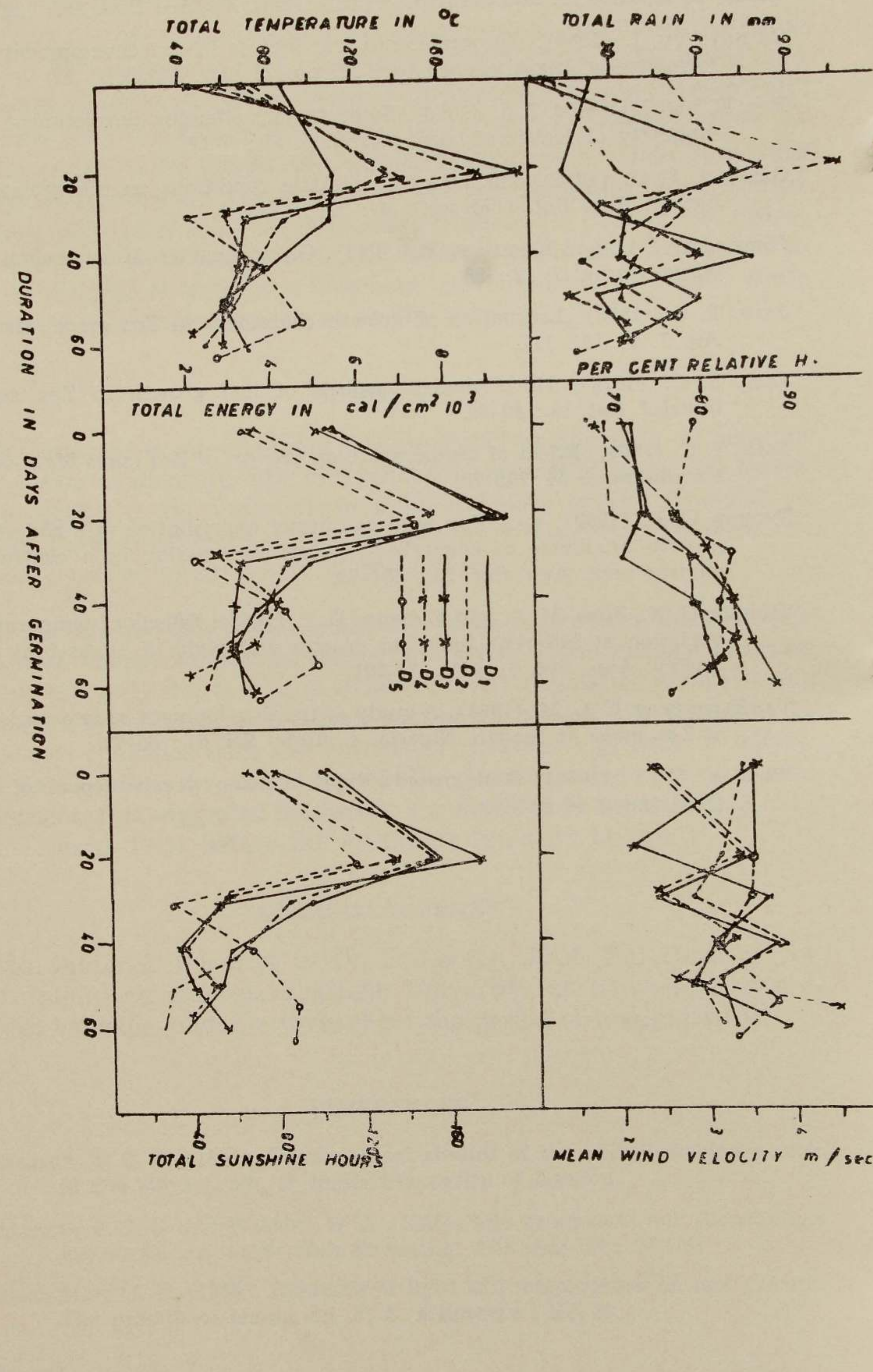


FIG.-1. MEAN CLIMATOLOGICAL DATA OF THE FIELD

FIG. 2 - MEAN GROWTH OBSERVATIONS:- LEAF

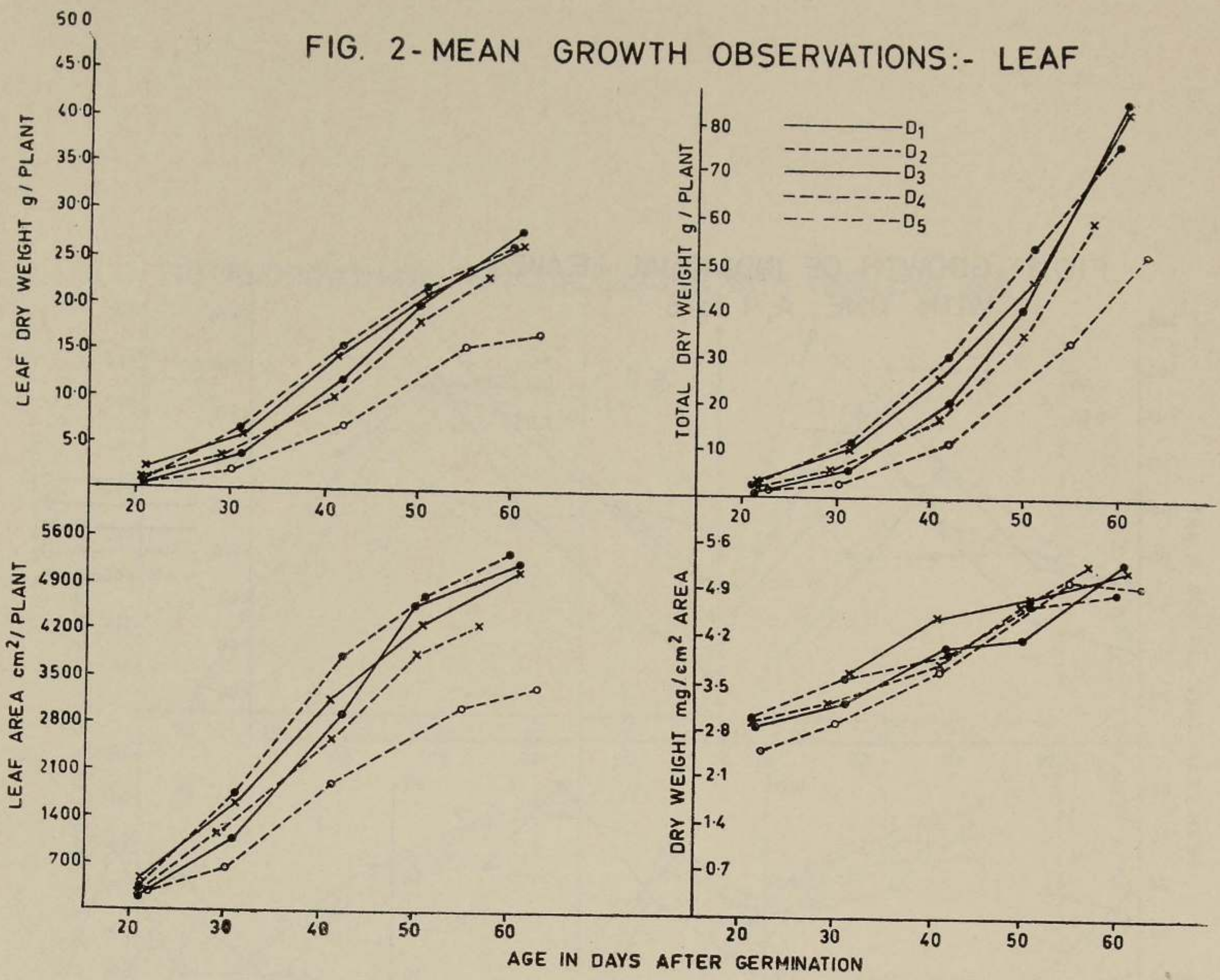


FIG.3 -GROWTH OF INDIVIDUAL LEAVES WITH TIME: A, 1 to 5

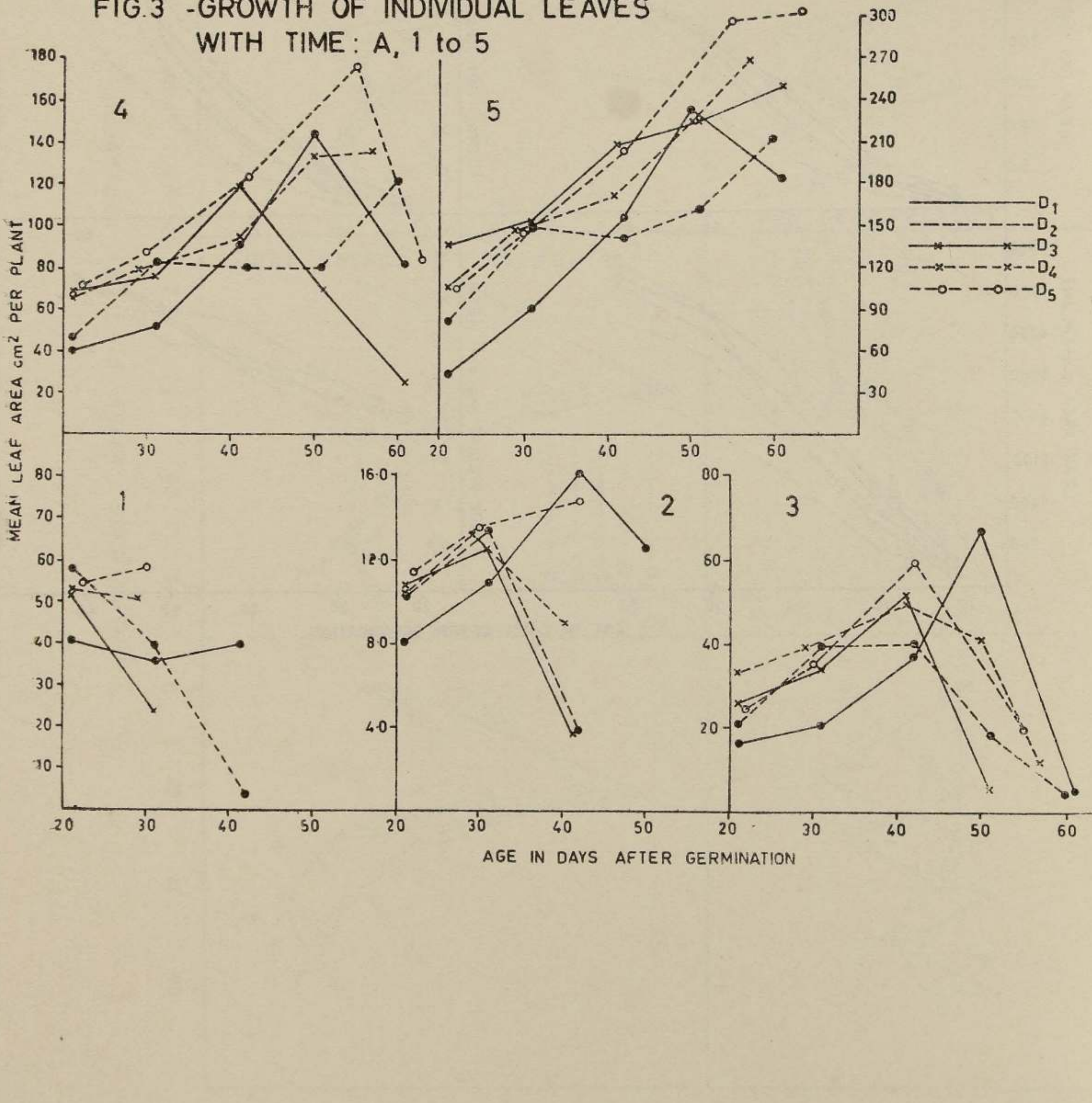


FIG. 4-GROWTH OF INDIVIDUAL LEAVES WITH TIME: B, 6 to 9

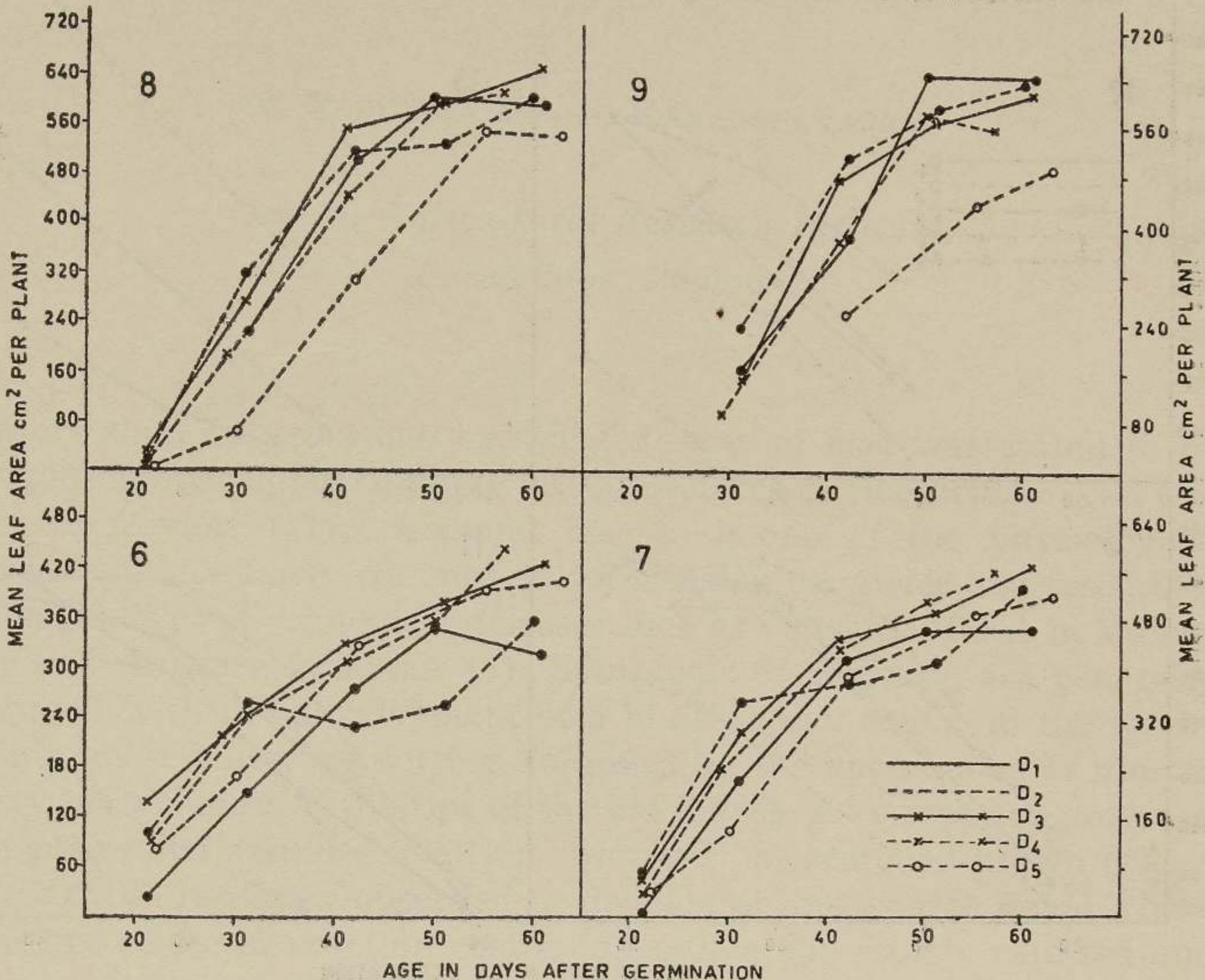
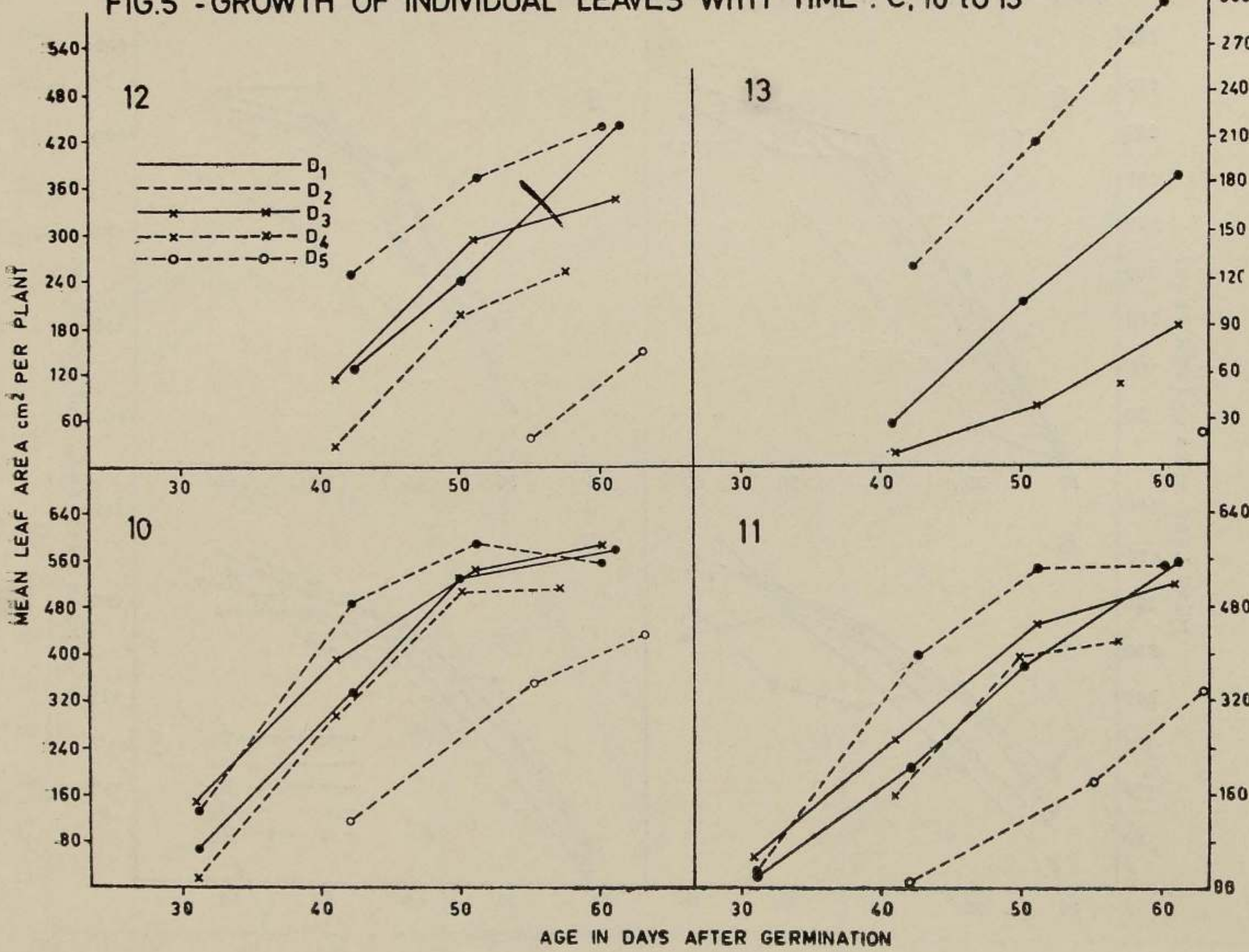


