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THE INFLUENCE OF DIFFERENT LEVELS OF CALCIUM AND PHOSPHORUS ON THE GROWTH, YIELD AND COMPOSITION OF TWO HIGH YIELDING VARIETIES OF RICE, PADMA AND JAYA

BY

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri P.N.Sivan Nayar, under my direct supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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C O N T E N T S

INTRODUCTION

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Rice is the principal and probably the exclusive food of several million people in the Far East and more so for those in South India. It, thus being the basis of nutrition for a large section of the human race, plays a part of no small importance in the World's economy.

The Asian countries, though account for 90% of the rice area, have to import rice to meet the food requirements of their people. A major breakthrough in agricultural production is required so that our food output can keep pace with the accelerating tempo of population growth. Thus the problem of stepping up rice production in every conceivable way is one of supreme importance.

There is considerable emphasis these days on intensive cultivation for stepping up crop yields. One of the established measures of increased crop production is the introduction of improved varieties of crops. Much research during the last many years has, therefore, been concentrated towards the breeding of new varieties which are resistant to pests and diseases, as well as lodging, and are thus capable of producing high yields. As a result, about 300 superior varieties of rice alone are under cultivation in the different agro-climatic regions of India. Of late, it has been realised that more increase in crop yields is possible through increased use of fertilizers than by the introduction of new varieties alone. Consequently, efforts are being made to combine both these means of high crop production. In India and abroad it has been noted with great interest that various improved varieties differ among themselves in their nutritional requirements.

Calcium is generally credited with a dual role in acid soils. Its direct function is to correct soil acidity and improve the soil structure and thus create an environment suitable to the growth and development of roots. At the same time it also performs several indirect functions, such as stimulating the microbiological activity and increasing the availability of other nutrients. Within the plant too, calcium performs several important functions. It is known to be closely related to the growth of the meristems, development and functioning of the roots and is involved in the functioning of certain respiratory enzymes. Apart from these functions attributed to calcium, its effect on the availability of other nutrients to plants is also of immediate concern to the agronomist.

The importance of phosphorus availability in crop production is emphasized by the fact that a deficiency in this element, is very often a limiting growth factor in many soil types. The problem of phosphate fertilization is also complicated by the phenomenon of "fixation". At the same time it is a very critical element in nutrition in as much as it controls several vital metabolic processes within the plant.

More than 90% of soils of Kerala are acidic in reaction and very low in available phosphorus. The necessity of applying calcium and phosphatic fertilizers for ensuring the maximum yields from the newly introduced high yielding varieties cannot, therefore, be over emphasized. Of the new varieties introduced into Kerala in recent years Padma and Jaya need particular mention. Whereas Jaya is noted for its excellence even over IR-8 in the matter of yields, Padma is known for its eating-qualities and moderately high yields. Hence the present investigation was undertaken with a view to studying the influence of calcium and phosphorus applications on the growth, yield and nutrient uptake of these two varieties.

REVIEW OF LITERATURE

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The concept of liming acid soils to induce beneficial effects on the availability and utilization of both native and applied phosphorus is a widely accepted corner stone of good soil management.

Ford (1934) concluded from his studies that increase in base saturation and consequent decrease in acidity by liming played an important role in increasing the availability of soil phosphorus.

Cook and Miller (1935) suggested that the mineralization of organic phosphorus is encouraged by the application of calcium carbonate.

Pierre et al (1935) reported that liming results in depression of crop yields.

Davis and Brewer (1940) reported that liming of soils low in calcium enables the crops to utilize larger quantities of phosphorus when applied as super-phosphate.

According to Vanderford (1940) the phosphorus content and the total amounts of phosphorus removed by soya beans and clover increased with increasing quantities of calcium applied.

Ghani and Aleem (1942) reported regular increase of available phosphorus with application of lime and concluded that the greater availability was due to the decomposition of organic phosphorus brought about by a change in reaction favourable for microbial activity. The same view has been expressed by Venkita chalam and Mariakulandai (1954).

Koch (1943) suggested that in laterite soils poor in calcium the availability of phosphorus is increased by liming.

Bohne (1950) reported that application of lime either as $CaCO_3$ or CaO to acid sandy soils did not in all cases improve phosphate nutrition and that the favourable effect of lime on phosphate nutrition was the result of better and increased root growth.

