Nutritional disorders of rice

1. Investigations on factors limiting rice growth

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Abnormal growth of rice was observed in two rice growing tracts, Panaliya and Galgamuwa, of the Kurunegala District in Maha 1966-67. Murungakayan 302 and H 4 were the varieties cultivated in these tracts. Affected plants were stunted in growth, poor in tillering and had dark green erect leaves. Attempts to resuscitate these plants, which were in the booting stage of growth, by foliar application of nitrogen and potassium fertilizers had little or no effect. In the following crop seasons, beginning Yala 1967, investigations were carried out to identify the factors underlying this abnormal crop behaviour and to find measures to ameliorate this condition.

MATERIALS AND METHODS

Experiments were carried out at Panaliya where the soil had the following characteristics:—pH 5.2; and 0.55 mg available P_2O_5, 0.18 m.e. exchangeable K, and 48.2 mg available Si O_2 per 100 gm soil.

Experiment I. Soil and foliar application of nutrients (Yala 1967)

The effects of major nutrients N,P, and K, and some micro nutrients when given as a soil or foliar application were investigated in a 2 replicated randomised block design experiment with the variety H 7 grown under broadcast conditions at a seed rate of 76 kg per hectare. Concentrated superphosphate, muriate of potash and urea were applied to all plots to supply 56 kg P_2O_5, 67 kg K_2O and 78 kg N per hectare, respectively. Phosphate was given as a basal dressing; potassium was split applied where 2/3 of the amount was given as a basal dressing at sowing and 1/3 was top-dressed 7 weeks after sowing; and nitrogen was split applied in the ratio of 1 : 2 : 2 at

sowing, 2 weeks and 7 weeks after sowing. The 7th week after sowing corresponded to pollen mother cell stage (PMC) of crop development. The final application of potassium and nitrogen was either given as a foliar spray or soil application depending on the treatments, whereas all earlier applications of nitrogen were applied to the soil. Certain treatments received a mixture of micro elements either as a basal dressing at sowing or as a foliar spray 7 weeks from sowing. The micro element mixture contained B and Mn at 2.2 kg per hectare, Zn and Cu at 0.22 kg per hectare and Mo at 0.11 kg per hectare. An organic sea weed extract, Sea Magic 3, from Chase Organics Ltd., England was used as a supplement in one treatment where it was sprayed at the 7th week after sowing at the rate of 11 litres product per hectare. A spray volume of 561 litres per hectare was used in all spray treatments. The details of the different treatments are given below :—

Treatment No.	*Amount of nutrients in kg per hectare*		
	Sowing	*2 WAS (a)*	*7 WAS*
1	16 N	31 N †	31 N †
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O†
2	16 N	31 †	31 N +
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O +
	Micro Elements	—	—
3	16 N	31 N +	31 N +
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O +
	—	—	Micro Elements + +
4	16 N	31 N +	31 N + +
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O + +
5	16 N	31 N +	31 N + +
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O + +
	—	—	Micro Elements + +
6	16 N	31 N +	31 N + +
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O +

Treatment No.	Amount of nutrients in kg per hectare: Sowing	2 WAS	7 WAS
7	16 N	31 N +	31 N +
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O ++
8	16 N	31 N +	31 N +
	56 P_2O_5	—	—
	45 K_2O	—	22 K_2O +
	—	—	Sea Magic ++ (11 litres per hectare)

+Top dressed ++Foliar spray (a) WAS—weeks after sowing

Experiment II. Forms of phosphate and soil amendments (Yala 1967)

The effects of application of different forms of phosphate, saphosphosphate and concentrated superphosphate; dolomitic limestone; and rice husk ash were investigated in a test designed as a randomised block with two replicates with H7 broadcast sown at a seed rate of 76 kg per hectare. One of the test plots received the recommended fertilizer application for Panaliya which consisted of 58 kg N per hectare, 35 kg P_2O_5 per hectare as saphosphosphate, and 47 kg K_2O per hectare (1) ; all other test plots received 78 kg N per hectare, 56 kg P_2O_5 per hectare as concentrated superphosphate, and 67 kg K_2O per hectare. Among these some plots received in addition rice husk ash or dolomitic limestone or a combination of these soil amendments at two levels of application. The details of the different treatments are described below :

Treatment No.	Amount of nutrients and soil amendments in kg per hectare: Sowing	2 WAS (a)	7 WAS	10 WAS
1	—	14.5 N	29 N	14·5 N
	35 P_2O_5	—	—	—
	31 K_2O	—	16 K_2O	—
2	16 N	31 N	31 N	—
	56 P_2O_5	—	—	—
	45 K_2O	—	22 K_2O	—

@ WAS—Weeks after sowing.