FIG.5 - GROWTH OF INDIVIDUAL LEAVES WITH TIME : C. 10 to 13



Nutrient deficiency and physiological disease of lowland rice in Ceylon

III. Remedy for bronzing disease of rice

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More than 10 years ago bronzing disease of rice was stated to be prevailing over approximately 40,000 hectares of rice fields in the wet zone of Ceylon (11). Bronzing disease is one of the physiological diseases of rice fairly common to some Asian countries and resembles other kinds of physiological diseases such as Penyakit Merah in Malaya (4) and Akagare in Japan (1). Symptoms of bronzing are generally initiated with the development of a bluish-green colour in the leaves occasionally following wilting, followed by the appearance of minute rusty brown spots at the tips of the old leaves. As symptoms progress, the entire leaf assumes finally a ' bronzed " or scorched brown colour. The disease has been observed to develop on boggy rice fields where soils are acidic in reaction coarse in texture and mostly rain-fed and situated below the rubber forests (2, 6). Although severe occurrence of the disease ceased recently with the extension of resistant varieties, it is still of sufficient importance to merit investigations directed at finding a practical remedy for the disease.

MATERIALS AND METHODS

Pots and field experiments, and chemical analyses of straw samples were conducted as described in the previous paper (9) except for special treatments.

Air-drying treatment in the pot experiment was done by leaving the soil in pots to dry for two weeks being protected from rain. On the other hand, in the wet series, soils were kept submerged more than one month before planting. In the field experiments conducted at Bombuwela, surface soil was ridged in many rows by deep ploughing and kept air-dried continuously and in a well-drained condition before cropping. In the wet series experimental plots were subjected to ordinary operations until planting. Lime (watered) was mixed with surface soil as thoroughly as possible at one week before planting. The amount of lime applied was calculated to raise the soil pH to 6.0. Fig. 1 shows one of the soil pH-lime curves.

Murungakayan 302, a local variety very susceptible to bronzing, was grown in Maha 1967-68 while in Yala 1968 the improved variety, H8, was used.

RESULTS AND DISCUSSIONS

Nutrient contents of bronzed plants

Already in 1952, Kandiah (3) anticipated that bronzing might occur owing to potassium deficiency prevailing in Minuwangoda area though he could not prove the actual effect of increased application of potassium fertilizer. Later many workers made efforts to find the main cause of bronzing disease. Inspite of the prevalence of conflicting points of view on the possible causes, most results are similar to each other in reporting a nutritional disturbance produced by low nutrient supplying power and reduced status of the soil.

On comparing the nutrient composition of straw listed in Table I. bronzed plants are generally very high in nitrogen and iron, and very low in the other nutrients, especially potassium, magnesium and silica. These plants were sampled from Bombuwela and Pussellawa fields, typical bronzing susceptible areas in Ceylon. Both are boggy and undrained throughout the season. Soils are characterized by abundant ferrous iron and scanty nutrients for the plants which frequently showed symptoms of phosphorus deficiency being associated with bronzing appearance and assuming purplish leaf colour. In Minuwangoda area near Colombo yellowish bronzing was observed to dominate in the sampling survey (9). The plants were deficient in magnesium and silica but were not opposed to have low potasium and high iron contents as the cause of bronzing. Such being the situation, it may be difficult to select a single cause for the occurrence of this disease.

Effect of N, P, K and slags on the growth and yield of rice

Pot experiments using bronzing susceptible soils were conducted to examine nutrient factors which will interact with growth inhibition. Significant difference in growth was obtained among treatments with N, P, and K. Results summarized in Table 2 give an indication that in Bombuwela soils response of the plants is stronger to potassium than to phosphorus and growth is disturbed most severely by the treatments with nitrogen only or nitrogen + phosphorus, particularly in the humic soil. However, no typical bronzing symptoms appeared in all treatments. Instead, small brown spots of necrosis, probably symptoms of potassium deficiency, developed on the leaves of stunted plants. This observation was justified by the element content in straw given in Table 3. Single application seems to cause iron intrusion to the plant. Slags are more or less effective to increase calcium and silica content in straw though they were less effective on the increase of panicle yield than nitrogen and phosphorus.

Experiments were continued with same designs in the next season and presented more definite results. Without potassium applied, the plants showed severe potassium deficiency, bearing extremely big spots of necrosis.

Effect of air-drying and liming the soil

Soils used in the above experiments had been once air-dried before submergence. Air-drying was thought to be a possible reason in preventing occurrence of bronzing, by alleviating production of ferrous iron which might be involved in this process. Experiments were thus undertaken to determine the effect of air-drying and liming the soil on the growth and yield of rice Bombuwela sandy soil was sampled from a farmer's field and taken to the plant cage in C. A. R. I. with the least delay to prevent drying on the way. The sample soil was then subjected to treatments of wetting and air-drying, and to the other treatments as described already. Data obtained are excerpted in Table 4. Typical bronzing disease appeared on the plants receiving N, P, and K in the wet series with a descending degree of symptom expression by the application of potassium, slag and lime, while in the air-dry series symptoms were alleviated remarkably except for the treatment with N. P. K. only. Almost all symptoms occurred on plants treated with slag or lime.

A high dose of phosphorus seemed effective in the prevention of symptoms only in the dry series. Plants in this series grew much taller and produced more tillers resulting in higher grain yields than in the wet series. Moreover in the dry series, effect of slag and lime addition was recognized but in the wet series no significant difference was obtained among treatments except for high potassium addition. Leaf colour in the dry series remained more green throughout the growth stage suggesting higher effect of nitrogen to the plants besides possibly alleviated iron toxicity (2, 4, 7, 10). Soil pH determined after crop was in general higher in the dry series increasing with usage of soil amendments (Table 5).

Field experiments to ascertain effects of similar treatments were conducted in Bombuwela Station and farmer's field. Because of the difficulty in drainage operation, air-drying of the surface soil seemed to be not enough to realize good effects as expected from the results of pot experiments. Moreover in the Experiment Station, field used for the dry series was not uniform and less fertile comparing field for the wet series. Nevertheless, bronzing symptoms observed in the course of growth were different between two series indicating almost complete prevention by liming and slight effect by slag application as is given in Table 6. Same situations were noticed also in the farmer's field experiment.

Yield data are excerpted in Table 7. In the Station field where acre yield is usually less than 40 bushels, good growth and yields resulted on the whole. Lime and potassium were quite effective in increasing grain yield especially in the wet series of the Station field while in the farmer's field slag addition appeared to promote yield increase. Taking account of the average grain yield of 20 bushels paddy in this area, growth status in all plots were so vigorous to be attractive to the farmers. If the drainage system was complete higher yields could be expected through the means of drying the soil.

Mechanism of the occurrence of bronzing disease

Disorder in the physiological activities in the bronzed leaves has been studied in detail by Inada (2) and Ota (6) who worked in Ceylon as Colombo-Plan experts following Yamada's research on the bronzing problem (11). With respect to the main cause of bronzing, iron toxicity theory was first presented by Ponnamperuma (7) who initiated the practical measure of liming as remedy for the disease (8). Aluminium toxicity theory by Ota (6) succeeded, assuming the low calcium medium as an associated condition. Recently, iron toxicity was supplemented with a condition of low potassium medium (5), and with an initial root damage by hydrogen sulphide (10).

In Ceylon, low supply of potassium by the soil evidently dominates in the bronzing-susceptible fields followed by low supply of phosphorus and magnesium. Single applicaiton of nitrogen fertilizer (sulphate form) and low available silica in the soil are not excluded as the nutritional causes. Moreover, frequent observations that bronzing disease is apt to occur in the boggy and reduced field condition on spots adjacent to rubber plantings, where abnormal meteorological conditions such as temperature and solar radiation may be somewhat unfavourable for plant growth. Although these secondary causes need further investigation, primarily the disease depends on the field conditions. Fig. 2 illustrates the mechanism of occurence as supposed from the the research and observation results.

Draining the field should be accompanied by liming the soil as an important remedy for bronzing. This measure is of general concern for improving soil conditions and increasing rice production in Ceylon together with the enhanced use of fertilizers and other soil amendments.

Details of results reported, are available in the reports of Colombo-Plan on the same title presented to Ceylon Government 1968 and Japanese Government (OTCA) 1969.

SUMMARY

Pot and field experiments using bronzing-susceptible soils were conducted from 1967-1968 to find remedies for the disease, based on the results of sampling survey.

1. Application of potassium fertilizer was most effective to increase the growth and yield of rice, followed by phosphate fertilizer and slag. However, even the balanced dose of NPK fertilizers did not eliminate bronzing symptoms.

2. Air-drying and liming the surface soil before planting increased rice production and prevented bronzing. Both measures are recommended as remedies to be used in association with an increased doses of potassium fertilizer and slag.

3. A mechanism for bronzing occurrence was postulated including some meteorological factors as secondary causes.

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Table 1.—Comparison of element content in straw between normal and bronzed rice plants sampled at heading or milk-ripe stage

A.—Mean element content :

Authors	*Varieties*	*Growth status*	*N* %	P_2O_5 %	K_2O %	*CaO* %	*MgO* %	Fe_2O_3 ppm	SiO_2 %
1. Ota	Mur. 302,	Normal	1.20	0.44	1.74	0.43	0.08	2620	7.86
(6)	H-4	Bronzed	1.73	0.57	0.84	0.22	0.03	3600	4.00
2. Mulleriyawa(5)*	—	Bronzed	1.11	0.19	0.68	0.15	0.09	680	7.45
3. Takijima	H-4, H-6,	Normal	1.13	0.41	2.02	0.58	0.20	1290	9.98
(9)	H-8	Bronzed	1.62	0.30	0.95	0.66	0.11	2330	6.61

B. Ratio of Bronzed to normal (%)

1	144	129	48	51	28	138	51
2.	98	46	34	26	45	53	75
3.	143	73	47	114	55	181	66

*Becuase of the absence of normal samples, those of (3) were used for calculating ratios. MnO content of bronzed plants was 406 ppm.

TABLE 2.—Effects of N. P. K. fertilizers and slag on the growth and yield of rice

(POT EXPERIMENTS, MAHA 1967–68, M–302)

Soils used		*Treatments**	*Plant height (cm)*	*Maximum tiller Number*	*Panicle number number*	*Yield (per pot)* Straw	Panicle	Total
I. BOMBU-WELA sandy	1.	N only	96.8	20.5	22.5	43.0	18.5	61.5
	2.	NP only	86.8	29.0	27.0	39.4	39.9	89.3
	3.	NPK	89.8	33.5	33.0	56.0	57.0	113.0
	4.	NP2K	92.8	35.0	34.0	62.2	67.8	130.0
	5.	NPK + Ca-s	98.2	28.5	28.5	48.5	57.8	106.3
	6.	NP2K+Ca-s	112.8	26.0	25.0	58.9	68.6	127. 5
	7.	NPK+Ca-s +Mn-s	100.2	26.5	24.0	53.8	58.9	112.7
	8.	NP2K+Ca-s + ,,	110.6	25.0	28.5	58.6	82.7	143.5
II. BOMBU-WELA humic (Clayey)	1.	N only	86.2	23.5	22.0	36.3	29.1	65.4
	2.	NP only	80.8	32.0	31.0	38.5	36.1	74.6
	3.	NPK	96.4	39.5	34.5	76.7	71.8	148.5
	4.	NP2K	99.5	40.5	40.0	90.5	81.5	172.0
	5.	NPK+Mn-s	101.4	41.0	39.5	83.4	86.8	170.2
	6.	NPK**	91.3	42.0	39.5	75.4	81.4	156.8
	7.	NPK**+Mn-s	92.7	41.0	38.5	82.9	82.6	165.5

Remarks : Standard fertilizers were added as follows : (g/pot)
N (ammonium sulphate)—1.5 g
P_2O_5 (conc. super phosphate)—1.0 g
K_2O (potassium chloride)—1.0 g
Slags—10 g

*Ca–s—Ca, Mg slag ; Mn–s—Mn slag (minor–element fertilizer).

**Mixture of conc. superphosphate and fused magnesium phosphate in equal amount was applied for P.

TABLE 3.—Element content in the straw of rice plants grown in Bombuwela humic soil

(MAHA 1967–68—MURUNGAKAYAN 302)

Treatments	*N* %	P_2O_5 %	K_2O %	*CaO* %	*MgO* %	Fe_2O_3 ppm	SiO_2 %
1. N only	1·02	0·17	0·28	0·84	0·31	1,610	2·27
2. NP only	1·78	0·34	0·20	1·16	0·18	1,290	2·55
3. NPK	1·09	0·17	0·57	0·78	0·38	1,040	2·08
4. NP2K	0·97	0·16	1·09	0·82	0·38	1,040	2·08
5. NPK+Mn slag	0·90	0·12	0·66	1·00	0·35	1,290	2·95
6. NP*K	0·96	0·22	0·48	0·71	0·38	1,040	1·99
7. NP*K+Mn slag	1·07	0·17	0·51	0·69	0·36	1,290	2·65

Figures are expresseed on air-dry weight basis.
*Refer to Table 2.