Albrecht and Smith (1952) indicated that the principal effect of liming acid soils was the supply of calcium as nutrient for plants.

Rogers et al (1953), studying the comparative efficiency of various phosphatic fertilizers, reported that liming will decrease the effectiveness of raw phosphates especially for crops that are not strong feeders. Raw phosphates are of little or no value when applied to calcareous soils.

Gokhale <u>et al</u> (1954) concluded that liming increases the soluble phosphorus fraction and decreases the percentage of added phosphorus unavailable to plants in laterite soils.

According to Robertson <u>et al</u> (1954) lime application increases the availability of applied phosphorus in soils having a high content of sesquioxides. There is no such effect, however, in soils with a low amount of sesquioxides.

Dhar and Singh (1955) attributed the increased availability of phosphorus due to liming to better oxidation of organic matter in alakaline medium.

Ekman (1955) concluded that liming stimulated the mineralisation of organic phosphorus compounds and reduced fixation of phosphorus.

The experiments conducted by Mandal <u>et al</u> (1955) also showed that paddy crop did not respond to liming.

Mariakulandai (1955) concluded that liming acid soils of Nanjinad markedly increased the availability and uptake of phosphorus by potato.

Balks (1956) reported that easily available calcium phosphates were formed under favourable conditions of soil reaction which is created by liming.

According to the investigations carried out by Doring (1956) heavy application of lime might lead to the formation of difficultly soluble calcium phosphate, though the addition of small amounts might increase the availability of sorbed phosphorus.

Florell (1956) obtained evidence that calcium favoured the formation of, and increased the protein content of, mitochondria. In view of the role of mitochondria in aerobic respiration and hence salt uptake a direct relationship between calcium and uptake of ions in general was indicated.

In the detailed studies conducted by Lawton and Davis (1956) successive increments of $CaCO_3$ decreased the available phosphorus and this decrease was due to the reduction of the ratio of $H_2PO_4^-$ to $HPO_4^=$ ions in the soil. Similar findings were also recorded by Neller (1953) and Robertson and Neller (1954).

Throps and Hobbs (1956) found increased uptake of phosphorus by plants from limed soils.

Degochi et al (1958) reported that heavy basal liming impeded tillering and decreased yield.

Gupta (1958) reported that the beneficial effects of liming was a maximum at earlier stages of growth and a minimum at the flowering stage.

Goralski and Moskal (1960) reported from the investigations on the influence of liming on phosphorus and calcium uptake, that application of $CaCO_3$ and CaO more than doubled the utilization of phosphorus from superphosphate and increased the uptake of soil phosphorus.

Koshy (1960) concluded from his experiments on three major soil types of Tennessee with sorghum as the test plant, that addition of lime and phosphate to the soil raised the soil pH, availability of phosphorus and total yield, although the rates of increase were different in the three soils.

Maleina (1960) reported that systematic application of phosphatic fertilizers increased the available phosphorus in the soil. Liming did not increase the total reserve of phosphorus but increased its availability.

Rai *et al* (1963) on studying the effects of lime on the production of upland crops found that liming increased the uptake of P_2O_5 by plants and the absorption was still higher when lime was added in conjunction with phosphatic fertilizers.

Mandal (1964) from his studies concluded that the use of lime followed by the application of organic matter might increase the availability of soil phosphorus under water-logged conditions.

Muliyar (1965) concluded that there was no significant effect for calcium on the height of plants.

Borlan and Militescu (1966) reported that liming increased the mobility of nitrogen and phosphorus and decreased that of potassium and boron.

Ito and Fujiwara (1966) in studies on calcium nutrition of rice plants reported that in calcium deficient media growth was poor. Calcium contents of plants increased with increasing calcium supply being highest at harvest.

Kurup (1967) from his fertility investigations of rice soils of Kuttanad concluded that phosphorus availability was maximised when lime at full lime requirement was applied.

Laker (1967) from his studies reported that previous application of lime stimulated phosphorus uptake though it had no significant effect on plant growth. Lime did not increase the soil available phosphorus reserves, but decreased its sorption capacity.

Mathen and Durairaj (1967) reported an increase in available phosphorus in Nilgris soils due to liming.

