# Nutrient deficiency and physiological disease of lowland rice in Ceylon

## II. Phosphate fertilizer use for phosphorus deficiency of rice plants

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A survey conducted on nutrient status of rice plants and soil had indicated clearly that phosphorus deficiency is the most common malady in rice fields throughout the Island (11). This substantiated by the fact that approximately 70 per cent of the total extent of rice fields are cultivated still without chemical fertilizer application. As in other Asian countries, statistical data in Ceylon (1) indicate that in the last decade fertilizer use has been confined to nitrogen with little or no application of phosphorus and potassium fertilizers. Such imbalanced use of fertilizers could very well aggravate disorders related to phosphorus balance particularly due to the low phosphorus status of most soils. Further, the current use of slow-acting saphos phosphate, pulverised rock phosphate, in wet zone rice fields could be a contributory factor effecting phosphorus deficiency in rice plants (2). Under these circumstances, experiments on the proper use of phosphate fertilizers were conducted to examine the effects of different forms and doses of phosphorus fertilizer in increasing rice production and this report deals with the results of such experiments done in Maha 1967-68 and Yala 1968.

## MATERIALS AND METHODS

*Phosphate fertilizers*

The forms of phosphate fertilizer used were saphos phosphate, fused magnesium phosphate and concentrated super phosphate. These phosphate fertilizers have $P_2O_6$ contents of 28 per cent (citric acid soluble), 20 per cent (citric acid soluble) and 42.5 percent (water soluble), respectively.

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*Pot experiments*

Four soils, Bombuwela sandy and humic, Panaliya clayey and Peradeniya clayey, were used. Properties of these soils been described in a previous report (II).

Pot soil cultures were conducted in the green house at the Central Agricultural Research Institute (C. A. R. I.) using the three forms of phosphate fertilizer. Wagner's pots having a surface area equivalent to 1/500,000 hectare were arranged according to a randomised block design with two or three replicates. All pots received 0.5 gm of N as amonium sulphate and 1 g of $K_2O$ as potassium chloride as a basal application, and 0.5 gm of N as ammonium sulphate as a top-dressing at the primordium initiation stage of growth. Phosphate was added at graded levels, i.e. O, 1, 2 and 3 gm of $P_2O_5$ per pot as a basal dressing. Approximately 21 day old seedlings of the variety H4 or H8 were transplanted one hill to a pot with three seedlings per hill. The soil in pots was kept flooded with tap water from transplanting till maturity of plants. Endrin (insecticide) was sprayed twice after the plants had reached the maximum tillering stage. Growth was measured every two weeks after planting. Yield data were collected on culm and panicle length, panicle number, and weight of straw and panicle or grain in each pot. Chemical analyses were done on the straw to determine the content of nutrient elements.

*Field experiments*

These experiments were conducted in Government Experiment Stations at Nalanda, Batalagoda, Karapincha and Bombuwela (sandy and humic). Properties of the field soils have been described in a previous report (11). Field experiments were also carried out in farmers' fields mainly in Kurunegala District where various growth disorders were noticed in rice plants. The soil profiles in these fields were examined and described (Table 1). Some chemical properties of the surface soil are described in Table 2.

Experimental plots were 10 × 20 feet in size and were separated by 1 foot bunds. The experiments were conducted on a randonized block design with two to four replicates. Approximately 21 day old seedlings of the variety H4 or H8 were transplanted at a spacing of 8 inches between rows and 6 inches within the row with 3 seedlings per hill. Some of the experiments in farmers' fields were broadcast sown. All fields were supplied with nitrogen and potassium fertilizers according to the recommendations of the Department of Agricuture for improved varieties (2). Phosphate fertilizers in three forms were added as basal application at the same doses as in the recommendations or at graded levels depending on the soil conditions.

Growth was measured in 20 hills for each plot, two to six times during the season at different stages of the crop. In broadcast experiments growth measurements were done on plants in two, one square foot areas per plot. Yield in each plot was recorded from rice plants harvested from 6 × 6 feet area.

## RESULTS AND DISCUSSION

*Pot experiments*

In Maha 1967-68 three soils were grown with H4. The results are summarized in Table 3. In Panaliya clayey soil, rice plants showed typical phosphorus deficiency symptoms in the absence of applied phospate. Plants were stunted, dark green in colour and did not produce tillers until about 60 days after sowing. Onset of flowering was delayed by 18 days compared to treatments receiving phosphate, reresulting in a very low panicle yield. Plants supplied with phosphorus in the form of saphos phosphate showed similar symptoms upto heading, and the yields were lower than with fused magnesium phosphate and conc. super phosphate. (Fig. 1) Less severe deficiency symptoms were seen in the experiment with Bambuwela sandy soil while with Bombuwela humic (clayey) soil there was no marked growth difference in plants receiving no phosphate and saphos phosphate. The reason for lack of severe phosphorus deficiency symptoms in these two soils is due possibly to these soils being repeatedly fertilized with phosphate fertilizer over a period of years. However, here too fused magnesium and conc. super phosphate were superior to saphos phosphate in straw and panicle yield. Fig. 1 shows the general condition of rice plants grown in Panaliya clayey soil at the maximum tiller number stage.