TABLE 4.—Effect of air-drying and liming the soil on the growth and yield of rice, and its degree of bronzing as cultured in the Bombuwela sandy soil

(POT EXPERIMENT, YALA 1968, H-8)

Treatments	*Effective tillers* %	*Longest panicle length (cm)*	*Yield (gm)* *Straw*	*Panicle*	*Grain*	*Chaff*	*(per pot) Grain/straw ratio* %
A—Series (Wet group)—							
1. NPK ****	63	24·5	48·7	34·4	27·7	2·8	57
2. N2PK ****	63	25·5	47·5	34·1	27·7	3·6	58
3. NP2K **	68	26·6	49·1	35·9	29·7	3·1	61
4. NP2K + Slag*	71	24·4	50·7	34·1	27·9	2·7	55
5. Limed, NPK*	72	25·1	44·9	30·7	24·5	3·1	55
6. Limed, NP2K	67	25·8	44·6	34·4	28·1	3·5	64
7. Limed, NP2K + Slag*	66	24·9	48·8	33·5	27·0	3·5	55
B—Series (Dry group)—							
1. NPK***	71	25·2	73·1	42·4	33·3	5·2	46
2. N2PK*	78	25·6	74·9	43·1	33·7	4·8	51
3. NP2K**	77	24·6	75·1	43·9	33·7	6·0	45
4. NP2K + Slag	78	26·3	74·9	49·4	38·9	5·8	52
5. Limed, NPK	87	26·5	69·5	47·3	38·7	4·5	56
6. Limed, NP2K	81	26·6	65·5	47·4	38·4	5·0	59
7. Limed, NP2K + Slag	90	26·0	76·6	53·4	42·1	6·7	55

Remarks.—Soil was sampled from the farmer's field where bronzing occured every season. Degree of bronzing was recorded at maximum tiller number stage, 5 weeks after transplanting. Marks * to ****, indicate portion of the bronzed leaves to the total leaves in one plant.

TABLE 5.—pH of Bombuwela farmer's field soil after a crop

(POT EXPERIMENT, YALA 1968)

Treatment No.	*Wet series*	*Air-dry series*
1	4·88	5·02
2	5·15	5·18
3	5·10	5·32
4	5·20	5·42
5	6·10	6·15
6	6·10	6·13
7	6·20	6·20

TABLE 6.—Growth status of rice plants at milk–ripe stage under varying the treatments for bronzing remedy

BOMBUWELA SANDY SOIL, YALA 1968, H–8

Series		*Treatments*	*Bronzing symptoms*	*Other diseases***			*Plant height (cm)*	*Tiller** number*
				Hl	*Bl*	*Sh*		
Wet	1.	NPK	Severe	+	+ +	+ +	143	35
	2.	NP2K	severe	+	+ +	+ +	151	35
	3.	NPK + slag	weak	+	+	+	143	38
	4.	NP2K + slag	moderate	+	+	+	141	38
	5.	Limed, NPK	—	+	+	+	157	32
	6.	Limed, NP2K	—	+	—	+	144	42
	7.	Limed, NPK + slag	—	+	—	+	143	44
	8.	Limed, NP2K + slag	—	+	—	+	154	43
	1.	NPK	weak	+ + +	+	+ + +	121	30
	2.	NP2K	—	+ +	—	+	134	34
	3.	NPK + slag	moderate	+ +	+	+	139	44
Air-dry	4.	NP2K + slag —	—	+ +	—	—	137	34
	5.	Limed, NPK	—	+ +	+	+	137	41
	6.	Limed, NP2K	—	+	+	+	140	34
	7.	Limed, NPK + slag	—	+	—	—	145	30
	8.	Limed, NP2K + slag	—	+ + +	—	+ +	152	38

Remarks : * Per 5 hills.

** Hl—Helminthosporium spot : Bl—leaf blast :

Sh—sheath blight. + + + many ; + + some ; + few.

TABLE 7.—Grain yields obtained with various treatments for bronzing remedy in the field experiments at Bombuwela—Yala 1968, H-8

Series	*Treatments*	*Experiment Station*		*Farmer's field*	
		bu/ac	*Percent of control*	*bu/ac*	*Percent of control*
Wet	1. NPK	32·5	100	—	—
	2. NP2K	58·1	179	4·73	100
	3. NPK+slag	38·4	118	—	—
	4. NP2K+slag	58·5	180	53·0	112
	5. Limed, NPK	67·1	206	46·5	98
	6. Limed, NP2K	81·1	250	66·9	141
	7. Limed, NPK+slag	63·6	196	—	—
	8. Limed, NP2K+slag	81·6	251	69·3	147
Air-dry	1. NPK	43·9	100	—	—
	2. NP2K	51·8	118	47·2	100
	3. NPK+slag	47·9	109	—	—
	4. NP2K+slag	49·3	112	61·0	129
	5. Limed, NPK	64·7	147	45·3	99
	6. Limed, NP2K	54·7	125	56·1	116
	7. Limed, NPK+slag	58·7	134	—	—
	8. Limed, NP2K+slag	54·0	123	69·1	146

Remarks : Standard fertilizers and soil amendments were applied as follows : (lbs./acre)

Lime—8,000 for Experiment Station ; 10,000 for farmer's filed.

Ca, Mg slag—2,000

N (Urea)—60 (split applied, 20+30+10).

P_2O_5 (fused Mg phosphate)—80 (basal).

K_2O (potassium chloride)—80 (split applied, 60+20).

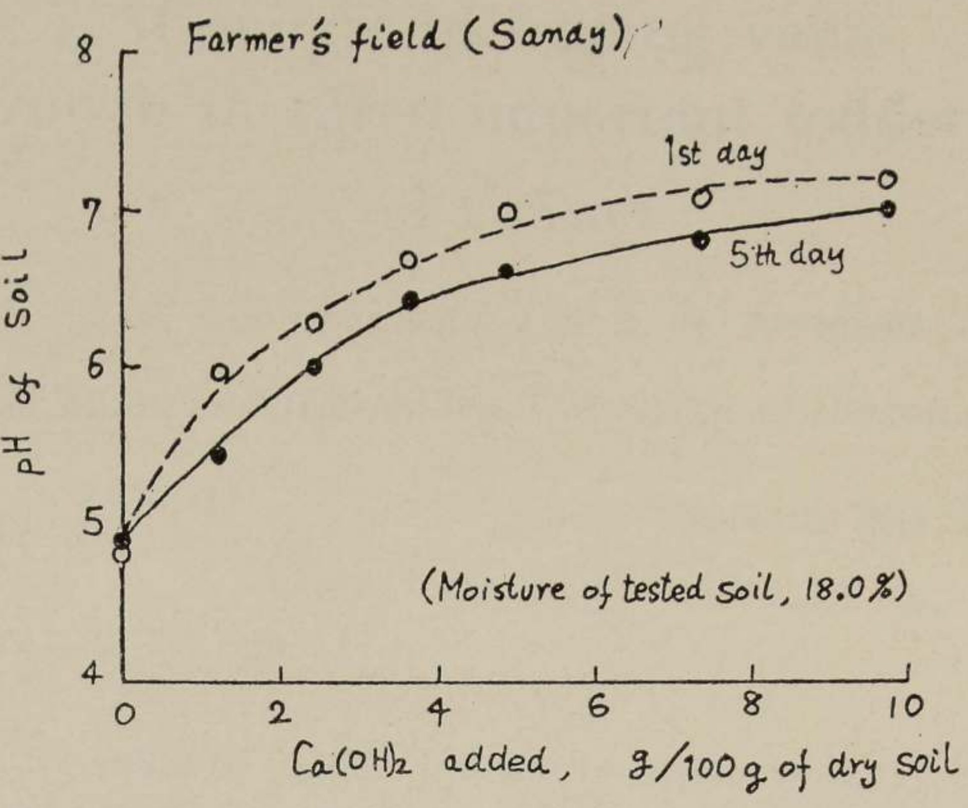

Fig. 1. $Ca(OH)_2$ added and increase in pH of soil taken from Bombuwela farmer's field.

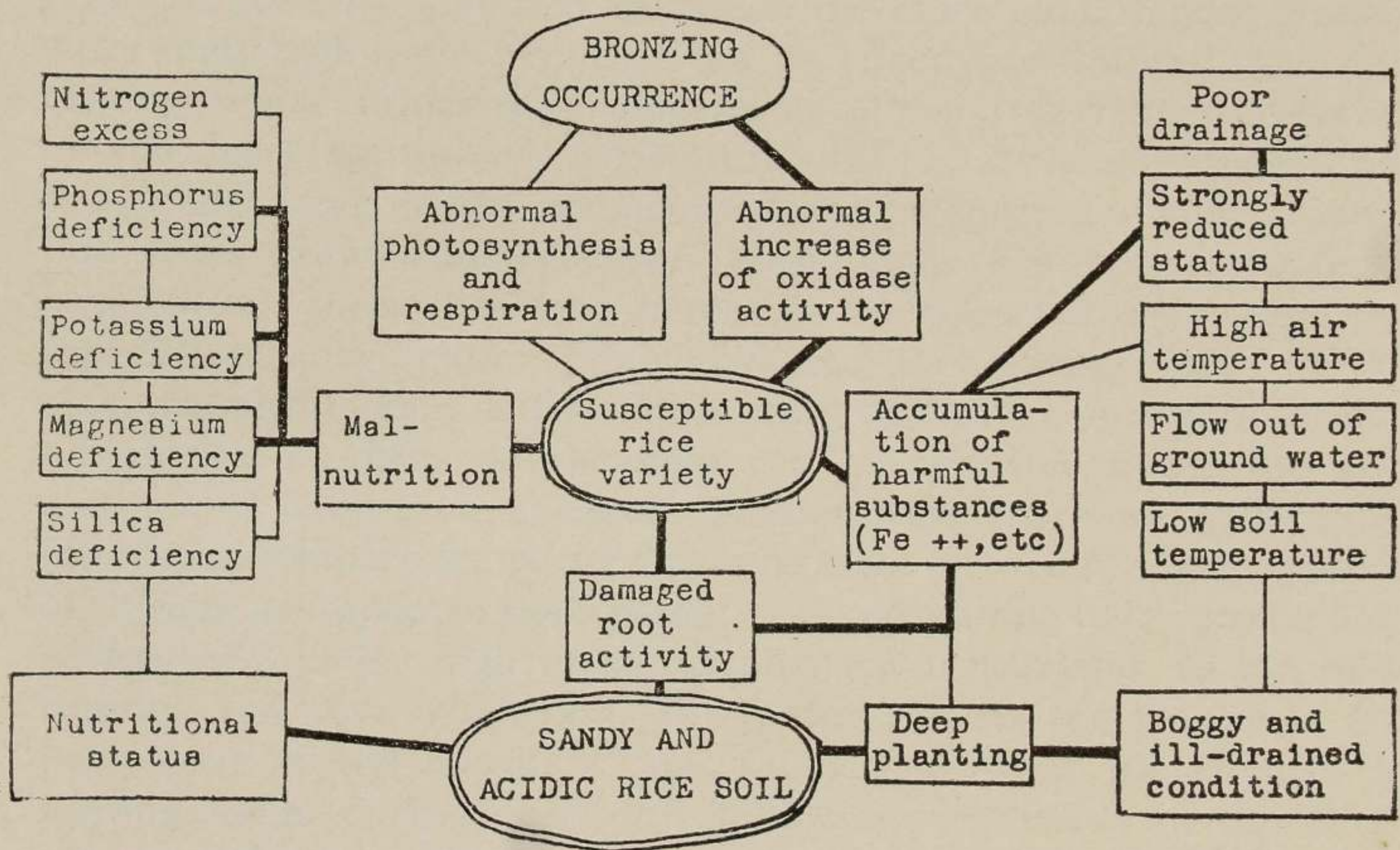

Fig. 2. Schematic diagram on the mechanism of occurrence of Bronzing disease.

Changes in feeding value with growth in three important fodder grasses of Ceylon

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INTRODUCTION

The potential value of fodder grasses for intensive dairy development on undulating and somewhat steep lands in the marginal plantation areas of the mid-country in the wet zone of Ceylon is under study at the present time. Indeed in such a situation planted pastures for grazing have only a limited value. On the other hand, fodder grasses with their high yield potential can be effectively utilized for zero grazing under intensive management. In the current context of Ceylon's progress towards agricultural diversification of marginal tea and rubber lands in the mid-country, the prospects for milk production from grass established on these lands has been repeatedly highlighted. It is therefore necessary to demonstrate clearly the capacity for dry matter production and the feeding value of the recommended fodders in the mid-country situation before an intensive programme of dairy development can be activated under the programme of Crop diversification. Studies were therefore undertaken in order to compare the performance of three important fodder grasses of Ceylon, in respect of their potential for sustaining dairy production, particularly under high levels of nitrogen fertilization in the mid-country wet zone of Ceylon. This paper reports the results of the first phase of the investigations designed to study the changes in feeding value during re-growth following defoliation of the three species of fodders. The experiment was conducted at the Department of Animal Husbandry, University of Ceylon, Peradeniya.

MATERIALS AND METHODS

Three important fodder grasses for the mid-country, namely Pusa giant Napier, Setaria and Guinea were included in the study.

Pusa giant Napier is a hybrid derived from a cross between ordinary Napier (*Pennisetum purpureum.* Schumac) and the millet (*Pennisetum typhoideum,* Riche). The Setarias are popular grasses of Africa, and selections of high digestibility obtained from them have been introduced into Ceylon. The variety used in the trial was *Setaria sphacelata.* Schumac. Stapf and Hubbard (Variety Nandi.) Guinea B is a popular ecotype of *Panicum maximum.* Jacq. well established in this country.

The fodder grasses were established in the field about two months prior to the actual commencement of the trial. The lay out was a split plot design with four replications. Each sampling sub-plot measured 10 ft. × 5 ft. and the size of each main plot was 20 ft. × 15 ft. Plants were regularly spaced in each plot at a distance of 2′ × 2′ Prior to the commencement of the trial all plots were cut uniformly to a height of 6″ above ground level. In addition, all plots were fertilized uniformly with a basal application of 100 lb. and 50 lb. P_2O_5 and a uniformly high nitrogen application at the rate of 300 lb. N per acre per year. Since the intention was to compare the response of the three fodder grasses to this high nitrogen application during a single period of re-growth following defoliation, the amount of N applied was calculated appropriately for the experimental period. The experiment commenced on March 14, 1971.

SAMPLING PROCEDURE

Since the main purpose was to study the changes in feeding value during uninterrupted growth within a cutting cycle of two months, it was decided to sample every 10 days, each time removing cumulative growth from the time of sampling plots. There were six such plots for each fodder grass and the total period of sampling was 60 days. At each sampling, the herbage was cut to 6″ from ground level as at the commencement, and the entire sample of herbage was then dried in a Unitherm drying oven at 100°C for six hours. A representative sub-sample was used for the determination of crude protein. Two grams of this sample were digested and distilled. The distillate was collected into 0.1 N sulphuric acid and titrated against 0.1N sodium hydroxide using bromo cresol green indicator. The crude protein was estimated by multiplying the Nitrogen content by 6.25. This figure was used as an index of feeding value of the herbage dry matter. Tiller counts were made at the end of 30 days and again at the end of the experimental period.

RESULTS

Mean crude protein contents of the herbage dry matter in respect of the three grasses at each sampling date are shown in table 1. The mean total protein yields in Kg per plot are shown in table II. Pusa giant Napier significantly out yielded the other two grasses in total protein yields. (P 0.01). Pusa giant was also superior to Setaria in respect of crude protein, at the final sampling at 60 days (P 0.05) but was just short of the significance level in respect of Guinea B. At the end of the experimental period, the decline in protein content was particularly marked in the case of Setaria, which proved to be the poorest in terms of quality.

Mean yields of herbage dry matter at each sampling date, (mean cumulative growth) for the two months of growth are shown in table III. Pusa giant Napier significantly out yielded Guinea B at 50 days but was not significantly superior to Setaria, although the yields appeared to be higher. This trend was maintained till the end of the experimental period. The percentage difference in mean total yield towards the end of the experimental period was 10.9% between Pusa giant, the highest yielder, and Guinea B, the poorest yielder. The initial growth and yield of Pusa giant Napier was not as rapid as that of Setaria. During this time, Setaria also showed a distinctly higher tiller number than either Pusa giant Napier or Guinea B.