Treatment No.	Amount of nutrients in kg per hectare		
	Sowing	*2 WAS (a)*	*7 WAS*	*10 WAS*
3	16 N	31 N	31 N	—
	56 P_2O_5	—	—	—
	45 K_2O	—	22 K_2O	—
	1031 RHA †	—	—	—
4	16 N	31 N	31 N	—
	56 P_1O_5	—	—	—
	45 K_2O	—	22 K_2O	—
	2062 RHA	—	—	—
5	16 N	31 N	31 N	—
	56 P_2O_5	—	—	—
	45 K_2O	—	22 K_2O	—
	1121 Dolomite ††	—	—	—
6	16 N	31 N	31 N	—
	56 P_2O_5	—	—	—
	45 K_2O	—	22 K_2O	—
	2242 Dolomite ††	—	—	—
7	16 N	31 N	31 N	—
	56 P_2O_5	—	—	—
	45 K_2O	—	22 K_2O	—
	1031 RHA 1121 Dolomite	—	—	—
8	16 N	31 N	31 N	—
	56 P_2O_5	—	—	—
	45 K_2O	—	22 K_2O	—
	2062 RHA 2242 Dolomite	—	—	—

† RHA—Rice husk ash.

†† Dolomitic limestone applied one week before sowing.

Experiment III. Forms of phosphate and soil amendments (Maha 1967/68)

This test was conducted under transplanted conditions with the variety H 8. Twenty-one day seedlings were transplanted at a spacing of 20 cm between rows and 15 cm within the row with 3 seedlings per hill. Details of treatments are listed below :

Treatment No.	*Amount of nutrients and soil amendments in kg per hectare*		
	Planting	*2 WAP **	*7 WAP*
1	—	14·5 N	29 N
	53 P_2O_5**	—	—
	31 K_2O	—	16 K_2O
2	—	14·5 N	29 N
	53 P_2O_5	—	—
	31 K_2O	—	16 K_2O
3	—	14·5 N	29 N
	53 P_2O_5	—	—
	31 K_2O	—	16 K_2O
	1121 RHA ‡	—	—
4	—	14·5 N	29 N
	53 P_2O_5	—	—
	31 K_2O	—	16 K_2O
	2242 RHA	—	—
5	—	14·5 N	29 N
	53 P_2O_5	—	—
	31 K_2O	—	16 K_2O
	1121 Dolomite §	—	—
6	—	14·5 N	29 N
	53 P_2O_5	—	—
	31 K_2O	—	16 K_2O
	2242 Dolomite	—	—
7	—	14·5 N	29 N
	53 P_2O_5	—	—
	31 K_2O	—	16 K_2O
	1121 RHA	—	—
	1121 Dolomite	—	—
8	—	14i5 N	29 N
	53 P_2O_5	—	—
	31 K_2O	—	16 K_2O
	2242 RHA	—	—
	2242 Dolomite	—	—

* WAP—Weeks after planting.

** Phosphate applied as saphosphosphate in this treatment only. Others received concentrated superphosphate.

‡ RHA—Rice husk ash.

§ Dolomitic limestone was applied one week before transplanting.

RESULTS AND DISCUSSION

Application of micro elements (B, Mn, Zn, Cu and Mo) either to the soil at planting or to the leaves (tops) as a spray at the PMC stage of crop growth had no significant effect on yield. Neither did the application as a foliar spray of the major nutrients nitrogen and potassium, either singly or in combination or together with a mixture of micro elements have any effect on yield. Similarly, there was no effect on yield as a result of spraying Sea Magic, a complete organic fertilizer, at the rate of 11 litres product per hectare. The growth of the crop was quite normal as assessed visually at various stages of development and yields recorded were of a reasonable level (Table 1). It is pertinent to state that in this experiment phosphate was given in the form of concentrated superphosphate whereas the form recommended for the area was saphosphosphate.