Similar results were obtained with C. A. R. I. clayey soil taken from the newly established rice fields in front of the Institute (Table 4). This soil is also one typically deficient in phosphorus. Optimum dose of phosphate for getting highest yield was found to be around 1.5 g $P_2O_5$ per pot containing soil. This dose is equivalent to 750 Kg per hectare.

The residual effect of phosphate fertilizers was examined in the next season, Yala 1968 using the same potted soils. There was no appreciable change in response pattern in the three soils.

The results of chemical analyses of straw taken from the Panaliya soil experiment are given in Table 5. Plants with no phosphate were abnormally high in nitrogen and potassium, and extremely low in phosphorus. The low magnesium and phosphorus contents are probably correlated in these plants. Phosphorus content in the straw increased with increase in level and availability of the phosphate fertilizers. Silica content obtained after determining ash contents of the samples was quite low. The relatively higher contents of silica in the samples grown with fused magnesium phosphate may be attributed to the effect of available silica contained in the fertilizer.

*Field experiments*

Haigh and Joachim (5) had stated as far back as 1933 that phosphoric acid is the limiting factor determining crop yield in Ceylon's rice soils. They reported later that the form of phosphate, be it either a slow-acting or fast-acting kind, had no difference on rice yields (6). Other investigators too found no signifiicant differences among several kinds of phosphatic fertilizers and because of its low unit cost, saphos phosphate had been recommended for the whole Island (3, 9). Recently, however, the recommendation has been changed to conc. super phosphate for the dry and part of the intermediate zone (2). This revision has been based partly on the results obtained from the fertilizer experiments of FAO Project (12).

Five field experiments were conducted in Government Experiment Stations and 18 experiments in farmers' fields in the wet and intermediate zones from Maha to Yala 1967-68. Saphos phosphate was found to be inferior to the improved phosphate fertilizers in increasing rice growth. Fig 2 gives one example of growth differences obtained at Panaliya. The yield ratio of grain in this experiment was saphos phosphate 56, fused magnesium phosphate 108 and conc. super phosphate 100. Less growth differences were observed among among phosphate fertilizers in the Bombuwela sandy and humic fields. Here the yield ratio of grain with saphos phosphate treatment was 86 and 91, respectively, showing a similar trend as obtained in the pot experiments. Results in Maha 1967-68 experiments are summarized in Table 6. Saphos phosphate was inferior to the other two forms of phosphate in all locations, even in the Acid Swamp Soils (Bombuwela) of the wet zone (8) and especially so in the farmers' fields where little or no fertilizer has been used in the past. Fused magnesium phosphate was generally less effective on initial vegetative growth than conc. super phosphate, but at later stages this difference evened out resulting at times in a higher number of productive tillers (Fig. 2). Better response of rice to this fertilizer recorded in the farmers' fields suggests its suitability for fields which are in strongly reduced condition and highly deficient in available soil phosphorus (7).

Experiments on levels of phosphate fertilizers were conducted on some of the farmers' fields of Kurunegala District. Table 7 gives the summarized results of the experiments. The Nikeweratiya field was very boggy and ill-drained and was claimed to yield usually less than 25 bushels of paddy per acre per season. Plants grown here showed severe deficiency symptoms of phosphorus despite the higher content of soil available phosphorus (Table 2). A striking difference in growth and yield was observed between treatments with saphos phosphate and conc. super phosphate. Increased straw growth and panicle number by the latter phosphate fertilizer account for the increase in grain yield. From these experiments, optimum or sufficient levels of phosphate in the forms of improved phosphate fertilizer can be estimated to be 75 to 150 lbs of $P_2 O_5$ per acre for normal soil or soil slightly deficient in available phosphorus, and 150 to 225 lbs for soil moderately or extremely deficient in available phosphorus. These levels of fertilizer are much higher than those reported by Rodrigo (10) which range from 20 to 120 Kg of $P_2O_5$ as saphos phosphate.

*Absorption of phosphate by the soil*

As described already, rice soils in Ceylon are generally deficient in available phosphorus, and characterised by fairly high phosphate available phosphorus, and are characterised by fairly high phosphate (11). Since these alluvial materials were derived mainly from the Reddish Brown Soils (8) produced under laterite formation, they are rich in sesquioxides of iron and aluminium which produce insoluable phosphates.

Fig. 3 gives examples of relationships between concentration of phosphate in reagent solution and amount of phosphate absorbed by the soil. In view of the large accumulation of ferrous iron during the cropping season, it seems that soil iron is active enough to account for the high absorption coefficient of phosphate. Soil alumina might also play a role in this absorption because aluminium phosphates are less available to rice plants (4) and there were instances where phosphate application was very effective in increasing rice production despite the high levels of available soil phosphorus (Bombuwela, Nikeweratiya, etc.)

Considering these results there is ample justification to recommend increased application of phosphate fertilizers to the rice fields. Highly effective phosphate fertilizers other than saphos phosphate should be used even in the wet zone for increasing rice production in low yield areas.

## SUMMARY

In view of the widespread occurrence of phosphorus deficiency in rice, pot and field experiments were conducted from 1967 to 1968 to investigate suitable forms and levels of phosphate fertilizer to be used in rice fields.