Setaria retained this superior stooling habit at the final sampling at the end of 60 days. The yield of Guinea B was the lowest of the three species.

The changes in feeding value with growth in the three fodder grasses is shown in figure 1.

TABLE I.—Mean crude protein percentage in herbage dry matter

Date of Sampling	24/3	5/4	15/4	25/4	5/5	15/5
Days of growth	10	20	30	40	50	60
Pusa giant Napier	21·52	22·06	16·58	12·58	13·03	12·20
Setaria	10·58	16·75	14·14	11·43	11·11	9·03
Guinea B	16·35	20·03	14·77	10·45	10·28	9·72

Coefficient of variation (sub. plot) = 12·66%

L. S. D. at 5% to compare two varieties for the same date of cutting = 2·61

L. S. D. at 1% to compare two varieties for the same date of cutting = 3·57

TABLE II.—Total Protein Content in Kg.

Date of Sampling	24/3	5/4	15/4	25/4	5/5	15/5
Days of growth	10	20	30	40	50	60
Pusa giant Napier	4·23	20·78	54·44	76·38	97·94	103·23
Setaria	6·24	20·72	47·12	62·15	79·67	72·98
Guinea B	3·04	16·95	34·33	45·41	64·15	73·90

Coefficient of variation (sub. plot) = 27·30%

L. S. D. at 5% to compare two varieties for the same date of cutting = 19·46 kg. per plot.

L. S. D. at 1% to compare two varieties for the same date of cutting = 26·60 kg. per plot.

TABLE III.—Mean herbage dry matter yields in grams—(Cumulative growth)

Date of Sampling	24/3	5/4	15/4	25/4	5/5	15/5
Days of growth	10	20	30	40	50	60
Pusa giant Napier	197	941	3,232	6,152	7,503	8,480
Setaria	580	1,255	3,326	5,477	7,076	7,893
Guinea B.	188	849	2,322	4,383	6,277	7,643

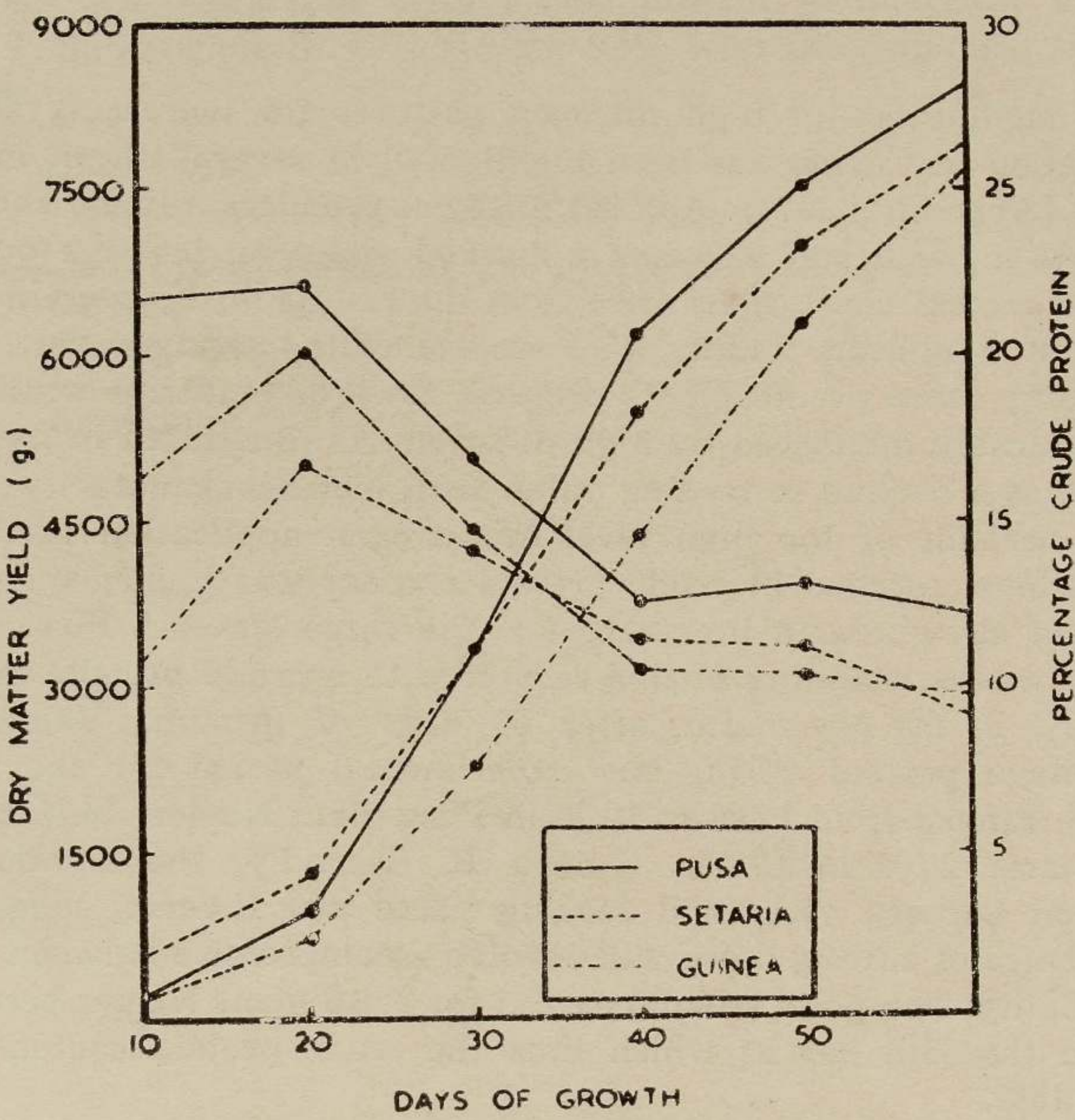
Coefficient of vatiation (sub. plot) = 17·59%

L. S. D. at 5% to compare two varieties for the same date of cutting = 1087·34 grams per plot.

L. S. D. at 1% to compare two varieties for the same date of cutting = 1496·24 grams per plot.

TABLE IV.—Mean number of productive tillers at 30 days and 60 days of growth

	30 days	*60 days*
Pusa giant Napier	45	35
Setaria	111	93
Guinea B.	85	76


9000
7500
6000
4500
3000
1500
DRY MATTER YIELD (g.)
30
25
20
15
10
5
PERCENTAGE CRUDE PROTEIN
PUSA
SETARIA
GUINEA
10
20
30
40
50
DAYS OF GROWTH

There was an inverse relationship between herbage yield and its feeding value in all three fodder grasses. In all cases the protein content showed an initial increase and then a rapid decline with growth. This may be attributed partly to the time lag between the application of the fertilizer and its uptake by the plants.

DISCUSSION

The significance of high nitrogen pastures for increasing animal production in Ceylon has been highlighted in several recent experiments (Appadurai 1970). Applied nitrogen produces a linear increase in herbage yield and also has a marked effect on herbage quality. Two important conclusions arise from the results of the present trial. The first significant finding is in respect of the changes that occur in feeding value as the plants progress towards maturity which can be favourably influenced by high nitrogen. As illustrated in figure 1, there was a decline in feeding value with increasing maturity. Even so on account of the high level of nitrogen application used, the lowest level reached in crude protein content was higher than that reported elsewhere in literature for the three grasses. Pusa giant Naiper was outstanding in this respect with a crude protein content of 12.2% in the dry matter after 60 days of growth. Values for percentage protein during the experimental period for the three grasses ranged from 22.06 to 12.20 in Pusa giant Napier, 16.75 to 9.03 in Setaria, 20.03 to 9.72 in Guinea B. Secondly, the relationship between herbage yield and feeding value was inverse, suggesting that choice of cutting dates will involve a compromise between yield and quality. The point of intersection for Pusa giant Napier occurred around the 35th day at which time the crude protein content was about 15%.

This is not an unduly close frequency for cutting, but the evidence indicates that extending the cutting interval to 60 days would almost result in a doubling of the yield. The other two grasses showed similar, although less spectacular trends. Recent evidence indicates that grasses with ten percent crude protein in the dry matter could be expected to meet the nutritional requirements of tropical cows yielding one gallon of milk per day (Whyte, Moir and Cooper 1959). High nitrogen applications such as practised here can thus be expected to produce more milk from grass on account of its enhanced feeding value. Based on these findings the economic opportunities that would arise if the marginal tea and rubber lands in the mid-country are planted with fodder grasses such as Pusa giant Napier for milk production from grass cannot be overemphasised.

ACKNOWLEDGEMENTS

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A method for classification of paddy soils of Ceylon

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INTRODUCTION

Modern systems of soil survey based on soil profile characteristics that are of agronomic significance to highland crops cannot be directly applied to paddy soils which are maintained in a flooded condition and are hence different from highland soils. Therefore it is necessary to develop special systems of classification for paddy soils.

Though rice constitutes the staple diet of more than half the world's population systematic studies on paddy soils are of comparatively recent origin and are relatively scanty.

Much of the work reported on paddy soil classification comes from Japan. The first stage of paddy soil classification studies in Japan started in 1930 and the first recognised system was proposed in 1940 by Kamoshita. He considered only natural hydromorphic paddy soils and divided them into five categories namely : Bog soils, Half bog soils, Lowland wet soils, Grey lowland soils and Brown lowland soils (Kamoshita 1940).

In addition to natural hydromorphic soils, paddy soils formed under the influence of irrigation water were also included in the classification systems proposed during early post war years. Uchiyama (1949) in his classification system recognised four fundamental types of paddy soils, Blue reducing type, Grey bleached type, Grey brown intermediate type and Brown oxidic type. In another system of classification proposed by Kanno (1956), water was considered to be the most important genetic factor in the development of paddy soils.

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He classified paddy soils based on the observable morpholigical features such as gley formation, mottle formation and bleaching that result from differences in water regime in a soil.

Since 1960, many workers have proposed several systems of paddy soil classification. Yamasaki (1960) defined paddy soil formation as the process of formation of eluvial A horizon and illuvial B horizon from parent soil, and distinguished paddy soils formed under the influence of ground water from those formed by the effect of surface water. Kanno (1962), proposing a still more modern system classified paddy soils based on the differences in hydromorphism as expressed in gleying and mottling.

A system quite different from the pedogenetic systems discussed so far was proposed by Oyama (1962). In his morphogenetic system paddy soils were named by the most diagnostic horizon in the profile. Seven such horizons were recognised, and hence seven great soil groups. Although he divided these into families, omission of lower categories was a notable deficiency.

The Pedologits Association in Japan in 1963 accepted a classification system essentially based on Kanno's system. Further improvements to this system were effected by Matsui (1966) in his system of paddy soil classification which was based on the characteristics of the original soil, hydrologic conditions in soil and the resulting hydromorphic properties. He recognised paddy soils derived from high land soils, alluvial soils and from bog soils and subdivided them according to the water regime, the nature of organic matter, characteristics of the parent soil, surface soil texture and important agricultural characteristics.

In Ceylon, among the paddy soil survey studies reported could be mentioned the all island survey of the fertility characteristics of rice soils (Panabokke and Nagarajah 1964) and the survey of rice soils in Hewagam Korale and Hapitigam Korale (Thenabadu et at 1967, a. b.). However, there is little or no information on methods of classifying paddy soils in Ceylon. The present study is an attempt to developing a system, following the modern methods of paddy soil classification.

General principles underlying modern paddy soil surveys

Unlike in other soils, water plays the most dominant role in paddy soil formation and hence in modern paddy soil surveys water is considered the most important genetic factor (Kanno 1956).

Paddy soils are normally submerged and are subjected to cultivation under this condition. This brings about certain unique changes in physical and chemical properties of soil. The plough layer contains appreciable amounts of plants residues. These organic residuces undergo microbial decomposition accompanied by microbial utilization of dis solved oxygen in water. As a result of this the plough layer and the plough sole become reduced and anaerobic conditions set in. Iron and manganese compounds undergo reduction to ferrous and manganous forms. Gley spots appear in the plough layer and the plough sole. Reduced forms of iron and manganese compounds which are soluble move down to the B horizon where oxidised conditions prevail and these ions undergo oxidation to ferric and manganic forms which get precipitated in the B horizon and form reddish brown or yellowish brown mottles. Thus due to the reductive eluviation of ferrous and manganous compounds from the plough layer and oxidative illuviation of ferric and manganic compounds in the B horrizon, paddy soil profile develops its specific morphology. This typical process of paddy soil formation is best observed in the paddy soils developed under the influence of surface water. In hydromorphic or ground water soils the B horizon is water logged and therefore reduced. Consequently in these soils oxidative illuviation does not take place and the B horizon remains gleyed.

Differences in morphological characters such as soil colour, gley formation and mottle formation that reflect oxidation reduction conditions in soil, which in turn depend on soil drainage, constitute the main criteria in modern paddy soil classification systems.

Paddy soils are derived not only from mineral soils but also from organic hydromorphic soils by removal of excess water. Therefore systems of paddy soil classification should necessarily include organic paddy soils. For this purpose criteria used in natural soil classification are employed with necessary modifications (Thorp 1935) ; Buckman and Brady 1964 ; Kamoshita *et at* 1967).

PROPOSED SYSTEM OF PADDY SOIL CLASSIFICATION

I. *Great Soil Groups*

Diagnostic criteria in classifying them are mainly based on the differences in hydromorphism due to the influence of ground water or irrigation water in the case of mineral paddy soils and in organic soils, on the content and degree of decomposition of organic matter.

Eight Great Soil Groups have been identified. These can be re-grouped into three main groups depending on the natural soil prior to Asweddumisation.

(1) Paddy soils derived from alluvial lowland soils—

1. Ground water gley paddy soils.
2. Surface water gley-like paddy soils.
3. Stagnant water gley-like paddy soils.

(2) Paddy soils derived from terrestrial soils—

4. Ground water gley paddy soils.
5. Surface water gley-like paddy soils.
6. Stagnant water gley-like paddy soils.

(3) Paddy soils derived from bog soils—

7. Pest paddy soils.
8. Muck paddy soils.

II. *Great Soil Sub-Groups*

These are transitional soils between two Great Soil Groups.

1. Intermediate gley-like lowland paddy soils.
2. Intermediate gley-like terrestrial Paddy soils.
3. Muck peat paddy soils.

III. *Soil Family*

Characteristics of original soils or materials, which fundamentally control the elementary processes of paddy soil formation are the diagnostic features used in identifying soil families. (Criteria are varied with every group of Great Soil Groups).

1. Derived from alluvial soils (eg. Paddy soils derived from coarse grained alluvial sediments etc.).
2. Derived from terrestrial soils (e.g. Paddy soils derived from reddish brown earth etc.).
3. Derived from bog soils.

Note.—Soil Families are recognised only when obvious differences in soil parent material are observed.

IV. *Soil Series*

Soil Families are classified into Series mainly on the basis of differences in development of paddy soil profile or intensity of elementary processes of paddy soil formation, such as intensity of gleyzation, mottle formation and bleaching, degree of decomposition of peat and thickness of peat and muck layers. Criteria are varied with every Great Soil Group and Great Soil Sub-group.

(I) Paddy soils derived from alluvial lowland soils—

(1) Ground water gley paddy soils :

Soil Series
- 1*a*. Strongly gleyed.
- 1*b*. Gleyed.

(2) Surface water gley-like pady soils :

Soil Series
- 2*a*. Strongly mottled
- 2*b*. Mottled

In consideration with sub-soil colour.

(II) Paddy soils derived from terrestrial soils—

(4) Ground water gley paddy soils :

Soil Series
- 4*a*. Strongly gleyed.
- 4*b*. Gleyed.

(5) Surface water gley-like paddy soils :

Soil Series
- 5*a*. Strongly mottled %
- 5*b*. Mottled

In consid eration with sub-soil colour.

(III) Paddy soils derived from bog soils—

(7) Peat paddy soils :

Soil Series
- 7*a*. Well decomposed
- 7*b*. Moderately decomposed
- 7*c*. Ill decomposed

In consideration with thickness of peat layer.