In experiment 2, conducted concurrently, the growth of plants in treatment 1, which received forms and amounts of fertilizer as recommended for the area, was distinctly inferior to that in all other treatments. Plant height and tiller counts made when the crop was 3 and 6 weeks old showed the distinct inferiority of plants in treatment 1 compared to those of the other treatments (Table II). Yield differences were, however, non significant (Table III). This was primarily due to the fact that prior to harvest there was severe lodging in all treatments except the first where saphosphosphate was used. Despite this lack of differences in yield, observations clearly indicated that in treatment 1 the growth of plants was quite inferior and the appearance was similar to that of plants observed to be abnormal in Maha 1966/67 season in this tract.

The indications from experiment 2 were that the form of phosphate had a significant role to play in determining the growth status of plants in the Panaliya soils. The design of the experiment however did not permit a definite statement on this but conclusive proof that the real problem was associated with the form of phosphate was obtained from the experiment conducted in Maha 1967/68. From growth data of the plants it was very clear that the determining factor was the form of phosphate (Table IV). Between treatments 1 and 2 in experiment 3 there was a very striking difference in growth of plants. The differences among other treatments were not as striking (Fig. 1 & 2). These differences were also reflected in the final yields (Table V). Treatments 1 and 2 in this experiment were identical except that the form of phosphate was different. When phosphorus was given in the form of concentrated superphosphate it resulted in

a yield increase of 78% over the treatment that received it as sapnosphosphate. This difference was the most striking. The next most striking effect was due to the combined influence of 2242 kg per hectare each of rice husk ash and dolomitic limestone.

The recommended form of phosphate for the Panaliya soils of the Kurunegala District was saphosphosphate at the time these experiments were undertaken (1) On the basis of soil fertility studies by Panabokke and Nagarajah (2) the soils of Dambadeni Hatpattuwa within which Panaliya is located are 'fairly low' in available phosphorus. The three experiments conducted clearly demonstrated that abnormal growth of rice observed at Panaliya was associated primarily with the form in which phosphorus was supplied. A mere change of the form of phosphorus from saphosphosphate to concentrated superphosphate resulted in a remarkable improvement of rice growth in the Panaliya soils. The results of these experiments indicated the need for a change in the form of phosphate in the fertilizer recommendations for this area.

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REFERENCES

1. A guide to fertilizer use in the cultivation of wetland rice in Ceylon, 1964. Departmental notes. *Tropical Agriculturist* Vol. CXX No. 1. pp. 31-52.

2. C. R. PANABOKKE and S. NAGARAJAH, 1964. The fertility characteristics of the rice growing soils of Ceylon. *Tropical Agriculturist* Vol. CXX No. 1 pp. 3-29.

TABLE I

Effect of soil and foliar application of major and minor nutrients on grain yield (Experiment 1)

Treatments	Grain Yield	
	kg/ha	Percent
1	2547 ..	100
2	2784 ..	109
3	3077 ..	121
4	2890 ..	113
5	2814 ..	110
6	2839 ..	111
7	3026 ..	119
8	3177 ..	125
L.SO. (0.05)	N.S. ..	N.S.
Coefficient of variation % ..	22·3 ..	—

TABLE II

Effect of different fertilizers and soil amendments on plant height and tiller production (Yala 1967)

Treatments	Age of Crop			
	3 Weeks		6 Weeks	
	Plant height (cm)	Tillers/ sq m	Plant height (cm)	Tillers/ sq m
1	33·3 ..	384 ..	53·0 ..	466
2	57·9 ..	607 ..	99·4 ..	791
3	57·8 ..	621 ..	100·8 ..	721
4	60·8 ..	679 ..	101·2 ..	751
5	58·7 ..	642 ..	102·4 ..	751
6	56·4 ..	588 ..	101·8 ..	756
7	58·0 ..	642 ..	106·4 ..	769
8	60·9 ..	683 ..	99·9 ..	764

TABLE III

Effect of different fertilizers and soil amendments on grain yield (Yata 1967)