1. Saphos phosphate that is still recommended to the wet zone by the Department was found inferior to the improved fertilizers, fused magnesium phosphate and conc. super phosphate in raising rice yields. Nutrient composition of straw gave clear evidence as to the degree of availability of the different phosphate fertilizers.

2. Sufficient level of phosphate application was estimated around 150 lbs of $P_2 O_5$ per acre depending on the degree of phosphorus deficiency of the soil.

Increased application of phosphate fertilizers is recommended taking account of the high absorption of phosphate by the soil. Improved phosphate fertilizers are indicated for use in rice fields in the wet zone instead of saphos phosphate.

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**TABLE 1.—Location and soil condition of farmers' rice fields where experiments were conducted**

| *Field No.* | *Location* | *Elevation feet* | *Drainage of the field* | *Soil horizon sequence* | *Texture sequence* |
|---|---|---|---|---|---|
| 1 | Tambutta* | 300 | Well | Ap-AC-(C) | LS-S |
| 2 | Galgamuwa* | 260 | poor | Apcn-C | L-SC |
| 3 | Maho* | 400 | Well | Ap-AC-(C) | SiL-SiL |
| 4 | Nikaweratiya | 130 | poor | Apg-ACg-Cgcn-IIC | CL-SL-SL-HC |
| 5 | Polpitigama* | 400 | well | Ap-ACcn-(C) | SL-LS |
| 6 | Hettipola | 120 | well | Ap-B2-BC-C | LS-LS-L-SL |
| 7 | Katupotha | 310 | well | Ap-AC-IIC | SL-LS-SL |
| 8 | Ibbagamuwa | 500 | imperfect | Ap-C-IICcn | L-LiC-SiC |
| 9 | Bingiriya* | 110 | moderately | Ap-AC-C-IIC | SL-SL-SL-CL |
| 10 | Kuliyapitiya | 240 | poor | Apg-AC-C | SC-LS-S |
| 11 | Bogamuwa | 500 | moderately well | Ap-B2cn-C-IICcn | L-L-SL-SL |
| 12 | Pannala* | 180 | poor | Apg-ACg-Cg | SL-SL-LiC |
| 13 | Godigamuwa | 560 | poor | Apg-Cg-IICg-IIICg | SC-SC-SL-LiC |
| 14 | Alawwa* | 130 | imperfect | Apg-ACg-Cg | SC-LS-S |
| 15 | Panaliya | 300 | poor | Apg-ACg-Cg-IICg | SCL-SCL-SiL-SCL |
| 16 | Warakapola—1 | 450 | poor | Apg-ACg-Cg | CL-L-LS |
| | Warakapola—2 | 450 | poor | Apg-ACg-Cg | SCL-SL-SL-L |

* These fields were used for fertilizer experiments other than phosphate fertilizers and are listed here for convenience.

**TABLE 2.—Some chemical properties of farmers' field soils used for field experiments**

| *Location No.* | *Soil colour* | | *pH* | | *Exchangeable ferrous iron, ppm.* | *Available* $P_2O_5$ mg/100g soil* | *Phosphate† absorption coefficient* |
|---|---|---|---|---|---|---|---|
| | *On Sampling* | *After air-drying* | *$H_2O$* | *KCL* | | | |
| 1 | 2.5 Y4/2 | 10 YR 6/2 | 5.5 | 5.0 | tr. | 3.35 | 500 |
| 2 | 2.5 Y4/2 | 2.5 Y 6/2 | 6.3 | 5.1 | tr. | 10.15 | 500 |
| 3 | 2.5 Y 7/2 | 10 YR 7/2 | 5.6 | 5.0 | tr. | 0.85 | 160 |
| 4 | N 4/0 | 2.5 Y 5/2 | 6.1 | 4.6 | 2,140 | 8.15 | 800 |
| 5 | 10 YR 7/3 | 7.5 YR 6/3 | 5.0 | 4.7 | tr. | 1.75 | 400 |
| 6 | 10 YR 5/4 | 10 YR 7/4 | 6.6 | 5.3 | tr. | tr. | 400 |
| 7 | 2.5 Y 4/2 | 10 YR/1 | 5.8 | 4.4 | tr. | 0.85 | 600 |
| 8 | 10 YR 4/3 | 10 YR 5/2 | 5.5 | 4.7 | tr. | 2.5 | 1,250 |
| 9 | 10 YR 4/2 | 10 YR 7/2 | 6.6 | 5.0 | tr. | 1.05 | 700 |
| 10 | 2.5 GY 4/1 | 10 YR 6/2 | 6.0 | 5.3 | 2,160 | 0.55 | 800 |
| 11 | 7.5 YR 3.5/4 | 10 YR 6/4 | 5.2 | 5.0 | tr. | 1.85 | 700 |
| 12 | 3.5 Y 4/4 | 10 YR 6/3 | 5.2 | 4.5 | 1,030 | 1.15 | 500 |
| 13 | 10 YR 4/2 | 10 YR 6/4 | 4.6 | 4.4 | tr. | tr. | 1,000 |
| 14 | 2.5 Y 4/4 | 10 YR 6/3 | 5.4 | 4.6 | 1,110 | 0.65 | 1,000 |
| 15 | 7.5 Y 3/2 | 10 YR 7/4 | 5.5 | 5.2 | 1,801 | 0.55 | 600 |
| 16-1‡ | 2.5 Y4 /4 | 10 YR 6/3 | 6.0 | 4.5 | 1,700 | 1.05 | 950 |
| 16-2 | 2 5 Y 3/4 | 10 YR 6/3 | 5.3 | 4.4 | 2,110 | 3.95 | 1,250 |

* Olsen's method (1954).