McLean and Balam (1967) reported that acidulations beyond 10% in soils less than 1/3rd calcium saturated and beyond 50% in soils 1/3 - 3/4 calcium saturated were not generally significantly beneficial to phosphorus uptake and percentage recovery of added phosphorus by maize.

In a greenhouse experiment Brown and Hills (1968) found that the application of lime depressed the growth of sugarbeet. Phosphorus and potassium applications had more beneficial effect than liming on this crop.

Edwards (1968) reported from his studies that the rate of phosphorus absorption by intact plants was markedly increased by increasing the calcium concentration of the nutrient solutions. The results indicated the role of low concentrations of calcium and magnesium on phosphorus absorption by plants grown in nutrient solution.

Loneragan et al (1968) have reported that on laterite gravelly sand the calcium concentration of the tops of 21 species of annuals was reasonably well correlated with published figures for the C.E.C. of roots. Dicotyledonus plants tended to have high calcium concentrations and C.E.C. values, whereas monocots had low values.

Patnaik et al (1968) from their studies using different liming and phosphorus materials in an acidic lateritic soil concluded that the addition of liming materials increased the availability of applied phosphorus as measured by soil content and plant uptake.

Sheldecker (1968) from his experiments on tomato reported that an indirect calcium deficiency was established induced by the relatively high potassium concentration. He concluded that low rates of calcium translocations to the aerial parts rather than inadequate uptake by roots, was responsible for the disturbances noted.

Sekiya (1968) suggested that prolonged calcium deficiency adversely affected the development of tiller buds.

Singh and Gangwar (1968) reported no correlation between available phosphorus and calcium phosphate in both low and upland soils.

Kabeerathumma (1969) reported a notable increase in the uptake of the major nutrients with increasing doses of lime by rice variety Culture 28.

Parish and Miller (1969) concluded that low levels of phosphorus accelerated maturity irrespective of calcium concentrations and that high levels of phosphorus delayed maturity. The converse was true of calcium. They have also indicated that the effects of phosphorus tended to dominate over those of calcium.

Mane et al (1969) reported that application of nitrogen, phosphorus and nitrogen + phosphorus increased the C.E.C. of roots of maize and French bean. The influence of nitrogen on root C.E.C. in maize was more marked than that of phosphorus application in French bean. The relationship between root C.E.C. and calcium content on plant tops was evident according to Donnan distribution.

Murrmann and Peech (1969) concluded from their studies that the amount of labile phosphate in soil reached minima at about pH 5.5 and rapidly increased as the pH was either increased or decreased. Their results indicated that phosphorus concentration in the soil solution was determined by the amount of labile phosphate rather than by the solution of crystalline phosphate.

The role of phosphorus in fertilising crops in our country was not properly understood till recently. It was generally believed that our soils are adequately supplied with phosphorus because response to phosphatic manuring had not been observed uniformly in all the States.

Sethi (1940) has reported that experiments conducted for 5 years showed no response to P_2O_5 applied singly or in combination. Several other experiments conducted at different places (Berhampur, Pattambi etc.) also showed no response.

Stewart (1947) pointed out that in many States the lack of response to phosphorus manuring might have been due to improper method of application.

But Dabin (1951) Parthasarathy (1953) and Desai <u>et al</u> (1954) reported significant increase in yield when phosphorus was applied in combination with nitrogen.

Siregar (1955) from Indonesia and Chandraratna (1957) from Ceylon also recorded no response to phosphatic fertilizers.

Nigar and Mandal (1957) did not find any significant increase in yield due to application of phosphorus for the first three years, but from the fourth year onwards significant increase in yield was recorded.

Reviewing the experiments conducted in Madras State, Mariakulandai (1957) reported no response for rice to phosphorus when applied alone, but when applied along with other nutrients like nitrogen there was an increased response to these nutrients.

Takajima et al (1959) reported that increased rates of phosphorus application accelerated tillering but inhibited panicle growth.

Verma (1960) noticed marked increase in grain yield when phosphorus was applied along with nitrogen. He also found that phosphorus, when applied alone, increased the yield but the differences were not significant.

Mahapatra (1961) reported no response to phosphorus by eight indica varieties of rice during the main season in Orissa.

Russel (1961) suggested that an excess of phosphorus over the actual requirement may depress crop yields.