(8) Muck paddy soils :

Soil Series
- 8*a*. Thick.
- 8*b*. Medium.
- 8*c*. Thin.

(9) Intermediate gley-like lowland paddy soils :

Soil Series
- 9*a*. Strongly pseudogleyed.
- 9*b*. Pseudogleyed.

(10) Intermediate gley-like terrestrial paddy soils :

Soil Series
- 10*a*. Strongly pseudogleyed.
- 10*b*. Pseudogleyed.

(11) Mucky peat Paddy soils :

Soil Series
- 11*a*. Thick.
- 11*b*. Medium.
- 11*c*. Thin.

Note.—(1) When identifications of mottles is difficult in the surface water type they are temporaily accommodated in the mottled series and sub-soil colour is taken as an indication of the degree of development of paddy soil profile.

(2) Thickness of organic layer from surface ; more than 50 cm. Thick 20-50 cm. Medium ; less than 20 cm. Thin.

V. Soil Types

Soil types are classified on the basis of the texture of the surface horizon. e.g. Coarse textured, Medium textured, Fine textured.

Note.—Coarse textured : Sandy loam, Loamy sand, Medium textured : Sandy clay, Sandy clay loam, Clay loam, Silty clay loam, Silt loam, Fine textured : Heavy clay, Light clay, Silty clay.

VI. Soil Phase

Subdivided or grouped, on the basis of differences in agricultural characteristics, such as agronomic and ameliorative, without itself being a category of the system of classification.

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Varietal differences in response to nitrogen fertilizer in rice

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INTRODUCTION

Plants differ in yield and yield potentials depending on varieties and strains. These differences can be attributed to differences in physiological traits, among which mineral nutrition, viz. ion aborbtion, translocation and utilization plays an important role. Because absorption of nutrients is mostly through the roots, differences in root characteristics also account for differences in nutrient absorption.

Of the soil-derived nutrient elements plants in general require nitrogen in the greatest amount, and varietal differences in nitrogen nutrition of plants have been reported by several investigators (3, 4, 5, 6, 7, 8, 9). In rice many nutritional variants are known and this in part accounts for its wide range of edaphic adaptations. In general, japonica varieties of rice respond more to nitrogen than indica varieties (2, 10, 15, 16).

Yamada (15, 16) reported differences in response to nitrogen between the indica varieties H-4 and Murungakayan 302. While H-4 responded well to increased nitrogen fertilization by increased grain production at all levels, Murungakayan 302 failed to respond at the higher levels of nitrogen. The increase in yield in H-4 was brought about mainly by an increase in the number of panicles and it was therefore classified as a panicle number type. Murungakayan 302, on the other hand behaved like a panicle weight type showing increase in grain number per panicle.

MATERIALS AND METHODS

This paper reports the findings of a field experiment conducted at Gannoruwa, Peradeniya during the season Maha 1959/60 to study differences in response to nitrogen of three varieties of rice, which was presented elsewhere (14).

The characteristics of the soil on which this investigation was conducted were as follows : —

Texture	sandy clay loam
pH	5.2
Cation exchange capacity	15.0 m.e. per 100g.
Organic matter	2.0 per cent.
Total nitrogen	0.15 per cent.
Available phosphorus	32.0 lbs $P_2 0_5$ per acre
Exchangeable potassium	0.10 m.e. per 100g.

The treatments consisted of three levels of nitrogen at the rates of 0,30 and 60 lbs. of element per acre supplied as ammonium sulphate. A third of the nitrogen was supplied at planting and the remainder at the time of primordia initiation. Phosphorus and potassium were applied at 100 lbs. $P_2O_5$and 50 lbs. K_2O per acre as concentrated superphosphate and muriate of potash respectively. The varieties of rice used were H-4, Murungakayan 302 and Murungan Samba 3081. Twenty-six day old seedlings were transplanted in plots of size 10 $\times$ 19.5 ft., which were separated from one another by 1 foot wide ridges. The seedlings were transplanted in rows at a spacing of 12 inches between rows and 6 inches within rows with three seedlings per hill. Growth records were maintained beginning two weeks from transplanting. Sixteen plants from each treatment were used for recording the number of tillers per plant and the height per plant.

Nitrogen in plant tissue was determined by the Kjeldhal method on a semi-micro scale. The total content of nitrogen in the tissues was estimated from the concentration of nitrogen and the dry weight in each case.

RESULTS AND DISCUSSION

The response to fertilizer is usually assessed in terms of increase in yield of harvested produce, as for instance an increase in grain yield in the case of rice. This may not however take into account a response in vegetative growth manifested by the plant with added fertilizer. If the addition of nitrogenous fertilizer brings about an increase in any growth attribute, as for instance the total dry weight then it would be reasonable to conclude that in this respect there has been a response to added fertilizer. If however, this response is not accompanied by an increase in grain yield it would be necessary to explain factors which contribute to vegetative growth but not to grain yields. For this purpose, the response to fertilizer nitrogen is analyzed in terms of growth of both vegetative and reproductive organs.

VEGETATIVE GROWTH

Tillering

Varietal differences in response to nitrogen fertilization were seen in respect of tiller production (Table I). Responses to increased nitrogen fertilization were seen initially (40 days) and up to maturity (124 days) with all varieties. H-4 consistently had more tillers per plant for any treatment than Murungakayan 302. Thus at maturity H-4 had approximately 30 per cent more tillers per plant at the no nitrogen level and approximately 10 per cent more at the 60 lbs. level of nitrogen than Murungakayan 302. Murungan Samba 3081 also showed a response to nitrogen fertilization which was closer to H-4 than that shown by Murungakayan 302 at 40 days, but at maturity the number of productive tillers were reduced considerably in plants receiving nitrogen at the rate of 60 lbs. per acre.

At maturity the increase in tiller number between 30 and 60 lbs. nitrogen per acre was 63 per cent for H-4 and 72 per cent for Murungakayan 302 (Table I). In Murungan Samba 3081 there was a reduction of approximately 9 per cent in the number of tillers between 30 and 60 lbs. nitrogen per acre. It should however be noted that although both varieties H-4 and Murungakayan 302 showed increased tillering due to increased nitrogen fertilization, the number of panicles per hill was increased only in the former variety (with the consequent increase in grain yield), while in the latter there was a reduction in both the number of panicles per hill and in grain yield (Table 3). In Murungan Samba 3081 also there was an increase in panicle number per hill and in grain yield with increased nitrogen fertilization, although the number of tillers per hill decreased at maturity at the higher level of nitrogen in comparison to that at the lower level.

Plant Height

The variety H-4 was generally the shortest and Murungan Samba 3081 the tallest at any level of nitrogen fertilization (Table 2). The variety Murungakayan 302 was intermediate in plant height. At high levels of nitrogen fertilization short varieties of rice perform better because they are less prone to lodging than tall varieties. Lodging of a crop generally results in yield reduction.

Under the conditions of this experiment the greatest response in plant height to added nitrogen was in H-4 between 0 and 30 lbs. N per acre. The next increment of nitrogen had much less effect on plant height in this variety although there were relatively larger increases in plant height between 30 and 60 lbs. nitrogen per acre in the other two varieties.

Weight of Straw

The dry weight of straw increased with increasing levels of nitrogen fertilization in H-4 and Murungan Samba 3081, but in Murungakaya 302 there was a reduction in weight at 60 lbs. nitrogen per acre (table 3).

YIELD AND YIELD COMPONENTS

Number of Panicles Per hills

There were differences among the three varieties of rice in the effects of nitrogen fertilization on the number of panicles per hill (Table 3). With increasing levels of nitrogen there was a steady increase in the number of panicles per hill in H-4, whereas in Murunkayan 302 there was a reduction in the number of panicles (Table 3). The behaviour of Murugan Samba 3081 was intermediate. Here too, like with H-4, there was an increase in the number of panicles per hill at 60 lbs. nitrogen per acre, but this increase was not as high as with H-4. The behaviour of H-4 and Murungakayan 302 to increasing levels of nitrogen fertilization was similar to the observations of Yamada (15, 16).

Weight per Panicle

In all three varieties the weight per panicle increased as the level of nitrogen increased from 0 to 30 lbs. per acre, and decreased at the higher level of fertilization (Table 3).

Grain Yields

In H-4 and Murungan Samba 3081 grain yields showed steady increase with increased application of fertilizer nitrogen from 0 to 60 lbs. per acre but Murungakayan 302 showed an increase from 0 to 30 lbs. nitrogen per acre and a reduction in grain yield at 60 lbs. nitrogen per acre (Table 3).

Excess nitrogen, in some varieties can lead to exhaustion of carbohydrates as a result of excessive vegetative growth and this may eventually result in high sterility in the panicles. In Murungakayan

302 there was imperfect grain filling and high sterility. However, the decrease in grain yield was also accompanied by a decrease in weight of straw.

The response in grain yield to the addition of nitrogen in H-4 and Murungakayan 302 confirm the findings of Yamada (15, 16). As stated by Yamada (15, 16) this investigation confirms that Murungakayan 302 is best suited for soils of relatively low fertility in contrast to the variety H-4 which has the potentiality for high yields on fertile soils or at high rates of fertilizer application. The other yield components such as spikelets per panicle, percentage ripened grain, and 1,000 grain weight have not been considered in this experiment.

NITROGEN IN PLANTS

The concentration and content of nitrogen in plant leaves of the three varieties at three stages of growth viz:—vigorous tillering; heading and harvest are presented in Table 4. The concentration of nitrogen in the leaves was generally highest at the stage of vigorous tillering and lowest at harvest in H-4 and Murungakayan 302 with intermediate values at heading indicating that these varieties are somewhat similar in their abilities to absorb this element. This may be attributed to their genetic relationship (Murungakayan 302 being a parent of H-4). In contrast the concentration of nitrogen in the leaves of Murungan Samba 3,081 was highest at heading (among the stages selected for tissues analysis in this investigation). Among these varieties Murungan Samba 3081 was further different in generally having the lowest concentration of leaf nitrogen at tillering and the highest at maturity at any level of fertilization.

The production of dry matter and the accumulation of storge products such as starch in plants is related to the balance between photosynthesis and respiration in which processes carbohydrates are produced and utilized respectively. Some investigators have studied the manner in which varieties respond to heavy fertilization.

In an investigation with three varieties of rice Takahashi, Iwata and Baba (12) found that a low response variety absorbed more nitrogen and exhibited vigorous growth but accumulated less carbohydrates in leaf sheaths and culms during the early stages of growth as compared with a high-response variety.

According to Baba (1) the number of spikelets produced per hill generally increases with increasing nitrogen supply, but the percentage of ripened grains tends to decrease beyond a certain level of nitrogen supplied, this tendency being more pronounced in low response varieties than in high response varieties. Increased supplies of nitrogen caused greater decreases in starch contents in leaf sheaths plus culms in low response varieties, indicating a greater reduction in starch accumulation under heavy application of nitrogen. According to Baba this may be due to the fact that low response varieties, during the early stages of growth, absorb nitrogen and increase vegetatives tissue and leaf area at the cost of photosynthetic product with the result that only a small proportion of the synthesized carbohydrates are utilized as starch. Thus the contents of lignin and cellulose increase with increase of nitrogen supply in these low response varieties. Similar results were obtained by Osada and Murata (10,11) who in a series of experiments on the relationship between photosynthesis and adaptability of varieties for heavy fertilization found that low response vareties of rice were less efficient in accumulating starch than high response varieties.

From these results it appears that nitrogen nutrition is intimately connected with the carbohydrate status of the rice plant. Those varieties that maintain an adequate carbohydrate supply particularly at the critical stages of growth such as primordia initiation and heading are able to utilize nitrogen continuously. Varieties that fail to respond to high levels of nitrogenous fertilizer do so mainly because of the exhaustion of carbohydrates in the plants.

SUMMARY

Three varieties of rice, H-4, Murungakayan 302 and Murungan Samba 3,081 were each grown at 0,30 and 60 lb. nitrogen per acre. Grain yields of the varieties H4 and Murungan Samba 3081 increased with each increment of nitrogen but that of Murungakayan 302 increased only up to 30 lb. nitrogen per acre and decreased at the higher level. The variety H4 showed an increase in panicle number with increasing levels of nitrogen whereas Murungakayan 302 showed a decrease at the higher level of fertilization. Straw weight increased with increasing nitrogen fertilization in H-4 and Murungan Samba 3,081 while in Murungakayan 302 there was a reduction in weight at the higher level.

ACKNOWLEDGEMENT

The authors are greatly indebted to Dr. L. H. Fernando, former Botanist, Department of Agriculture, for his guidance, encouragement, and valuable suggestions during this investigation. Acknowledgment is also due to Mr. H. M. S. Wijeratne of the Division of Botany, Department of Agriculture, for his valuable technical assistance during this investigation.

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Table 1.—Effect of Nitrogen Fertilization on Tillering

(Average number of tillers per plant)

Variety	*Level of Fertilizer (lbs. N. per acre)*	*Age of Plants (Days)*						
		40	*61*	*68*	*75*	*90*	*114*	*124*
H-4	0	4·1	5·4	5·4	5·8	5·5	5·5	7·0
	30	5·6	7·3	7·1	7·5	7·6	8·0	7·1
	60	7·5	9′2	9·4	9·3	11·5	11·8	11·6
Murungakayan 302	0	3·8	4·7	4·7	3·9	4·9	4·5	4·8
	30	4·0	5·1	5·1	5·1	5·4	5·6	6·1
	60	4·7	7·1	7·6	7·7	10·4	10·9	10·5
Murungan Samba 3081	0	3·6	5·3	5·6	5·8	5·5	6·3	4·5
	30	5·5	7·0	7·0	7·1	7·0	7·8	8·5
	60	6·5	9·6	9·6	8·9	9·5	10·4	7·8

TABLE 2.— Effect of Nitrogen Fertilization on Plant Height (ems.)

Variety	*Levels of Fertilizer (Lbs. N. per acre)*	*Age of Plants (Days)*					
		40	*61*	*68*	*75*	*90*	*114*
H-4	0	48·9	53·0	59·2	64·3	74·4	90·3
	30	49·9	59·8	63·8	69·9	93·0	108·8
	60	49·3	62·8	67·8	75·3	95·0	115·8
Murungakayan 302	0	55·0	63·1	68·7	73·2	92·2	106·6
	30	50·6	64·9	67·1	73·7	89·8	110·1
	60	54·2	68·6	75·3	82·3	105·4	130·2
Murungan Samba 308	0	50·3	60·3	62·8	71·1	88·5	108·9
	30	47·0	60·8	66·7	74·7	99·9	121·0
	60	51·0	67·2	70·4	77·8	103·0	135·4

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TABLE 3.—Effect of Nitrogen Fertilization on Yield and Yield Components of Varieties

Variety	Level of Fertilizer (lbs. N. per acre)	Grain yield per hill (gm.)	No. of panicles per hill	Weight per panicle (gm.)	Weight of straw per hill (gm.)	Grain : Straw ratio
H 4	0	15·42	5·8	2·66	28·62	0·54
	30	18·72	7·0	2·67	37·14	0·50
	60	24·90	9·6	2·59	47·83	0·52
M. 302	0	13·27	4·2	3·14	25·19	0·53
	30	21·52	5·8	3·17	38·13	0·56
	60	8·77	3·4	2·59	28·07	0·31
M. S. 3081	0	15·50	6·0	2·58	23·72	0·65
	30	17·52	5·6	3·14	33·94	0·52
	60	22·22	7·3	2·12	44·38	0·50

TABLE 4.—Effect of Nitrogen Fertilization on Concentration and Content of Nitrogen in Leaves at three stages of Growth (per hill of 3 plants)

		STAGES OF GROWTH					
		Vigorous Tillering		Heading		Harvest	
Variety	*Levels of Fertilizer (Lbs. N per acre)*	*Concentration of N (%)*	*Content of N (gm.)*	*Concentration of N (%)*	*Content of N (gm.)*	*Concentration of N (%)*	*Content of N (gm.)*
H-4	0	2·4	0·010	2·3	0·109	0·8	0·027
	30	3·0	0·019	2·1	0·139	0·8	0·025
	60	2·2	0·017	2·6	0·197	0·9	0·037
Murungakayan 302	0	3·3	0·012	2·1	0·016	0·6	0·011
	30	3·7	0·015	2·4	0·176	0·9	0·022
	60	3·4	0·017	2·6	0·182	0·9	0·033
Murungan Samba 3081	0	1·6	0·005	1·9	0·093	2·2	0·038
	30	2·5	0·012	2·8	0·177	1·1	0·025
	60	2·7	0·021	3·4	0·294	1·2	0·055

Performance of four varieties of guava, *(Psidium guajava, L.)* in the intermediate zone of Ceylon

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SUMMARY

Varieties Safaeda, Seedless, Wickramasekara and Allahabad were grown at Kundasale to study their performance under the soil and climatic conditions of the intermediate zone of Ceylon. This region receives an annual rainfall of approximately 55 inches.