† Official method of soil analysis, Japanese Government (1950). Coefficient is defined as mg of $P_2O_5$ absorbed by 100g of soil from 2.5% amonium phosphate solution.

‡ Colombo District ; the others, Kurunegala District.

**TABLE 3.—Effect of forms and doses of phosphate fertilizers on growth and yield of rice. (Po texpts., Maha 1967-68, H-4)**

| *Soils used* | *Treatments** | *($P_2O_5$, gm/pot)* | *Plant height (cm)* | *Maximum tiller number* | *Panicle number* | *Yield (gm/pot)* Straw | Panicle | Total |
|---|---|---|---|---|---|---|---|---|
| I. Panaliya clayey | 1. No. P. | 0 | 95.7 | 10.0 | 9.5 | 15.2 | 18.9 | 34.1 |
| | 2. SP | 1 | 10808 | 37.5 | 27.0* | 51.7 | 47.7 | 99.4 |
| | 3. ,, | 2 | 104.7 | 47.0 | 28.0* | 62.7 | 50.4 | 113.1 |
| | 4. FP | 1 | 105.1 | 53.0 | 28.5‡ | 71.3 | 46.5 | 117.9 |
| | 5. ,, | 2 | 107.0 | 48.5 | 24.0‡ | 67.0 | 37.3 | 104.3 |
| | 6. CP | 1 | 106.0 | 52.5 | 25.0‡ | 70.5 | 37.3 | 107.8 |
| | 7. ,, | 2 | 108.0 | 43.0 | 29.0† | 61.4 | 45.1 | 106.5 |
| II. Bombuwela sandy | 1. No. P | 0 | 98.6 | 32.5 | 20.5 | 52.3 | 51.9 | 104.2 |
| | 2. SP | 1 | 95.5 | 34.5 | 17.5 | 42.5 | 48.2 | 90.7 |
| | 3. ,, | 2 | 101.1 | 31.0 | 21.5 | 44.6 | 57.9 | 102.5 |
| | 4. ,, | 3 | 102.4 | 30.0 | 19.5 | 45.5 | 49.1 | 94.6 |
| | 5. FP | 1 | 111.1 | 41.0 | 23.5† | 59.9 | 57.1 | 117.0 |
| | 6. ,, | 2 | 111.3 | 40.5 | 27.0* | 67.5 | 63.3 | 130.8 |
| | 7. ,, | 3 | 112.7 | 39.5 | 23.5† | 64.4 | 48.9 | 113.3 |
| | 8. CP | 1 | 106.7 | 43.5 | 25.0‡ | 71.5 | 37.9 | 109.4 |
| | 9. ,, | 2 | 105.3 | 46.0 | 27.5‡ | 70.2 | 41.6 | 111.8 |
| | 10. ,, | 3 | 114.4 | 45.5 | 26.0† | 62.3 | 49.5 | 111.8 |
| | 11. FP+ CP | 2 | 112.5 | 48.0 | 25.0† | 63.5 | 56.0 | 118.5 |

*S/P—Saphos phosphate ; FP—fused magnesium phosphate ; CP—conc. super phosphate.

Chemicald amage by Endrin spray was marked with * to ‡ according to the grade of damage. Results of Combined analysis of variance using 7 treatments of three soils are as follows :

| | C.V. (%) | L.S.D.— 5% | 1% |
|---|---|---|---|
| Panicle yield : | 8.56 | 10.2 | 14.8 |

**TABLE 3.— Effect of forms and doses of phosphate fertilizers on growth and yield of rice. (Pot expts., Maha 1967-68, H-4)**

| | Soils used | Treatments* ($P_2O_5$, gm/pot) | | Plant height (cm) | Maximum tiller number | Panicle number | Yeild (gm/pot) Straw | Panicle | Total |
|---|---|---|---|---|---|---|---|---|---|
| III. | Bobmuwela humic | 1. No. P | 0 | 99.8 | 36.5 | 20.5 | 43.0 | 56.8 | 99.8 |
| | | 2. SP | 1 | 100.5 | 37.5 | 18.5 | 41.0 | 52.1 | 93.1 |
| | | 3. ,, | 2 | 104.5 | 35.5 | 19.5 | 45.3 | 52.7 | 98.0 |
| | | 4. FP | 1 | 101.2 | 38.5 | 26.0 | 53.9 | 64.4 | 118.3 |
| | | 5. ,, | 2 | 108.3 | 35.0 | 23.5 | 48.7 | 64.5 | 113.2 |
| | | 6. CP | 1 | 104.1 | 38.5 | 22.7 | 48.6 | 58.3 | 106.9 |
| | | 7. ,, | 2 | 105.9 | 40.5 | 27.0 | 55.0 | 63.3 | 118.3 |