Reviewing the factors affecting the uptake of phosphorus by rice Simpson (1961) has reported a strong positive interaction between the rates of applied nitrogen and the rates of applied phosphorus on the uptake of phosphorus, both the soil and fertilizer phosphorus uptake being affected.

From an experiment conducted at Bagwai, Madhya Pradesh, to study the response of three rice varieties to three different levels of P_2O_5 Verma (1961) concluded that the improved varieties tried gave higher response than the local variety.

The role of phosphorus in various metabolic activities in the plant was stressed by Wallace (1961).

Reviewing the phosphorus fertilization of paddy, Davide (1964) concluded that unless a soil is deficient in phosphorus, yield response to addition of phosphatic fertilizers in field experiments could not be obtained.

Fujiwara (1964) reported that a low supply of phosphorus suppressed protein synthesis in plants. High supplies of this element increased the contents of nucleic acid phosphorus and phospholipid phosphorus. Nucleic acid actually promotes heading in rice as it controls the vegetative growth through protein biosynthesis and reproductive growth through flower initiation.

Ishizuka (1964) observed that after flowering the phosphorus content in the leaves and culm began to move to the grain. He has concluded that there is a close relationship between carbohydrate metabolism and phosphorus uptake.

Kasai and Asada (1964) reported that at maturity 80% of the phosphorus in the entire plant was in the grain. Using isotope P^{32} these workers were able to find out that 60-80% of the total phosphorus absorbed at each stage of growth was translocated to the grain.

Potti (1964), reviewing the fertilizer experiments at the various rice research stations in Kerala has reported a nil response to phosphorus.

Dagi (1965) reported that the average response to phosphorus was only half that of nitrogen.

Mariakulandai and Thyagarajan (1965) also reported a nil to non-significant response to phosphorus at the rate of 40 lbs P_2O_5/acre for Kuruvai crop.

Patnaik et al (1965) concluded that the phosphorus absorbed beyond the tillering stage tended to accumulate in the grain, straw and roots with no advantage to grain production.

Srinivasulu and Pawar (1965) from their studies on the influence of N, P and K on some of the quantitative characters of two indica x japonica hybrids concluded that phosphorus has no significant influence on the number of tillers, length of panicle, percentage of filled grains, weight of 1000 grains and the yield of grain and straw.

According to Tamhane et al (1965) phosphorus increases the number of tillers, number of productive tillers and the ratio of grain to straw in cereals.

Kalam et al (1966) from the experiments conducted at Karamana has reported the absence of direct or cumulative effects for phosphorus.

Moolani and Sood (1966) found that paddy yield declined with increasing rates of phosphorus application and this adverse effect was lessened by applications of nitrogen.

Reviewing a series of experiments conducted from 1936 - 1941 in Mysore State, Raheja (1966) has reported a nil or non-significant response to phosphorus application, similarly from the results of experiments conducted in Madras State from 1959 - 1963 Mariakulandai and Chami (1967) have reported a non-significant response to phosphorus by rice when applied through legumes.

Mustafa and Durairaj (1967) reported that in a pot experiment conducted to study the influence of various forms and doses of phosphorus, all phosphorus treatments increased phosphorus uptake by grain but there was no significant difference between treatments.

Park (1967) in his studies on varietal differences in nutrient absorption by rice has reported that there was no difference in nitrogen and phosphorus uptake by different varieties of paddy in normal, humus-rich or poor sandy soils.

Singh and Pancholy (1967) concluded that phosphorus uptake increased with increasing rates of phosphorus application upto 90 kg/hectare. Total phosphorus uptake increased with age reaching a maximum at harvest.

Singh (1967) reported that phosphorus fertilization did not modify grain and straw yields and other yield attributes in wheat barring total shoots (which decreased with increasing levels of phosphorus) and number of grain/earhead (which was maximum at the initial level of phosphorus).

Volke and Inostroza (1967) reported that in a factorial experiment, nitrogen and phosphorus improved tillering but reduced the number of grain/earhead in winter wheat. Phosphorus increased and nitrogen decreased the 1000 grain weight. It was also shown that both and nitrogen and phosphorus increased yield which was positively correlated with tillering and plant height and negatively correlated with number of grains/earhead.