Treatments	*Grain Yield*	
	kg/ha	*Percent of Control*
1	2971 ..	100
2	3530 ..	119
3	3369 ..	113
4	3450 ..	116
5	3238 ..	109
6	3394 ..	114
7	3929 ..	132
8	3581 ..	120
L.S.D. (0.05)	N.S. ..	N.S.
Coefficient of variation % ..	12.9 ..	—

TABLE IV

Effect of fertilizers and soil amendments on plant height and tiller production (Maha 1967–68)

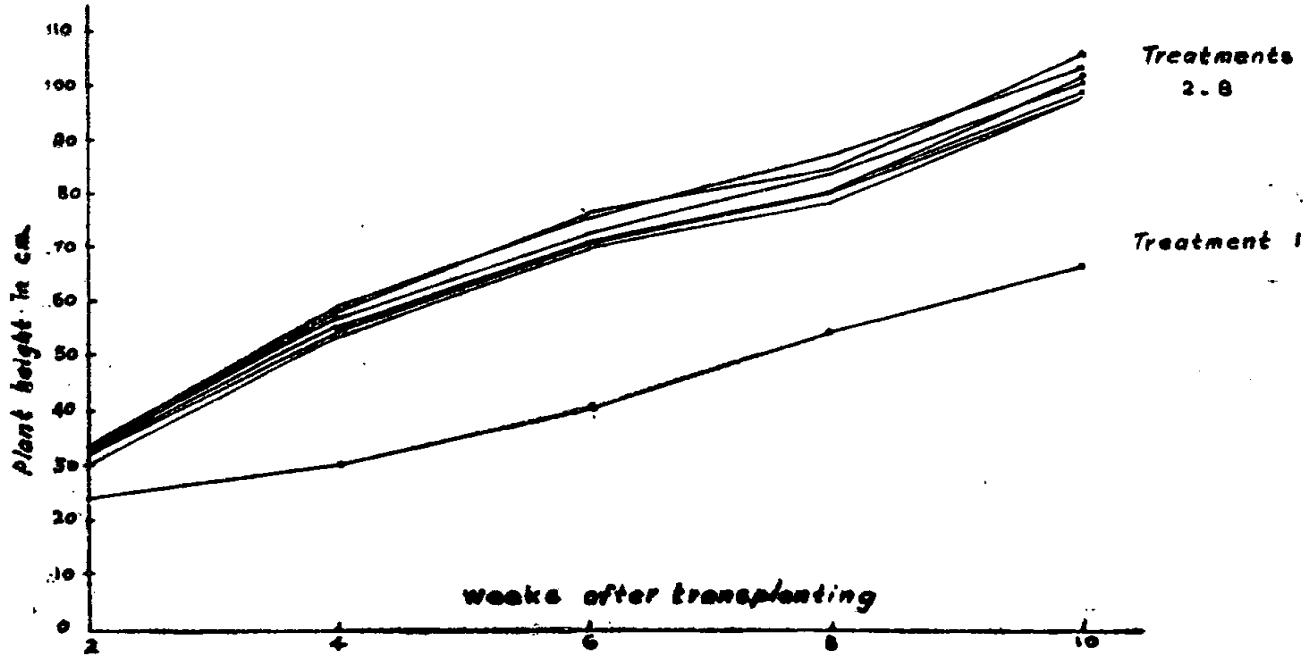
Treatment	Time after Transplanting									
	2 Weeks		4 Weeks		6 Weeks		8 Weeks		10 Weeks	
	Plant height (cm)	Tillers/ sq m.	Plant height (cm)	Tillers/ sq m	Plant height (cm)	Tillers sq m	Plant height (cm)	Tillers/ sq m	Plant height (cm)	Tillers/ sq m
1	24	116	31	126	41	139	55	174	67	236
2	33	142	55	232	70	258	78	268	98	265
3	30	129	54	229	72	258	81	281	98	291
4	32	155	56	226	72	252	81	265	102	265
5	32	113	55	213	70	252	81	268	99	281
6	34	126	57	216	72	252	84	284	101	274
7	32	155	58	249	79	284	85	297	106	287
8	34	139	59	265	76	310	87	320	104	326

TABLE V

Effect of fertilizers and soil amendments on yield of rice (Maha 1967–68)

Treatment	*Grain Yield*	
	kg/ha	*Percent of Control*
1	1942 ..	100
2	3455 ..	178
3	4060 ..	209
4	4257 ..	219
5	3651 ..	188
6	4040 ..	208
7	4252 ..	219
8	4393 ..	226
L.S.D. (0.05) ..	807 ..	—
Coefficient of variation % ..	9 ..	—

Fig. 1: Effect of treatments in experiment 3 on plant height.