**TABLE 4.—Effect of forms and doses of phoshpate on yield and yield components of rice.—C.A.R.I. clayey soil, Yala 1968, H–4**

| Treatment* No. | Longest panicle length (cm) | Number of panicles (per pot) | Effective tillers (%) | Yield (gm/pot) Straw | Panicle | Total | Grain | Grain-straw ratio (%) |
|---|---|---|---|---|---|---|---|---|
| 1. No P | 25 2 | 10.0 | 83 | 23.9 | 12.2 | 46.1 | 11.1 | 46 |
| 2. SAP–0.5 | 27.3 | 19.5 | 67 | 55.6 | 36.4 | 92.0 | 33.9 | 61 |
| 3. „ –1.0 | 26.9 | 22.7 | 73 | 58.4 | 39.2 | 97.6 | 36.4 | 62 |
| 4. „ –1.5 | 26.0 | 24.3 | 72 | 63.4 | 42.9 | 106.3 | 39.6 | 62 |
| 5. „ –2.0 | 26.6 | 22.0 | 73 | 60.9 | 38.1 | 99.0 | 35.3 | 58 |
| 6. FMP–0.5 | 26.8 | 22.0 | 80 | 55.0 | 37.4 | 92.4 | 34.9 | 63 |
| 7. „ –1.0 | 27.0 | 25.0 | 75 | 68.1 | 44.9 | 113.0 | 41.8 | 61 |
| 8. „ –1.5 | 27.7 | 23.4 | 64 | 68.0 | 48.6 | 116.6 | 45.3 | 67 |
| 9. „ –2.0 | 26.8 | 23.5 | 69 | 65.3 | 47.2 | 112.5 | 44.2 | 68 |
| 10. CSP–0.5 | 26.8 | 24.7 | 73 | 64.4 | 38.8 | 103.2 | 35.8 | 56 |
| 11. „ –1.0 | 27.4 | 23.0 | 75 | 63.4 | 41.7 | 105.1 | 39.2 | 62 |
| 12. „ –1.5 | 26.6 | 25.7 | 80 | 66.0 | 40.9 | 106.9 | 38.0 | 58 |
| 13. „ –2.0 | 26.5 | 26.3 | 71 | 65.4 | 49.0 | 114.4 | 42.5 | 65 |
| 14. CSP–2.0† | 26.5 | 29.7 | 76 | 91.2 | 49.2 | 140.4 | 45.1 | 49 |

*SAP—Saphos phosphate ; FMP—Fused Mg. phosphate ; CSP—Conc. Super phosphate

†Applied with higher dose of N and $K_2O$, (1.5 g. of each).

Analysis of variance on grain yields : C.V—7.44% ; L.S.D.—3.6 (1%) ; 2.6 (5%)

**TABLE 5.—Nutrient content in straw of rice plants grown in Panaliya clayey soil under varying forms and levels of phosphate applied to the soil (H–4, Maha 1967/68)**

| Treatments $P_2O_5$,gm/pot | N* % | $P_2O_5$ % | $K_2O$ % | CaO % | MgO % | $Fe_2O_3$ ppm | $SiO_2$ % | As % |
|---|---|---|---|---|---|---|---|---|
| No phosphate | 1.03 | 0.09 | 1.42 | 1.13 | 0.23 | 1610 | 3.76 | 6.84 |
| Saphosphos. | | | | | | | | |
| 1.0 | 0.66 | 0.12 | 1.07 | 1.05 | 0.31 | 1360 | 2.54 | 5.98 |
| 2.0 | 0.59 | 0.18 | 0.91 | 1.08 | 0.24 | 2500 | 2.14 | 5.19 |
| Fused Mg. phos. | | | | | | | | |
| 1.0 | 0.61 | 0.23 | 0.95 | 1.00 | 0.36 | 1040 | 3.31 | 6.57 |
| 2.0 | 0.60 | 0.33 | 1.00 | 0.95 | 0.34 | 720 | 4.44 | 7.36 |
| Conc. super phos. | | | | | | | | |
| 1.0 | 0.64 | 0.28 | 1.03 | 0.86 | 0.36 | 1610 | 2.23 | 5.00 |
| 2.0 | 0.65 | 0.34 | 1.00 | 0.93 | 0.33 | 2180 | 2.34 | 6.05 |

*Remarks :* * Figures are expressed on air-dry weight basis of the sample.



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**TABLE 6.—Effect of phosphate fertilizers on rice yields in field experiments (Maha crop 1967-68, H-4 and H-8)**

| *Number of locations* | *Forms of phosphate fertilizer* | *Mean grain yield (bushel/acre)* | *Yield difference (Bushel/acre)* | *Yield ratio (%)* |
|---|---|---|---|---|
| 5 Government Stations .. | Saphos phos. .. | 67.4 .. | – 5.5 .. | 93 |
| | Fused Mg phos. .. | 75.3 .. | + 2.4 .. | 102 |
| | Conc. s. phos. .. | 72.9 .. | 0 .. | 100 |
| 8 farmers' fields .. | Saphos phos. .. | 41.7 .. | – 19.6 .. | 68 |
| | Fused Mg. phos. .. | 68.2 .. | + 6.9 .. | 111 |
| | Conc. s. phos. .. | 61.3 .. | 0 .. | 100 |

*Remarks :* Standard application of fertilizers was as follows:—

Nitrogen—45 lbs. of N as ammonium sulphate or 39 lbs. of N as urea per acre as basal and top dressing.