Lodha <u>et al</u> (1969) from their studies on the effect of phosphorus application on wheat found that the yield increased significantly with applied phosphorus over no phosphorus and that the NPK contents were highest at the flowering and milky stages.

Naphade (1969) has concluded that rice showed a significant positive response to phosphorus and that the plant uptake of phosphorus increased with the increase in native and applied phosphorus. There was a significant positive correlation between grain yield and the total uptake of this element.

From studies on the effect of graded doses of phosphorus in conjuction with lime on rice, Suseelan (1969) has reported that increasing the levels of phosphorus application resulted in increased contents of P_2O_5 in grain and straw.

Tiwari and Singh (1969) reported that phosphate application had positive significant response on yield, plant height, tiller number and number of grains/earhead. But there was no effect on the weight of 1000 grains.

MATERIALS AND METHODS

MATERIALS AND METHODS

A pot culture experiment was designed to study the influence of different levels of calcium and phosphorus separately and in combinations on the growth and yield characters, as well as the nutrient uptake and composition of two varieties of rice, Padma and Jaya. The details of the experiment are furnished below.

1. Varieties	V1	.. Padma
	V2	.. Jaya
2. Levels of calcium	C_o	.. 0 kg CaO/ha
	C_1	.. 500 "
	C_2	.. 1000 "
	C_3	.. 2000 "
3. Levels of phosphorus	P_o	.. 0 kg P_2O_5/ha
	P_1	.. 25 "
	P_2	.. 50 "
	P_3	.. 100 "

A completely randomized design with three replications was used for the experiment. The various treatment combinations were as follows.

		V1	V2
1.	..	P_oC_o	P_oC_o
2.	..	P_oC_1	P_oC_1
3.	..	P_oC_2	P_oC_2
4.	..	P_oC_3	P_oC_3
5.	..	P_1C_o	P_1C_o
6	..	P_1C_1	P_1C_1
7	..	P_1C_2	P_1C_2
8	..	P_1C_3	P_1C_3
9	..	P_2C_o	P_2C_o
10	..	P_2C_1	P_2C_1
11	..	P_2C_2	P_2C_2
12	..	P_2C_3	P_2C_3
13	..	P_3C_o	P_3C_o
14	..	P_3C_1	P_3C_1
15	..	P_3C_2	P_3C_2
16	..	P_3C_3	P_3C_3

The soil used was collected from the kayal lands attached to the Agricultural College, Vellayani. The mechanical and chemical composition of the soil are given in Table I

TABLE I (a)

Mechanical composition of the soil used for the pot culture experiment

Coarse sand	..	37.8%
Fine sand	..	13.6%
Silt	..	9.2%
Clay	..	34.2%

TABLE I (b)

Chemical characteristics of the soil

pH	..	5.3
Moisture	..	1.72%
Loss on ignition	..	1.52"
N	..	0.192%
P_2O_5	..	0.041%
K_2O	..	0.153%
CaO	..	0.098%
MgO	..	0.032%
C.E.C.	..	4.38 me./100 g
Lime requirement	..	2000 kg CaO/ha

Earthenware pots of uniform size of 6" x 10" were used for the experiment. Six kg of the air dry soil was weighed into each pot. Lime at the required rates was then added into each pot and mixed well with the soil. After three days the required amounts of P_2O_5 were also added in the form of superphosphate. (16% P_2O_5). The soil in each pot was then puddled by the addition of tap water and 25 day old seedlings were planted on 6.11.1969 at the rate of 2 plants/pot. The seedlings were raised from seeds obtained from the Central Rice Research Institute, Cuttack in two separate pots.

Nitrogen and potash were applied in split doses at the rate of 100 kg nitrogen and potash/ha each as ammonium sulphate (20% N) and muriate of potash (60% K_2O) 50% as basal, 25% as top dressing 20 days after planting on 26.11.1969 and the remaining 25% after a further period of 20 days on 16.12.1969.

Controlled irrigation was given to the pots at a uniform rate and optimum moisture conditions were maintained throughout the experiment.

The pots were kept free of weeds. The plants were sprayed with paramar as a prophylactic measure against stem-borer attack.

Variety V1 (Padma) was harvested on 25.1.1970 (106 days) and variety V2 (Jaya) harvested on 15.2.1970 (127 days).