Variety Safaeda was the highest yielding, both in total weight and in the number of friuts. The average fruit weight of this variety was also the highest.

The productive life span of guava under these experimental conditions was 8 years. Seedlings of the variety Allahabad died earlier than the other varieties.

INTRODUCTION

A large number of varieties of guava has been cultivated in this country for a long period. These are either hybrids that have evolved naturally or varieties introduced from abroad. However, the yield potential of these varieties and their performance under local conditions have not been investigtaed. The commercial exploitation of this crop for the fresh fruit market and for the processing industry has been as a result of its value as a rich source of vitamin C.

Guava, is seen to grow satisfactorily in the wind swept and semi-dry areas below the Beragala—Belihuloya road, Walapane area and the Monaragala district. In the utilization of these poor soils for cropping, guava could be used profitably. Recent developments in Ceylon and abroad show that markets for guava jelly, jam and juice are very extensive.

This trial was conducted in the Horticultural Research Section of the Government Farm, Kundasale. Kundasale is situated in the Intermediate zone of Ceylon and receives an annual rainfall of approximately 55 inches.

The soil in the land used for this trial was an immature brown loamy soil (Panabokke—1967), with a depth of not more than 2½ ft. Below this layer of soil is the immature, partly weathered crumbly parent material. This soil is typical of the poor soil on which guava grows in the wild state.

MATERIALS AND METHODS

Four varieties of guava were tested in this trial. These varieties were Safaeda, Seedless, Wickramasekera and Allahabad.

This trial was laid down in October, 1956, using the randomized block design with 6 replicates. Each block had 4 single tree plots which were planted with a single variety. Plants were spaced 20 feet×20 ft. making the block size 80 feet×20 feet. Planting holes were prepared by cutting pits 18 inches×18 inches×18 inches, and they were filled with a mixture of top soil and compost well in advance of planting. The plants were carefully tended and manured with 1:2:1: NPK fertilizer mixture, in January 1957, at the rate of 3 lbs. per plant. The same quantity of fertilizers per plant having the same proportions of NPK was given in April, 1958. The entire experimental area was planted with *Stylosanthes gracilis*, H.B & K. to keep the weeds under control and to improve the organic matter and nitrogen status of the soil. After the *Stylosanthes* cover was established clean weeding was confined to the areas immediately around the bases of the plants an the remaining areas were selective weeded.

As the guava trees showed sings of yellowing during the *Yala* season of 1960, a supplementary application of cattle manure, at the rate of 30 lbs. per tree, was given in July that year. This application was followed by the regular annual application of the NPK mixture at the rate of 3 lbs. per tree.

Harvest data were collected continuously from *Yala* 1958, up to the end of *Maha* 1964-65. As 50% of the plants died due to severe dry weather in 1965 the experiment was abandoned at this stage. The yield data collected from this trial were the net yields of harvest after heavy bird damage and other losses were discounted.

RESULTS

In May, 1957, some of the plants were observed to be in flower. Up to the end of December, 1957, only 4 trees yielded fruits but these yields were not used in the analysis.

The yield data and average weight of fruits per variety are given in tables I and III. Table III also shows the total number of plants that died during the period the experiment was conducted.

Yield data from replicate III, were not used and this block was left out in the analysis (TableII), as it gave unusally low yields. The losses caused by animals were assumed to be normal and distributed at random and the data were analysed ignoring this loan in yield.

DISCUSSION

The data indicate that the variety Safaeda was superior to the other three varieties at the 1% level of significance (Tables I & II). The variety Allahabad was superior to the variety " Seedless " and the varitey Wickramasekara was the lowest yielder. The poor performance of Allahabad could be attributed to the death of 4 plants and probable genetic variability of seedlings used in the experiment.

The death of Allahabad trees (highest out of the 4 varieties) was unexpected. This is probably due to the sensitivity of this variety to shallow soils, of the type found in Kundasale.

The variety Wickremasekara had the highest number of surviving plants at the conclusion of the experiment. Yet it yielded the smallest number of fruits and consequently the lowest yield per plot. Seedless variety which yielded a lower fruit number than Wickramasekara produced fruits with the lowest fruit weight (Table II.) However, under the soil and climatic conditions that prevailed at the Horticultural Section of the Kundasale Farm the variety Wickramasekara fared very poorly.

Another very important fact that emerged from this trial is that the guava plant is shortlived under the soil and climatic conditions in which this experiment was conducted. The productive life span of guava under these conditions appears to be not more than 8 years. Under the system of management practised in this trial at Kundasale, steps have to be taken to replant guava every 10 years.

The income from guava was very unattractive when a pound of fruits fetched only 10 cents in 1957. The current price of 20 cents per pound (1970), gives a better margin of profit. With higher levels of management and better control of losses due to pests and other causes the varieties Safaeda and Allahabad could give much higher profits than at present.

It is concluded that the variety Safaeda grown in the shallow soils at Kundasale (in the intermediate zone of Ceylon) gave the highest yields in weight and number of fruits per acre (Table III). The varieties Seedless and Wickramasekara were poor in their perfomance and did not give economic returns under the conditions in which experiment was conducted.

ACKNOWLEDGEMENT

This experiment was designed under the guidance of the late Dr. D. V. Ariyanayagam, then Acting Horticultural Officer and Mr. P. Kanapathipillai, Statistician, formally of the Department of Agriculture. It was supervised by Dr. L. H. Fernando when he was Acting Horticultural Officer.

The assistance redered by the officers of the Horticultural Section of the Kundasale Farm during the period this trial was conducted and the officers of the Division of Horticulture, Central Agricultural Research Institute who helped in the processing of the data is deeply appreciated and acknowledged.

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TABLE I.—Total Yield of Fruits (in pounds) from Yala 1958 to Maha 1965

Variety	*Replicate I*	*Replicate II*	*Replicate IV*	*Replicate V*	*Replicat VI*	*Total*	*Average of five Replicates*
Safaedad ..	496·05..	639·27..	723·52..	542·13..	574·14..	2975·11..	595·02
Allahaba ..	362·01..	90·33..	326·38..	327·69..	549·57..	1,655·98..	3315·'20
Seedless ..	138·68..	89·51..	130·53..	105·42..	158·92..	623·06..	1243·61
Wickramasekara ..	102·36..	67·22..	60·65..	108·11..	91·49..	429·83..	85·97

L.S.D.=5% 132·88 lbs.
1% 187·84 lbs.

TABLE II.—Total number of Fruits Harvested per plot from Yala 1958 to Maha 1965

Variety	*Replicate I*	*Replicate II*	*Replicate IV*	*Replicate V*	*Replicate VI*	*Total*	*Mean*
Safaeda ..	2117 ..	2640 ..	2995 ..	2228 ..	2276 ..	12,256 ..	2451·2
Allahabad ..	1803 ..	423 ..	1746 ..	1500 ..	2316 ..	7,788 ..	1558·6
Seedless ..	1094 ..	639 ..	942 ..	797 ..	1193 ..	4,665 ..	933·0
Wickramasekara..	612 ..	480 ..	423 ..	764 ..	610 ..	2,889 ..	577·8

L.S.D. = 5% 581·2
1% 815·8

TABLE III.—Yield of Fruit Weight and Numbers of Fruits for 8 years, and Number of Plants that Died

Variety	*Total Wt. of fruits from 5 plots (lb.)*	*Total No. of fruits from 5 plots*	*Av. Wt. of fruits (ozs.)*	*Yielo per acre lb. for 8 yrs.*	*Average yield per year (lb.)*	*Total No. of plants that died*
Safaeda ..	2975·11..	12,256..	3·88 ..	64,798..	8,100..	3
Allahabad ..	1655·98..	7,788..	3·40 ..	36,068..	4,508..	4
Seedless ..	623·06..	4,665..	2·14 ..	13,571..	1,697..	3
Wickramasekara ..	429·23..	2,889..	2·38 ..	9,362..	1,170..	2

Chemical sprays for controlling soil erosion

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INTRODUCTION

Cover crops and mulching are two of the most effective and widely used methods for controlling soil erosion. But there are times and circumstances when a chemical spray which binds the soil aggregates would be helpful, either as a supplement to cover crops and mulching, or instead of them. For example, in tea land between pruning and the establishment of new growth, or in highland cultivation with annual crops, between seeding and the establishment of a vegetal cover, the soil is exposed to erosive forces, and the establishment of cover crops for a short period, or mulching may not be entirely feasible.

A sample of a proprietary product called "Curasol", (kindly supplied by Messrs. Hoechst (Ceylon) Company Ltd.), was tested in a preliminary experiment to assess its influence on splash erosion.

MATERIALS AND METHODS

Curasol is a white, viscous liquid which can be readily mixed with water for spraying at any desired concentration. In the test, Curasol was sprayed at the rate of 10 grams per square foot, which is equivalent to 900 lb./acre, while the spray dilution used was equivalent to 440 gallons spray fluid per acre. The test plots were 10′ ×10′ and in each plot were four "splash samplers" for measuring splash erosion. There were two sprayed plots and two unsprayed control plots. The splash sampler consisted of a wide mouthed plastic bottle with a metallic vane placed vertically in the bottle. The bottle was placed in a cavity made with a soil auger, so that the lip of the bottle was level with the soil surface, (Fig. 1).

During rain storms, the splash erosion which takes place causes some of the splash in the vicinity of each sampler to be thrown up against the vane, and falling rain washes the soil into the bottle. After each rainstorm the splash samplers were brought into the laboratory and the amount of soil collected in each bottle, was filtered, dried and weighed.

The experiment was commenced on February 15th 1971 and continue till the end of April. During this period the splash due to 12 rainstroms was measured. The soil splash due to some rains which occured between the 5th and 20th April could not be measured due to the disorganization of work due to unavoidable circumstances.

RESULTS AND DISCUSSION

In Table 1 are given the detailed results of soil splash for each of the 12 rainstorms, while in Table 2 is given a summary of the results for comparing the soil splash from the first six rainstorms and the last six rainstorms.

From Table 1 it will be seen that the variation of soil loss among the sub-samples from a plot is sufficiently small to consider the technique of assessment of soil splash, satisfactory for the purpose.

From Table 2 it is seen that for the first six rains (i.e. between February 25—March 29th) the soil splash in the treated plots is less than half that in the untreated plots, while for the last six rains the treated plots had about 3/4 the soil splash of the untreated plots and for the full period of 12 rainstorms, the treated plots had about 2/3 the splash erosion of the controls.

It is clear that Curasol reduces splash erosion considerably for several weeks after application.

It must be mentioned that this is only an assessment of splash erosion. Whether Curasol influences flow erosion in any way would be assessed in a subsequent investigation. It is claimed that Curasol does not reduce the infiltration properties of soil, because it is stated that, " Curasol is not so much like a plastic foil, as similar to a porous, three dimensional network, anchored to a certain depth into the soil ". If this is the case, then flow erosion would not increase in a Curasol treated soil surface, and may in fact be less than on bare untreated soil. Visually, the Curasol treated plots showed a distinct persistence of the soil aggregates on the surface, while in the control plots there was a marked " surface sealing " effect as a result of the breaking down of aggregates by splash erosion and subsequent rearrangement to form a less pervious condition.

CONCLUSION

The practical usefulness of Curasol and similar materials would of course depend on cost. Cost data is not yet available. But it should be mentioned that the Rubber Research Institute of Ceylon has kindly made available a sample of modified rubber latex for assessment of its usefulness as an erosion control spray. This is being done. If rubber latex proves to be beneficial in this respect, then the feasibility of uing erosion control sprays in Ceylon is materially increased, with a concomitant decrease in the soil erosion problem, which is one of Ceylon's biggest agricultural problems.

Fig.1 Sketch of Splash Sampler

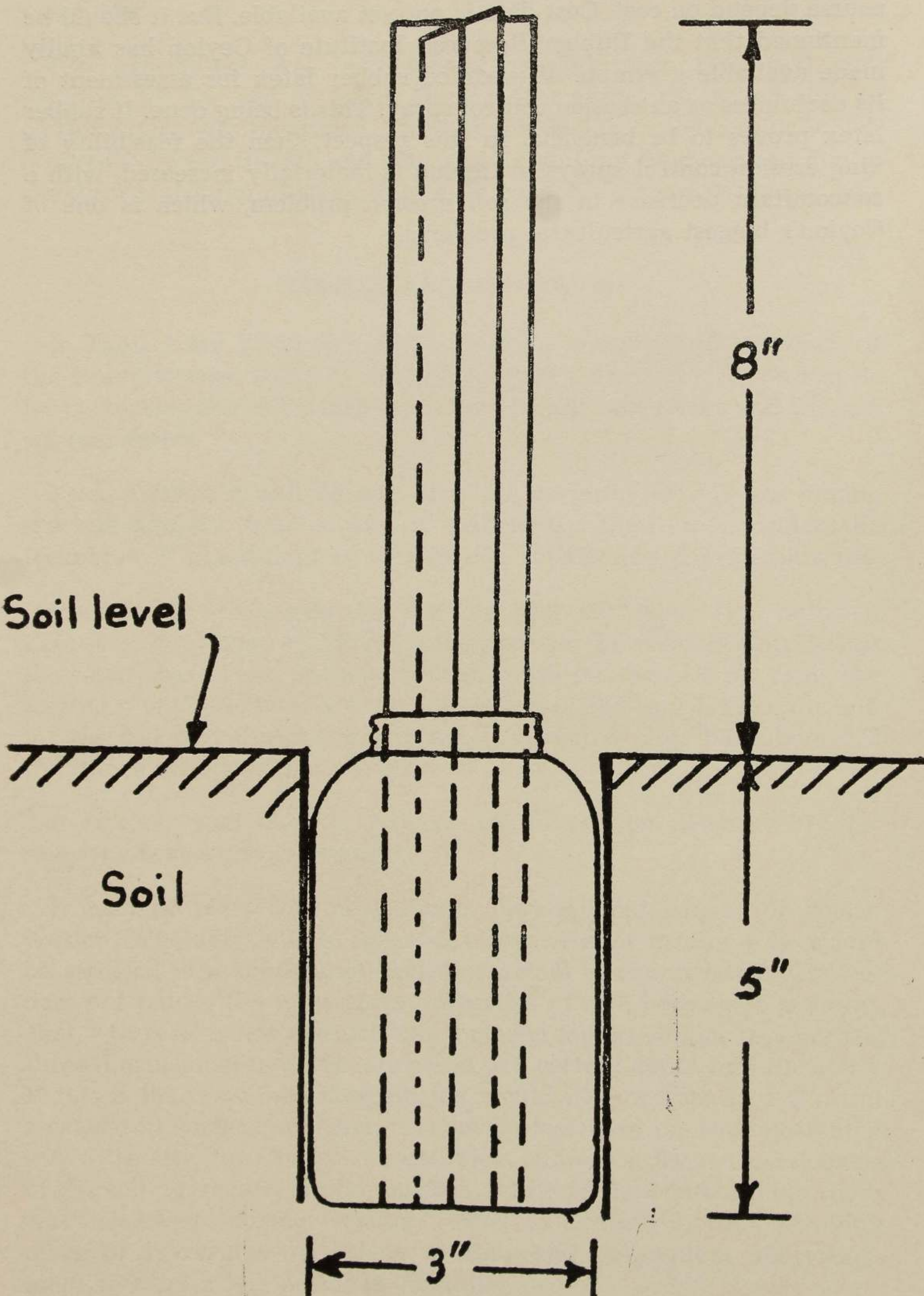

TABLE 2.—Average Soils Splash in Grams per Sampler

	From Six Rainstorms between Feb. 25 and March 29	*From Six Rainstorm between March 30 and April 25*	*From All 12 Rainstorms*
Curasol Treated Plots	19·0	24·0	43·1
Normal Untreated Plots	40·3	31·7	72·1
	59·3	55·7	