Phosphorus—47 lbs. of $P_2O_5$ per acre as basal dressing.

Potassium—42 lbs. of $K_2O$ per acre as basal and top dressing.

**TABLE 7.—Effect of forms and levels of phosphate fertilizer on yield of rice in field experiments**

*Nikaweratiya clayey soil, Yala 1968—H-7*

| *Treatments* | | *Panicle length* | *Panicle number* | *Yield (per acre)* | | | *Yield ratio* |
|---|---|---|---|---|---|---|---|
| *Phosphate* | *$P_2O_5$ (lbs./acre)* | *(cm)* | *(sq. foot)* | *Straw (lbs.)* | *Grain (lbs.)* | *Grain (bushel)* | *of grain (%)* |
| Saphos phosphate .. | 0.. | 21.8.. | 20.0.. | 1888.. | 2794.. | 60.7.. | 100 |
| | 75.. | 22.4.. | 21.6.. | 1906.. | 2894.. | 62.9.. | 104 |
| | 150.. | 23.8.. | 23.7.. | 1950.. | 3124.. | 67.9.. | 112 |
| | 225.. | 23.8.. | 22.6.. | 2203.. | 3032.. | 65.9.. | 109 |
| Conc. super phosphate .. | 75.. | 22.9.. | 24.3.. | 2687.. | 3700.. | 80.4.. | 132 |
| | 150.. | 23.9.. | 24.8.. | 2449.. | 3853.. | 83.8.. | 138 |
| | 223.. | 22.5.. | 27.4.. | 2940.. | 4214.. | 91.6.. | 151 |
| Fused Mg. phosphate .. | 150.. | 23.8.. | 27.6.. | 3024.. | 4291.. | 93.3.. | 154 |
| *Bogamuwa loamy soil, Yala 1968, H-4* | | | | | | | |
| Saphos phosphate .. | 0.. | 26.7.. | 19.7.. | 3924.. | 2821.. | 61.3.. | 100 |
| | 75.. | 27.9.. | 20.7.. | 3915.. | 2802.. | 60.9.. | 99 |
| | 150.. | 30.0.. | 17.2.. | 4690 | 2994 | 65.1.. | 106 |
| | 225.. | 30.2.. | 16.9.. | 3867.. | 2859.. | 62.2.. | 101 |
| Conc. super phosphate .. | 75.. | 30.2.. | 21.7 | 5306 | 3377.. | 73.4.. | 120 |
| | 150.. | 28.9.. | 19.7.. | 5632.. | 3636.. | 72.5.. | 118 |
| | 225.. | 28.7.. | 21.5.. | 6064.. | 3099.. | 67.4.. | 110 |

Remarks :—Other fertilizers common to all treatments were as follows :—

Nitrogen (ammonium sulphate)—75lbs. of N per acre as split application

Potassium (Potassim chloride)—75 lbs. of $K_2O$ per acre as split application.

Analysis of variance on grain yieds at Nikaweratiya : C.V.—6.87% ; L.S.D.—5.4 (1%): 4.0 (5%).