The grain and straw from each pot were placed in separate paper bags and dried in an air oven at 70°C. The yields of grain and straw were recorded separately. The grain and straw were ground in an electric grinding mill and stored in air tight plastic containers for chemical analysis.

<u>Plant performance studies</u>

The following observations were made regarding the growth and yield characteristics of the two varieties for the various levels of calcium and phosphorus:-

1 Number of tillers per plant as on the 45th day after sowing
2 Number of productive tillers as on 90th day after sowing
3 Height of plant as on the 75th day after sowing
4 Length of earhead
5 Yield of grain/pot

6. Yield of straw/pot
7. Grain-straw ratio, and
8. Weight of 1000 grains.

Laboratory studies

Chemical analysis of the plant materials, both grain and straw, was carried out using standard analytical methods as given in Piper (1950) and Jackson (1967).

Nitrogen and phosphorus were determined colorimetrically using a Klett Summerson photo electric colorimeter in the triple acid extract.

Potash was determined using an EEL flame photometer and calcium and magnesium by the Versenate titration method as described by Jackson (1967).

The data obtained were analysed statistically and the results recorded.

RESULTS

RESULTS

The experimental results relating to the influence of different levels of calcium and phosphorus on the growth, yield, nutrient content and uptake of nutrients by rice are given below.

A. GROWTH

The data relating to the influence of different levels of calcium and phosphorus on the growth characters such as number of tillers, productive tillers, height of plant and length of earhead are presented in Tables II and III.

1. Number of tillers

The results in Table II for variety Padma indicate that the differences between the levels of calcium as regards this character are not statistically significant. The response to different levels of phosphorus and the combination between the two are also not statistically significant.

However, it may be noted that the largest number of tillers (10.2) was produced at the highest level of calcium application viz., 2000 kg CaO/ha and the lowest (9.4) at the 500 kg CaO/ha level. The other two levels gave intermediate results. Of the different levels of phosphorus tried 25 kg P_2O_5/ha gave the maximum number of tillers (10.3) and the 0 level the minimum (9.6). In variety Jaya (Table III) an application of calcium at 1000 kg CaO/ha produced the largest number of tillers (9.5) while the lowest number (8.5) was obtained for the no calcium treatment. Of the different phosphorus treatments an application of phosphorus at 25 kg P_2O_5/ha produced the maximum number of tillers per plant (9.7) and the 0 treatment the minimum (8.3).

2. <u>Productive tillers</u>

From Table II it may be noted that the number of productive tillers was not influenced by the different levels of calcium, phosphorus or their combinations. Of the different levels of calcium tried 1000 kg CaO/ha was found to be the most effective (9.9) and 500 kg CaO/ha, the least effective (8.8). As regards the different levels of phosphorus tried 50 kg P_2O_5/ha has given the best result (9.7) and the 0 treatment the lowest (8.7).

In variety Jaya (Table III) also the largest number of tillers (7.1) was obtained for a calcium application of 1000 kg CaO/ha, whereas the lowest number (6.1) was obtained for the no calcium treatment. Similarly phosphorus at 100 kg P_2O_5/ha produced the largest number (6.9) of tillers per plant and the zero level the lowest number (6.1).

3. Height of plant

For variety Padma the maximum height of 66.7 cm was obtained at an application of calcium at 2000 kg CaO/ha and for Jaya the maximum height of 69.2 cm was reached for the calcium application at 1000 kg CaO/ha. The lowest plant heights, viz., 63.8 cm and 63.4 cm, in the two varieties were for the treatments of 500 kg and 0 kg CaO/ha respectively. Of the different levels of phosphorus tried the maximum height (66.5 cm) was recorded for 100 kg P_2O_5/ha and the minimum (63.9 cm) for 50 kg P_2O_5/ha in variety Padma. For variety Jaya the heighest (70.0 cm) and lowest (64.0 cm) plant heights were obtained for phosphorus applications of 100 kg P_2O_5/ha and 50 kg P_2O_5/ha respectively.

4. Length of earhead

The length of earhead in variety Padma was seen influenced by the different levels of calcium, phosphorus and their combinations. An application of 1000 kg CaO/ha gave the maximum length (18.3 cm) and the 0 level of calcium the minimum (16.5 cm). As for the effect of phosphorus on this character, a level of 100 kg P_2O_5/ha produced the longest earheads (18.9 cm) and the 0 treatment the shortest (15.7 cm).