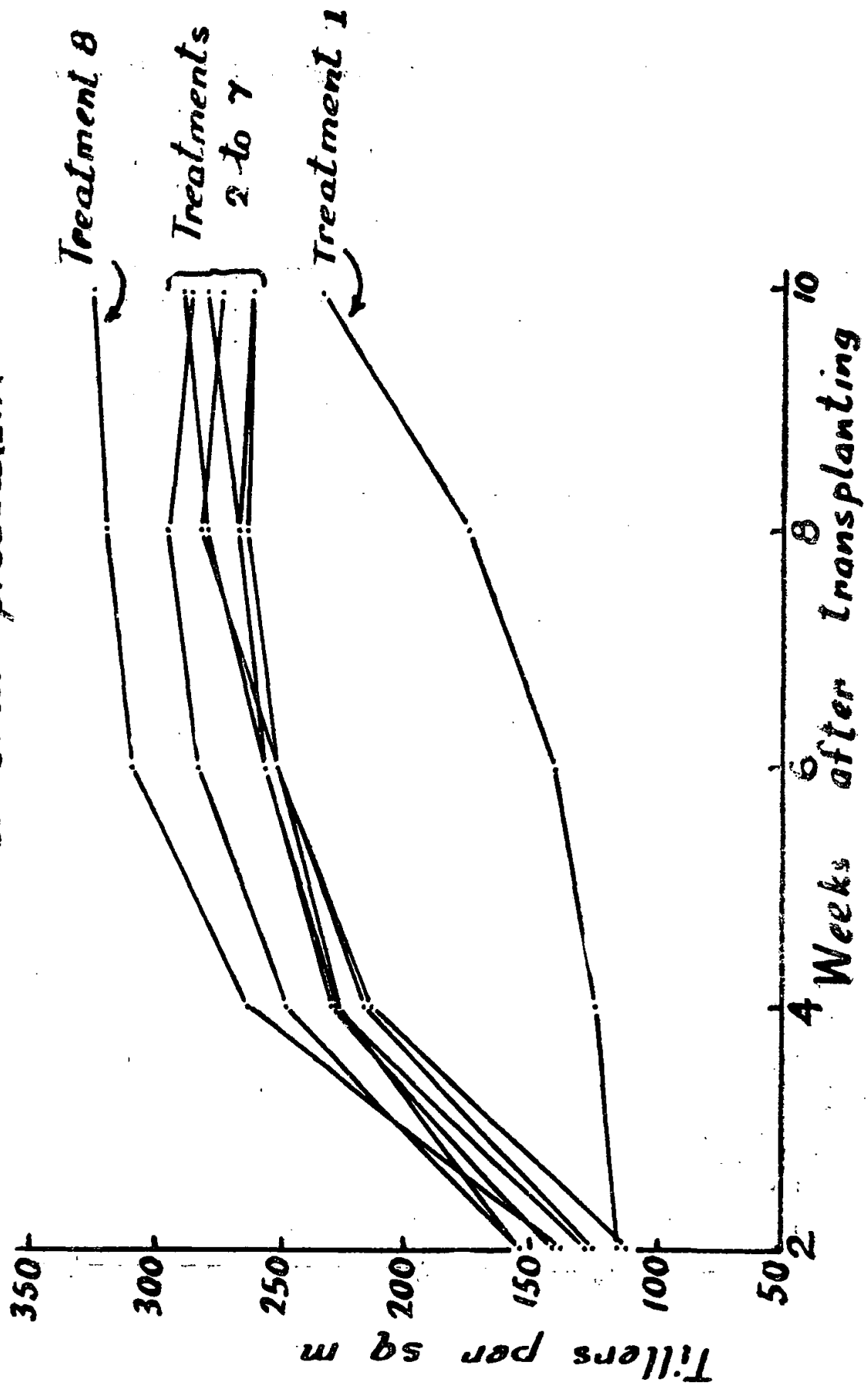


Fig. 2 Effect of treatments in experiment 3 on tiller production.