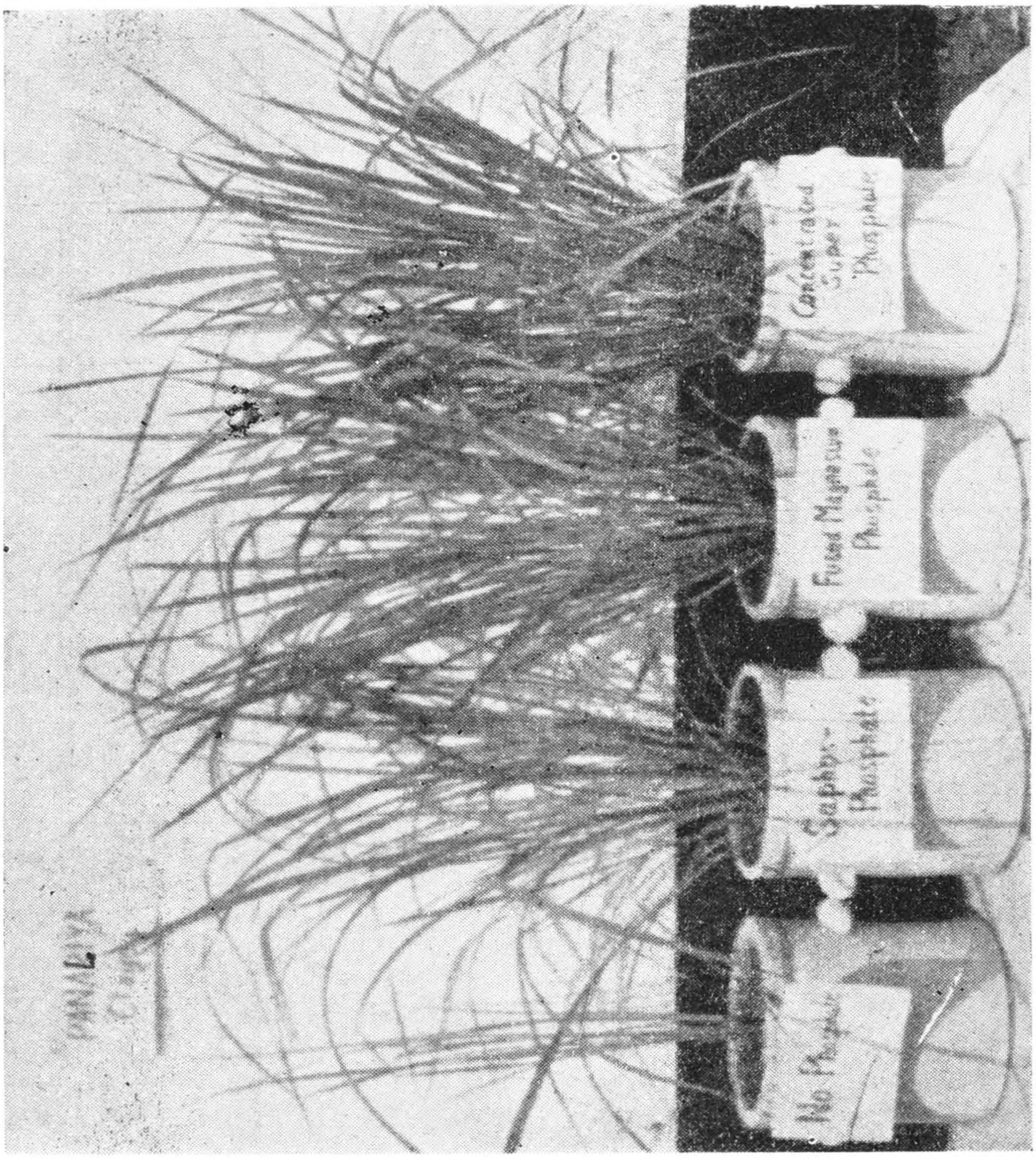


Fig. 1. Growth appearance of plants cultured in Panaliya clayey soil. (Maximum tiller number stage, from left to right. No phosphate, Saphos phosphate, fused magnesium phosphate and conc. superphosphate.)