TABLE 1a.—Grams of Soil collected in Curasol Treated Plots

Date	*Feb. 25.*	*Feb. 26*	*Feb. 28*	*Mar. 4*	*Mar. 26*	*Mar. 29*	*Mar. 30*	*April 1*	*April 4*	*April 21*	*April 25*	*April 28*
Rainfall in Inches	1·21	0·40	0·6	0·58	1·38	1·62	1·21	0·70	2·30	0·58	0·91	1·75
Approximate Duration of Rain in Hours	1 hr.	½ hr.	1 hr.	1 hr.	½ hr.	1½ hrs	2 hrs.	1 hr.	2½hrs.	¾ hr.	1½ hrs.	2½hrs.
Plot 1	1·96	2·21	0·91	1·82	2·82	3·01	1·37	1·24	4·09	2·47	1·38	3·40
	2·54	1·07	1·02	0·49	3·92	3·45	1·67	2·00	4·05	1·24	1′46	1·46
	4·39	1·76	1·44	0·40	2·70	2·88	1·90	1·31	2·02	0·16	2·62	2·67
	1·76	1·71	1·35	0·31	2·61	1·50	0·87	0·94	3·20	0·29	3·57	1·29
Average	2·71	1·68	1·18	0·75	3·01	2·71	1·45	1·38	3·45	1·04	2·25	2·11
Plot B	1·86	3·48	0·52	0·25	1·51	1·66	0·93	0·93	4·05	2·00	2·61	1·02
	0·80	1·76	0·56	0·28	2·14	1·59	1·16	0·91	3·16	3·78	3·93	2·37
	1·01	1·74	0·55	0·10	1·64	1·48	1·24	0·91	5·59	1·97	1·87	2·00
	1·48	1·67	0·41	0·12	1·44	N.R.	N. R.	1·02	2·64	2·03	1·81	0·97
Average	1·28	2·16	0·51	0·18	1·68	1·18	1·07	0·94	3·86	2·44	2·55	1·54

N. R. = No Reading taken because sampler was toppled over

TABLE 1 (b).—Grams of Soil Collected in Normal Untreated Plots

Date	*Feb. 25*	*Feb. 26*	*Feb. 28*	*Mar. 4*	*Mar. 26*	*Mar. 29*	*Mar. 30*	*April 1*	*April 4*	*April 21*	*April 25*	*April 28*
Plot C	6·22	5·42	1·84	1·26	3·94	5·36	2·67	2·45	5·19	1·58	2·64	2·17
	6·24	3·99	2·34	2·14	4·59	7·32	1·25	0·87	4·95	2·53	3·57	1·61
	6·31	4·07	2·57	1·30	6·89	0·90	3·22	2·71	3·34	3·49	3·31	3·39
	7·10	4·50	1·34	1·39	5·94	2·81	0·55	0·95	2·56	2·92	1·84	1·18
Average	6·46	4·49	2·02	1·51	5·34	4·09	1·92	1·74	4·01	2·63	2·84	2·08
Plot D	5·82	3·81	2·50	1·45	4·16	1·99	1·23	0·98	5·39	1·76	3·19	4·57
	3·49	4·11	1·82	0·88	6·19	5·22	3·40	2·18	2·89	2·67	2·30	0·93
	4·87	3·19	1·60	1·24	5·95	2·23	1·03	1·82	5·95	3·64	4·86	1·66
	4·45	4·69	2·02	1·43	4·68	4·33	2·71	2·21	3·57	2·03	1·85	3·30
Average	4·65	3·95	1·98	1·25	5·24	3·44	2·09	1·79	4·45	2·52	3·05	2·61

Cell division and cell elongation in the developing leaves of *Zea Mays*

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Growth of leaves or any other organ of a plant is a result of cell elongation, cell division or both. Much work has been done to investigate the morphological aspects of leaf growth in graminaceous crops, but even today very little is known about the regions of cell elongation and cell division of growing leaves. Epidermis increases in area as a result of continued division and enlargement of epidermal cells which is a reflection of continuous changes in internal tissues of young plants. But how long and at which portion of leaf this division and enlargement takes place has not yet been fully investigated. The problem is more difficult in the graminaceous crops as the extreme base of leaf is the point of attachment of leaf sheath to the stem and not to the leaf blade. What is the basis of growth in leaf sheath and leaf blade ? Where is the region of elongation and division of cells, and how long are they active are important to understand the growth in its real sense ?

Ashby and Wangerann (1950) reported that enlargement of *Ipomea* leaves took place through cell division from 0.5 to 2.33 cm^2 and thereafter the growth of leaf was entirely due to cell enlargement. Jones (1956) also suggested that division took place only at a small portion of leaf and for a short time. But Brown (Milthorpe, 1956) did not agree to this and stressed that in his preliminary investigations on lupin leaves, division went on for a longer period. Wangermann taking part in discussion of Jone's paper also stressed that cell division does continue even after expansion commences. More recent workers however, indicated that the division continue for a longer period than suggested by previous workers and the expansion process goes on simultaneously for a considerable time (Sunderland, 1960 ; Milthorpe and Newton, 1963 ; Maksymowych, 1963). Morphological analysis of growth of individual maize leaves has already been published by the author (Jain, 1970).

MATERIAL AND METHODS

The investigations were conducted at the University of Louvain (Belgium) under two different sets of experiments :— (i) Preliminary investigations to locate the region of elongation and division of cells in leaf blade by horizontal markings (ii) By studying the transverse sections of leaf sheaths under microscope. In the first case plants germinated on 9th July, 1967, were measured for their growth of internodes and leaves in the green house for the age of 4, 5, 8, 11, 16, 19, 22, 30, 36, and 47 days after germination. The growth was measured by making horizontal marks by pencils having no chlorophyll solvent on the stem (leaf sheath) and leaf blades. The horizontal markings were made at definite intervals to obtain the definite growing region for further detailed studies. The details of the pots, type of soil and the green house environment have already been published (Jain, 1970).

The results of these preliminary investigations indicated that there was no meristematic activity in the leaf blade as well as the visible leaf sheaths. The leaf blade was increasing in its length mainly by pushing from down side with no visible changes in tissues of lamina. Study of the young leaf sheaths was therefore made to locate the region of elongation and division of cells by cutting transverse sections.

Transverse sections of leaf sheaths :

Transverse sections of different young leaf sheaths (9 days old, 4 visible leaves) were studied. The lamina was carefully removed and the portion of leaf encircling stem was separately taken out carefully. The details of the transverse sections studied are given as follows—

Leaf sheath No. based on leaf position	*Number of sections*	*Transverse section number and the specific portion of leaf sheath cut*
1	Two	1. Base lower half and 2. upper half
2	Two	3. base lower half and 4. upper half
3	Three	5. base 1 cm., 6. the middle and 7. the top
4	Four	8. base 1 cm., 9. base 1–2 cm., 10. between 2 and 4 cm. and 11. rest of the portion
5	Three	12. the base 1 cm., 13. base 1–2 cm. and 14. rest of the portion

The base indicates the part of the leaf sheaths near the point the sheath is attached to the stem, and the top the leaf sheath near the point the sheath attached to the lamina.

The stained sections (Hematoxyline and Fast green) were compared by taking the photographs at difinite point. The first vein let from the side of the main vein (left or right) was taken for comparison. As the photographs were not clear to indicate the precise details of the sections, comments were made simultaneously looking to the sections under microscope.

RESULTS

I.*Studies made by horizontal markings* :

The length of internodes was recorded from the position of leaf blade on the shoot as the stem is covered by sheath and was not pissible to locate without injuring the plants. Practically this was a measure of difference between the bases of two consecutive leaf blades.

The first three internodes come out at the age of 4, 5 and 9 days respectively whereas internodes 4th and 5th were visible only at the age of 16 and 30 days (table 1). The elongation took place only at the joint of sheath and leaf blade and only in the last two or three internodes as evidenced by horizontal makings. But it was interesting to note that there was no much diffeence between the visible sheaths elongating and sheaths inactive. The fault was then traced out. These marking observations gave an idea that the stem was elongating by the elongation of internodes at the junction of two. Gut actually the marks were made on the two different sheaths and the elongation was the result of some activity at its base (the sheath part attached to the stem).

TABLE 1.—Length of internodes at the various stages of crop growth in green house

Age in days after germination	*Internodes.................................length in mm.*										
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
4	12										
5	21	23									
6	28	27									
9	29	30	10								
10		32	19								
11		33	28								
12			32								
16			35	18							
19				50							
22				77							
30				89	35						
36				91	108	23	18				
43					122	89	50	57	20		
47						109	56	73	59	43	23

The growth of internodes was mainly caused through increase in length of last two internodes with very small or no activity in the older internodes. The growth continued till the formation of ligule at the joint of leaf sheath and blade.

II. *Transverse sections of leaf sheaths* :

Fourteen transverse sections were prepared from a young maize plant as indicated earlier. These sections were compared by taking the microscopic photographs. The meristematic activity was judged by the relative size of cells, and nucleus and the degree of differentiation was estimated by counting the number of sieve tubes and vessels. The comparison of various sections is indicated in table 2.

Figure 1 A, B & C indicates the changes in meristematic activity of leaf sheath 3 and figure 2 A, B, C and D that of leaf sheath 4. The meristematic activity in the same leaf sheath was maximum at its base and decreased gradually towards the joint of leaf sheath and leaf blade. Figure 1D is not taken from the veinlet, but it is the transverce section of the youngest tissue of the youngest leaf sheath 5th, section no. 12). The activity of nucleus and the chromosomes in this section is clearly visible which is a sign of active meristematic activity.

It is also evident in table 2 that the levels of section 9 and 13 were also active and these were just the further ends of the sections 8 and 12 respectively. There was no meristematic activity in leaf sheath 1 and 2 and very little only at the base in sheath 3. This suggests that the growing cycle of leaf 1 and 2 is already completed.

TABLE 2—Meristematic activity in different parts of leaf sheaths of young maize plant (9 days old, 4 visible leaves)

Section No.	*Portion of leaf sheath*	*No. of sieve-tubes*	*No. of vessels*	*Collenchymatous tissues*	*Relative size of Cell*	*Relative size of Nucleus*	*Degree of Meristematic activity*
1	Leaf 1, ½ base	5	4	—	Fully exp.	V. small	No more
2	Leaf 1, ½ top	3–4	3	—	do.	do.	do.
3	Leaf 2, ½ base	4–5	1	—	do.	do.	V. little
4	Leaf 2, ½ top	5–6	Young	Young	do.	do.	No more
5	Leaf 3, base 1 cm.	3–4	—	—	Comp. small	Small	Little
6	Leaf 3, middle	6	6	+	do.	V. small	V. little
7	Leaf 3, top	7–8	8	+	Expanded	do.	No more
8	Leaf 4, base 1 cm.	—	—	—	V. small	Biggest	Most active
9	Leaf 4, base 1–2 cm.	1	—	—	Small	Big	Active
10	Leaf 4, middle	1	—	—	Comp. small	Mediam	Less active
11	Leaf 4, top	3	—	+	do.	Small	V. little
12	Leaf 5, base 1 cm.	1	—	—	V. small	V. big	Most active
13	Leaf 5, middle	—	—	—	Comp. small	Big	Active merist.
14	Leaf 5, top	1–2	—	—	Small	Small	Little

exp. = Expanded.
Comp. = Comparatively.
V. = Very.
Marist. = Meristematic.

DISCUSSION

The study of transverse sections of leaf sheaths indicated that there was no meristematic activity in leaf sheaths 1 and 2 and very little in leaf sheath 3 on the 9th day after germination. Similar observations were recorded by the author (Jain, 1970) while measuring the length of leaf blades by horizontal markings. The growth of leaves 1, 2 and 3 was completed in 4, 5 and 9 days after germination respectively. Whereas, the growing cycle of leaves 4 and 5 started after 4 and 7 days (visible leaf blade) and continued till 12 and 17 days respectively. Thus, the active part of the leaf is the leaf sheath and particularly the portion very near to the attachment with stem. On the basis of these results the following hypothesis could be given regarding the regions of elongation and division of cells in maize leaves.

HYPOTHESIS

The primordia coming out of growing apex gives rise to some active cells. These cells multiply and elongate the region at the base of the sheath so that *first phase* may be the ' multiplication of dividing cells '. This was indicated by the higher meristematic region in the base of visible leaf sheath 4 than the youngest leaf 5. These cells at the top of the region elongates and become bigger cells ; simultaneous multiplication of cells still took place at the base, as the cells are highly meristematic. Thus the *second phase is* division and elongation phase. The young cells now continue to elongate pushing the old and mature cells. The cells forming leaf blades are relatively mature, as the activity of division and elongation took place near the junction of stem and leaf sheath. So the *third phase* is ' elongation dominating ' as the elongation is mainly responsible for the growth of leaves during this period. The *fourth and last* phase is probably the ' elongation ' as there was growth even when the cell were not in a stage of multiplication. Moreover the cells at the base too increases in size with time. This is a qualitative hypothesis based on the results in the present investigations. The quantitative data can be collected regarding the length and duration of different phases.

The morphological growth hypothesis given above resembles the four different phases of growth given by Dale (1964) based on the estimation of volume of cells (fresh wt./No. of cells) in *Phaseolus vulgaris*. His four stages are (1) Division commences, (2) Exponential phase of division commences (3) Emergence unfolding and (4) Division ceases. However the division phase appeared to continue longer than reported by Dale in the present investigations. Dale

(1964) mentioned that division ceases when the leaf covers 17 per cent of its total length. Little meristematic activity was observed in the present investigations even at the base of 3rd leaf sheath which has completed about 2/3rd of its total blade length. The leaf 4th sheath was under most active meristematic conditions at its base, which too has completed about a little less than half of its total blade length. Thus the division continued longer than reported by Dale for *Phaseolus vulgaris*. The value of Dale was also smaller than indicated by Milthorpe and Newton (1960) for lupin. The variation in the results may be because of the fact that the visible elongation region is not responsible for growth and the results may be different if the data are based on the study of a part of leaf blade. This may also be due to differences in growth habits of various species.

SUMMARY AND CONCLUSION

Investigations were carried out at the Institute of Agronomy, University of Louvain (Belgium) in the year 1967-68 to locate the region of elongation and division of cells in growing leaves of *Zea mays*. The results of green house experiments are summarised as follows :

(1) It was observed by horizontal markings that the leaf blade was pushed from its sheath and there was very little activity in the blade itself.

(2) In the study of transverse sections of leaf sheaths of young maize plants (9 days old), meristematic activity was maximum near the junction of stem and leaf sheath and was reducing towards more mature parts of leaf sheaths and blade.

(3) An hypothesis was given indicating the four different phases of leaf growth namely :—(1) Multiplication of dividing cells or elongation of multiplying region, (2) Division of cells with simultaneous elongation in the upper mature cells, (3) Elongation of cells with little activity of division in the basal cells and (4) Elongation of remaining active cells.