Of the various levels of calcium tried, an application of 2000 kg CaO/ha produced the longest earheads (20.8 cm) and the no calcium treatment the shortest (18.4 cm) in variety Jaya. As for the effect of phosphorus on this character P_2O_5/ha at 100 kg gave the longest earheads (21.0 cm) and the 0 level the shortest (17.3 cm) in this variety.

TABLE II

Influence of different levels of calcium and phosphorus on the growth characters of rice, variety - Padma

Levels of lime kg/ha.	Levels of P_2O_5 kg/ha	Growth characters			
		No.of tillers per plant.	No.of productive tillers.	Height of plant. cm	Length of earhead. cm
0	0	10.0	8.7	64.4	12.7
	25	10.1	9.3	67.3	16.7
	50	10.1	8.7	61.5	18.1
	100	10.0	8.7	66.7	18.6
	Mean	10.05	9.0	64.9	16.5
500	0	10.0	9.3	64.0	13.7
	25	9.0	8.0	62.0	18.0
	50	9.3	9.7	63.3	17.8
	100	9.0	8.3	66.0	18.2
	Mean	9.4	8.8	63.8	16.7
1000	0	10.1	9.3	64.0	19.0
	25	12.0	9.7	68.0	17.6
	50	11.0	10.0	66.3	16.9
	100	11.0	10.7	66.3	19.6
	Mean	11.0	9.9	66.1	18.3
2000	0	8.5	8.0	67.5	17.5
	25	10.1	10.7	67.0	18.2
	50	12.0	10.5	64.5	15.7
	100	10.1	10.0	67.0	19.4
	Mean	10.2	9.8	66.7	17.7
All levels	0	9.6	8.7	65.3	15.7
	25	10.3	9.4	66.1	17.6
	50	10.2	9.7	63.9	17.1
	100	10.0	9.4	66.5	18.9
C.D.at 5% level		N.S.	N.S.	N.S.	1.021

TABLE III

Influence of different levels of calcium and phosphorus on growth characters of rice, variety - Jaya

Levels of lime kg/ha	Levels of P_2O_5 kg/ha	Growth characters			
		No. of tillers per plant	No. of productive tillers	Height of plant cm	Length of earhead cm
0	0	8.7	5.3	61.7	15.0
	25	8.3	6.3	65.3	19.6
	50	7.7	5.7	56.3	18.6
	100	9.3	7.0	70.0	20.6
	Mean	8.5	6.1	63.4	18.4
500	0	7.7	5.7	64.7	16.1
	25	9.3	6.0	67.3	19.2
	50	9.3	7.3	66.0	18.2
	100	8.0	6.3	71.0	20.4
	Mean	8.6	6.3	67.7	18.5
1000	0	8.0	6.3	67.3	18.0
	25	11.7	7.7	72.7	18.3
	50	10.0	7.7	68.0	20.7
	100	8.3	6.7	69.0	21.1
	Mean	9.5	7.1	69.2	19.5
2000	0	8.9	7.3	67.0	20.3
	25	9.7	6.7	72.3	17.8
	50	7.7	6.0	65.7	22.3
	100	10.7	7.7	69.0	22.1
	Mean	9.2	6.9	68.5	20.8
All levels	0	8.3	6.1	65.2	17.3
	25	9.7	6.7	69.9	18.6
	50	8.7	6.7	64.0	19.9
	100	9.1	6.9	70.0	21.0
C.D. at 5% level		N.S.	N.S.	N.S.	1.429