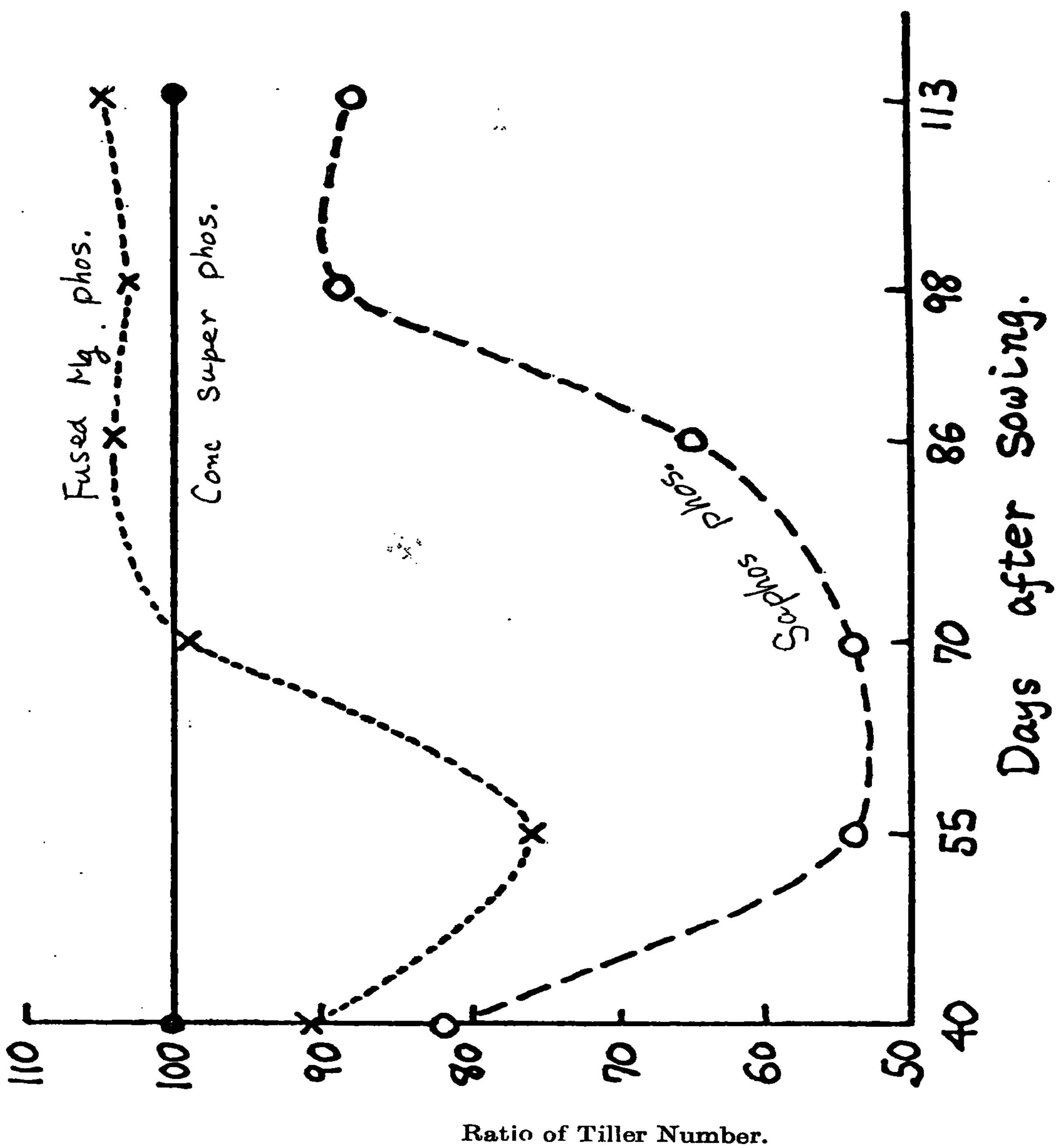


Fig. 2. Comparative growth of rice as affected by forms of phosphate.
(PANALIYA, Maha 1967-68, H-8.)

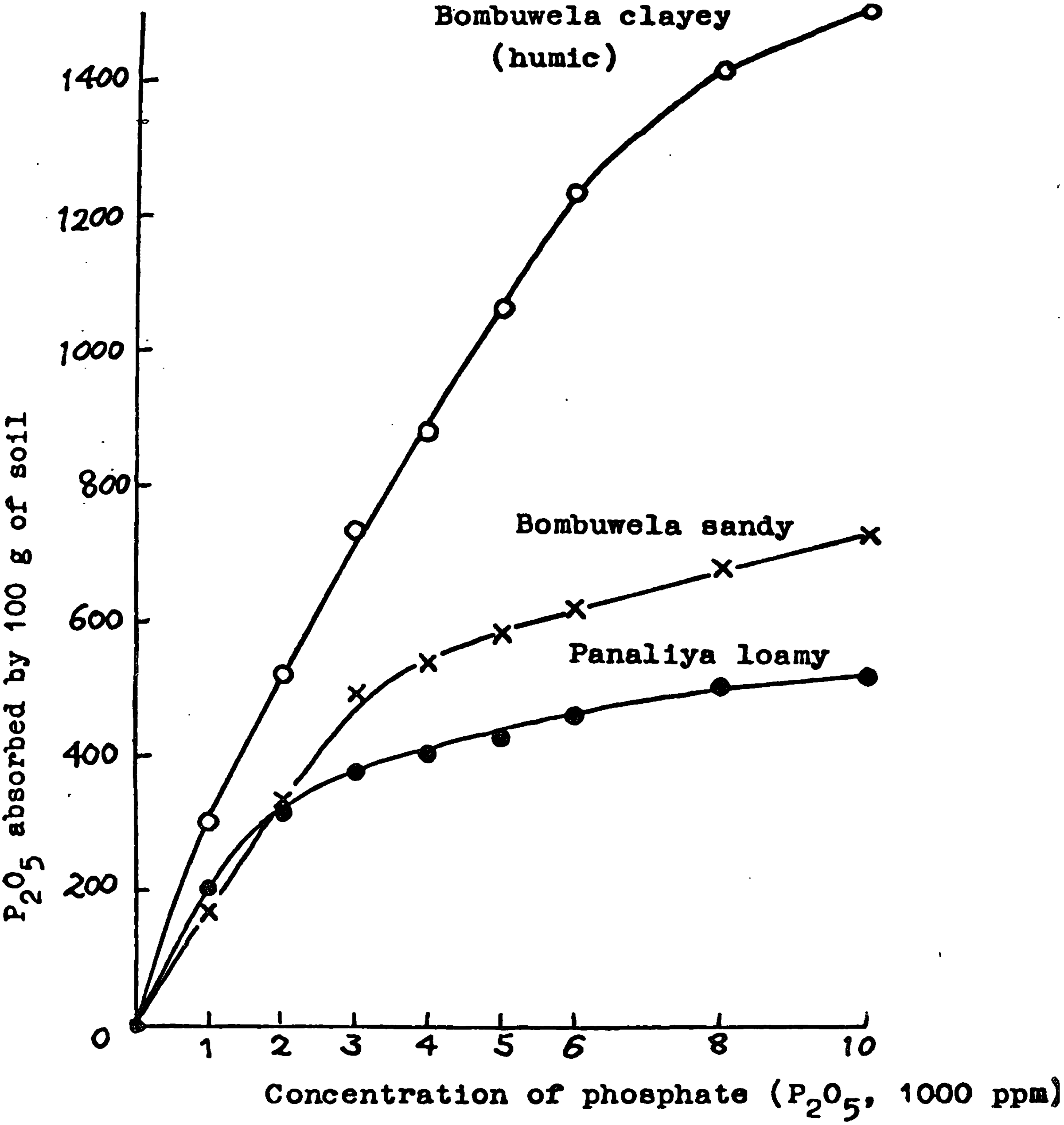


Fig. ?. Phosphate absorption by rice soils with increase of phosphate concentration in the reagent solution.