ACKNOWLEDGEMENT

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6—K 7996 (10/71)

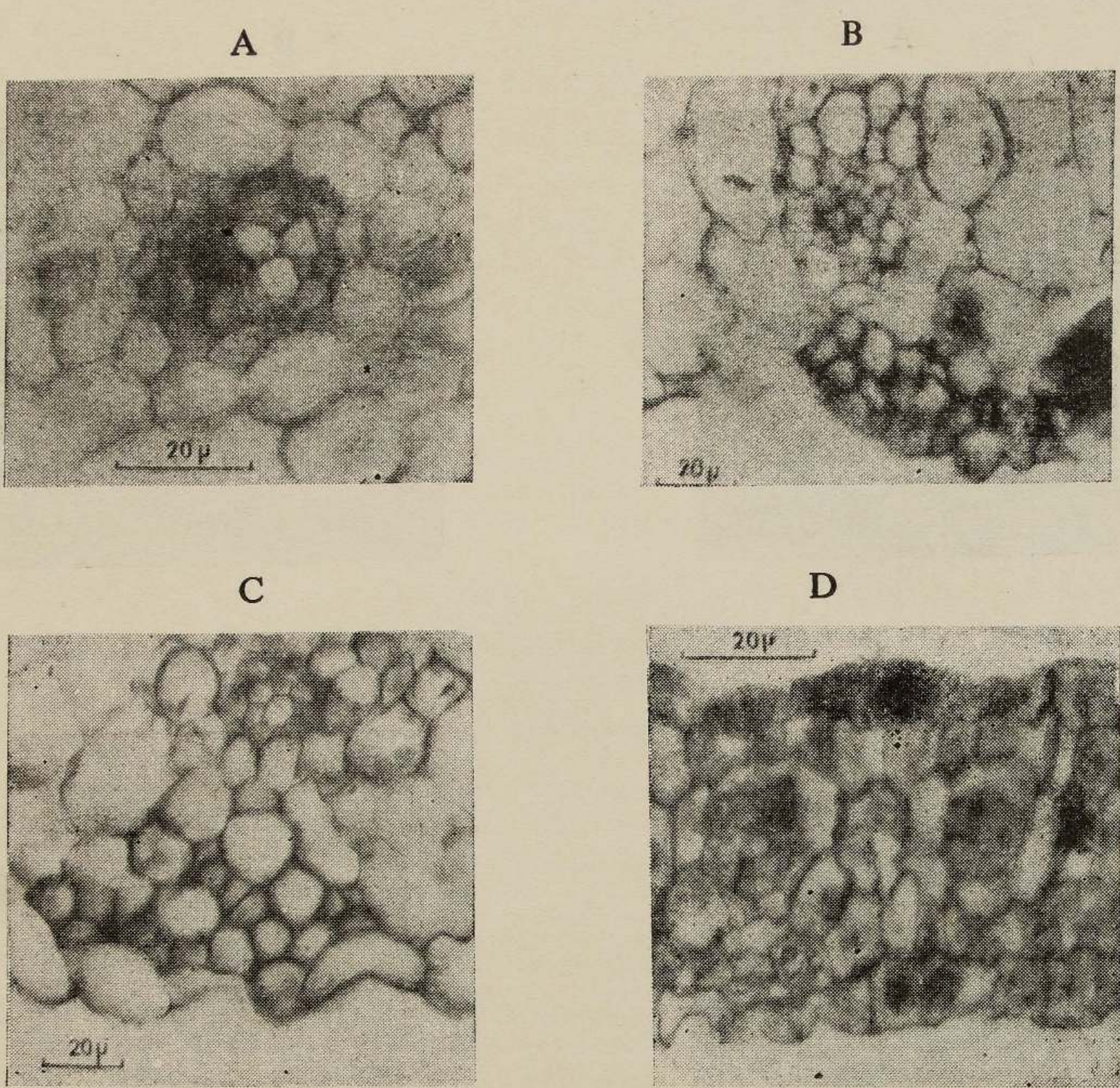

Plate 1. A, B, C, and D, are section no. 5, 6, 7, and 12 respectively in Table 4.

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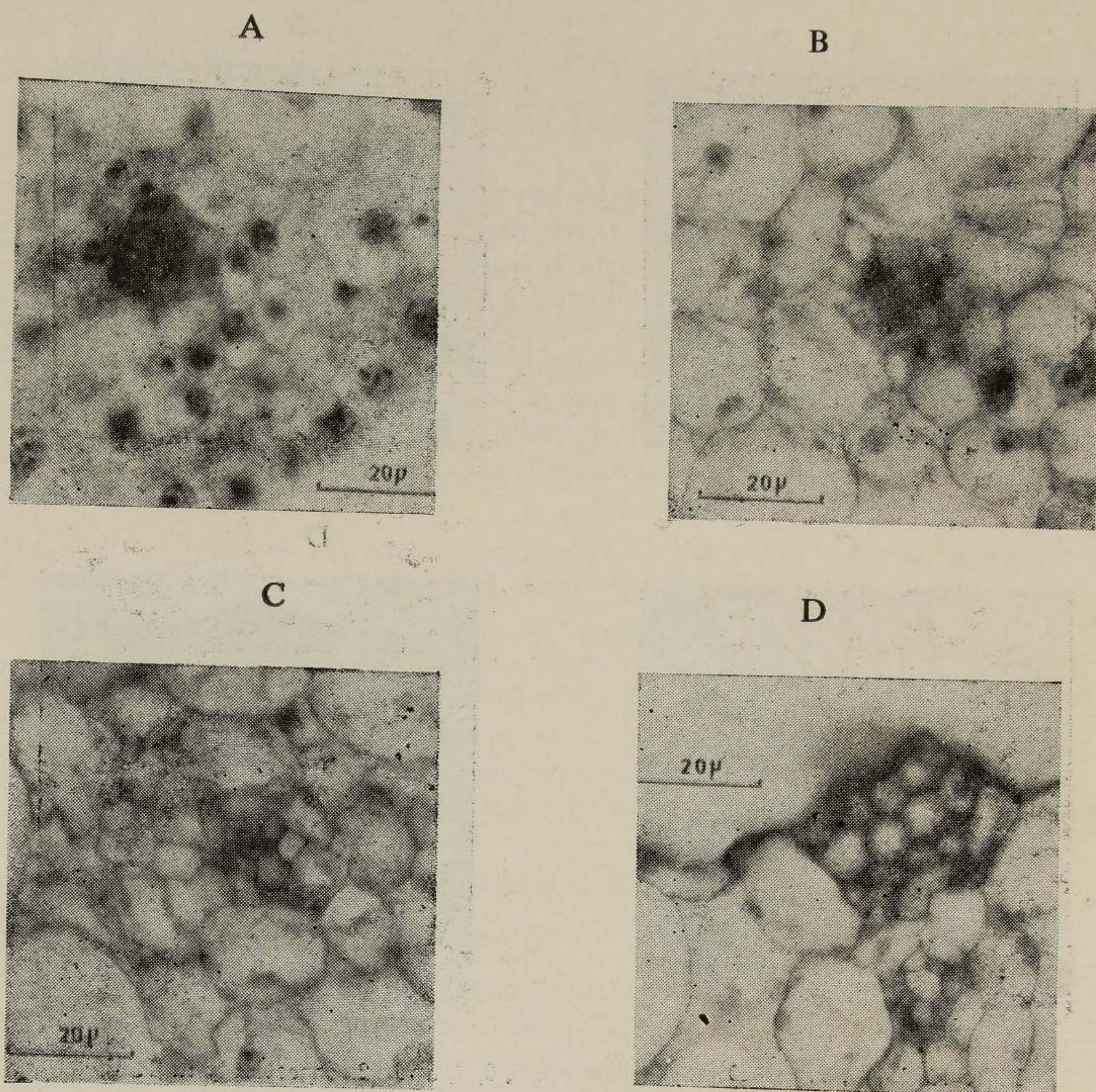

Plate 2. A, B C, and D are section no. 8, 9, 10 and 11 respectly in Table 4

RESEARCH NOTE

Response of Maize *(Zea Mays)* to Fertilizers at Bibile and Maha Illuppallama

A 3 × 3 × 3 factorial experiment confounded in 3 block of 9 plots each, with three replications, using O, 50 and 100 1b N/acre as ammonium sulphate, O, 40 and 80 lb. P_2O_5/acre as concentrated superphosphate and O, 30 and 60 lb. K_2O/acre as muriate of potash was conducted at Agricultural Experimental Station, Bibile and Agricultural Research Station, Maha Illuppallama on Maize (T-48) during Maha 1969/70. Phosphours and potassium were applied as basal dressing. Nitrogen was given in two split doses, one-fourth as basal and three-fourths at 4 weeks after planting (knee high stage). A plot size of 10 ft. × 25 ft. and a spacing of 10 ins. in the row and 2½ ft. between the rows were used.

The soil analysis and the main effects of N, P and K for the two locations are presented in Table 1, 2 and 3 and the results summarized as follows :—

(i) At both locations 50 lb. N/acre was significantly superior (at 1% level) to the O level and there was no significant difference between the 50 and 100 lb. levels of N.

(ii) At Bibile P gave a significant response at the 1% level. The 80 lb. P_2O_5/acre level was significantly superior to both 40 and O lb. P_2O_5/acre levels. On the other hand, at Maha Illuppallama there was no significant response to P.

(iii) There was no significant response to K at both locations.

(iv) None of the two factor interactions was statistically significant.

The results at Bibile are in agreement with those obtained for the variety Dixie 22 by Kathirgamathaiyah and Dharmarajah.[1] The response of maize to fertilizers at both locations appear to follow closely the nutrient status of the soils. The lack of response to P at Maha Illupallama is possibly due to the very high phosphorus status of this soil (Table 1). Such a build-up is likely under regular heavy dressings of P fertilizers. Likewise the satisfactory K status of the soils explains the absence of response to this nutrient. Although the N status of these soils are low, the maximum limit appears to be around 50 lb. N/acre for this variety at both locations. This result is in agreement with that obtained by earlier workers.[1]

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TABLE 1.

Soil Analysis

	Bibile	*Maha Illuppallama*
pH	5·2	5·5
Total N%	0·09	0·12
Available Phosphorus (Olsen's) lb. P_2O_5/acre	16·0	86·0
Exchangeable Potassium (m.e. %)	0·15	0·36
Organic Matter%	1·62	1·70

TABLE 2.

Mean Yields of Maize in Bu/ac. at Bibile

Level	*N.*	*P.*	*K.*	*L.S.D.*
0	41·9	39·8	46·9	5%–4·2
1	47·6	46·7	46·9	1%–5·6
2	49·7	52·7	46·3	

TABLE 3.

Mean Yields of Maize in Bu/ac. at Maha Illuppallama

Level	*N.*	*P.*	*K.*	*L.S.D.*
0	26·0	41·2	41·9	5%–5·4
1	48·9	41·2	41·2	1%–7·3
2	48·9	41·7	40·8	

Mass Production of Pineapple Planting Material

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(Received 12th June, 1971)

INTRODUCTION

Demand for local canned pineapples has increased to such an extent that new canneries are established to process more fruits. Inspite of this, and the financial assistance given as a subsidy to plant pineapple for diversification of cropping in commercial plantations, and the loans given to small holders, the extent under pineapple has not expanded appreciably.

Spacing trials conducted by the Division of Horticulture, C. A. R. I., Peradeniya, have shown that optimum sized fruits for canning are produced when plant densities range from 13-15,000 plants to the acre (for the variety Kew). An acre of pineapple planted at this density yields 10-15,000 suckers suitable for planting, during the second year, or after the first crop of fruits is harvested. In addition to this, crowns, slips and butts could also be used for planting. It appears that the limiting factor to rapid expansion of the area under pineapple is the planting material.

Studies conducted in Ceylon and in other pineapple growing countries such as Hawaii, Australia and Malaysia show that in addition to the vegetative parts normally used for propagation of pineapple, stems cut into small segments, and single leaf cuttings of crowns subtending axillary buds could also be used to produce plantings.

METHODS OF PROPAGATION

The following methods of propagation tested out by the Division of Horticulture are described below.

A.—*Stem segments :*

(1) Pineapple plants normally produce short stems but at flowering they elongate. Healthy plants were selected after harvest, and their leaves were removed to expose the stems. They were then cut transversely into pieces about one inch thick, dipped in a 1% solution of potassium permanganate and planted in sand beds so that they rested on their flat sides and were fully covered by sand. (See sketch). After 4 weeks the buds on these stem segments started to sprout and the small plants produced were replanted in pots containing a well drained medium rich in organic matter. However, the growth of these plantings was slow and they produced fruits after 30 months.

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Each stem was cut into between 15-24 pieces. Most of the cuttings produced on an average one planting, while some produced as many as five and still others none.

(2) Pineapple plants both before and after stem elongation were selected and cut into segments having 3-5 whorls of leaves. Each of these segments were cut longitudinally into 4 pieces (see sketch.) Some of these segments had all their leaves removed, dipped in a solution of potassium permanganate and planted in sand beds, so that the surface with buds was upwards. The other set of pieces had their leaves trimmed to 4-5 inches in length, and planted upright.

Stem segments with the trimmed leaves produced on the average one vigorous planting, while those without leaves produced weak plantings. The common practice in Hawaii is to multiply a selected clone by planting stem segments with trimmed leaves in nursery boxes and then in the field.

B.—*Planting of buds.*

Pineapples are harvested with 4-8" of the fruit stalk. The elongated stem which supported the fruit, if allowed to remain produces suckers well above ground level. These suckers produced high up on the stem collapse when they bear fruits, causing heavy losses. To avoid this loss the suckers produced high up on the stems could be removed for use as planting material or the stems could be cut back to 4-6" above ground level soon after harvest. Repeated removal of suckers delay the next harvest and, exhaust the mother plants.

Butts, or segments of stems (see sketch) removed after harvesting the fruits could be used for producing a large number of suckers suitable for planting. For this purpose they are planted in nurseries.

Shallow drains 8 inches wide and 6 inches deep were made in ploued up and harrowed land, spacing, them 16-18" apart. The butts were then placed lengthwise along furrows so that they rested end to end. The leaves were pressed down so that they rested between the stems and the edge of the furrow (see sketch). Placement of the leaves enabled the axillary buds to force their way up through the leaf bases and the soil. Removal of leaves deprives the young plants of the food reserves and auxins in the leaves. Cutting or trimming them was cumbersome and expensive.

Stem placed in the furrows were covered with a 2-3 inch thick layer of soil. Deep burial of stems or use of ill-drained soil caused stem rot and resulted in poor sucker production. Between 6-8 weeks after planting the first crop of suckers emerged above the soil. When these suckers were watered fortnightly with a solution containing ½ lb. of urea and ½ oz. cane sugar per gallon of water to wet the suckers thoroughly the growth of plants was very much hastened. Young suckers can be allowed to remain till they are sufficiently grown for planting out in the field or transplanted in a second nursery.

About 25,000 butts could be planted in one acre of nursery. This produces between 100,000—200,000 suckers per acre, giving an average of about 6 suckers per butt. In experimental studies as many as 25 suckers were produced from one butt.

C.—*Crown Segments*

Pineapple crown is a continuation of growth of the vegetative bud, after the flowers are produced. It is a miniature plant with leaves, nodes, internodes and axillary buds. These axillary buds remain inactive and dormant under normal conditions. The Pineapple Research Institute, Hawaii has made use of these axillary crown buds to produce plantlings, by growing them in vermiculate or sand as media. This method was adopted in Ceylon for multiplication of clones selected on the basis of fruit shape, colour, and size. However, it was not considered for commercial production of pineapple plants as these plants take over 24 months to produce fruits even with intensive care and attention.

Crown of mature fruits were taken and their tiny basal scale leaves were removed. Below this layer all the leaves with discernible axillary buds were out off with the small piece of stem attached to it. This piece of stem was sterlized by dipping in a solution of potassium permanganate, or cerasan, and planted in pots or beds with river sand. When river sand or vermiculate is used sterilization of the leaflet is not essential.

When propagation is done on a field scale, nursery beds 4 feet wide, and of a convenient length could be used for planting crown segments. Sand beds, and beds with 4 inch layers of coir dust or paddy husk covered with a one inch thick layer of sand were also used for planting. These beds were raised above ground level to facilitate drainage, and linde with bricks or off-cut timber.

The beds with mulching material below the layer of sand were at an advantage in that they retained sufficient moisture below the surface while the upper layer of the medium was well drained even during wet weather. A scaffolding made with unwoven coconut leaves provided shade, reduced the beating action of rain drops and excessive dessication during dry weather.

The freshly cut crown segments with leaves were planted in these rooting media, and watered when necessary during dry whether. In 4-6 weeks time the buds began to sprout and in 8-12 weeks the small plantings were sufficiently developed for transplanting in polythene bags or second nursery beds prepared by incorporating organic matter and sand to facilitate good drainage.

These young plantlings could be made to grow faster by watering with a nutrient solution containing N P K and trace elements. With intensive care and attention these plants could be made ready for planting in about 6 months. On an average 20 plantlings could be produced from a crown, when the crowns are cut by experienced workmen.

STEM SEGMENTS