B. YIELD

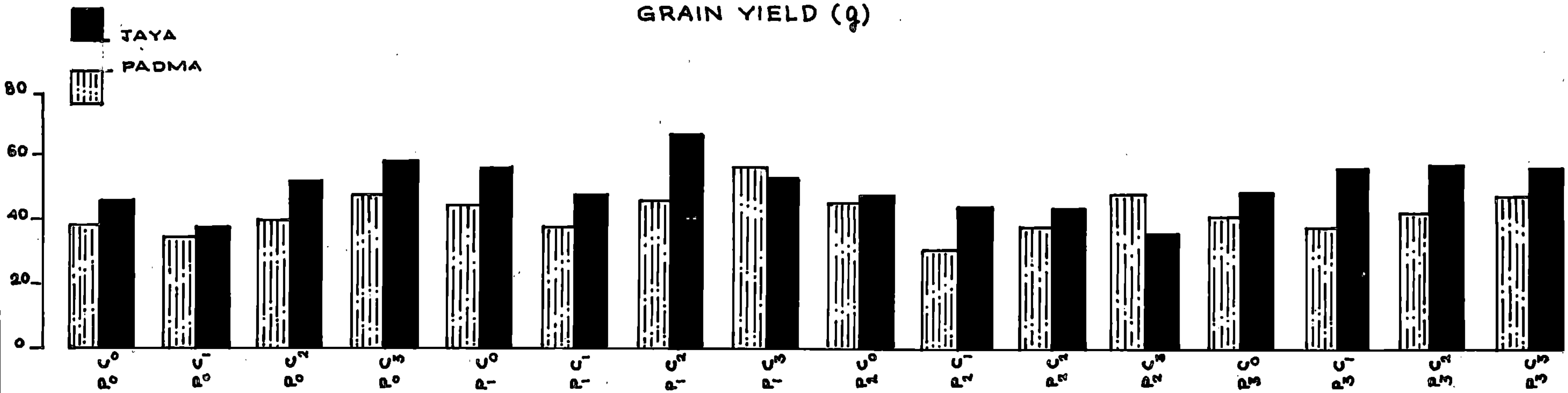
The results relating to the effect of different levels of calcium and phosphorus on yield characters, such as weight of grain, weight of straw, grain-straw ratio and the weight of 1000 grains are presented in Tables IV and V.

1. Yield of grain

Considerable differences exist among the four levels of calcium and phosphorus tried in the experiment in influencing the yield of grain, though these differences were not statistically significant. Calcium at the rate of 2000 kg CaO/ha was seen to be superior to all the other levels tried. The highest yield recorded per pot (40.4 g) was for this level of calcium application and the lowest (30.5 g) for an application of 500 kg CaO/ha. As regards the effect of phosphorus, the best results were obtained for an application of P_2O_5 at 25 kg/ha (39.7 g/pot) and the lowest for the level of 50 kg P_2O_5/ha (32.6 g/pot).

In the case of variety Jaya (Table V) the situation was slightly different. Calcium application at the rate of 1000 kg CaO/ha gave the highest yield

GRAIN YIELD (g)



STRAW YIELD (g)

FIG 1a

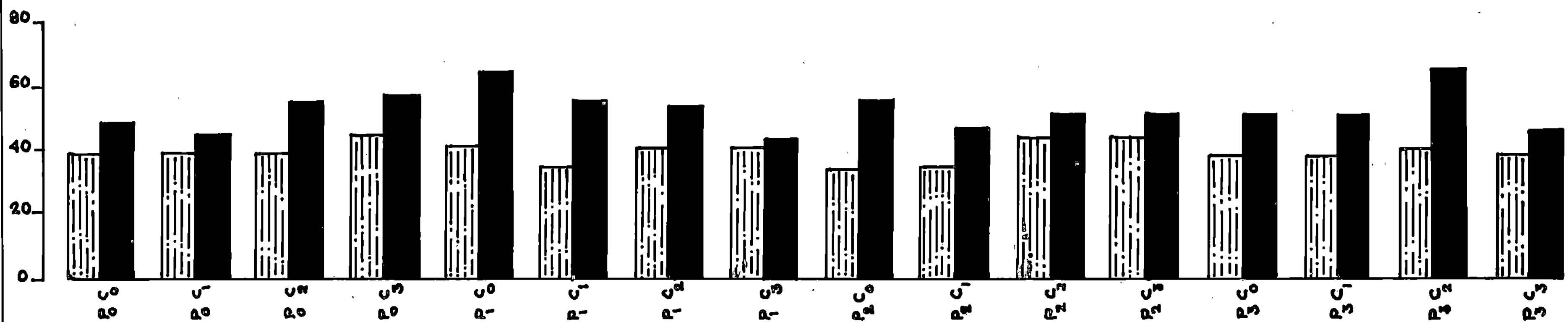


FIG: 1b

(50.8 g/pot) and 500 kg CaO/ha the lowest (39.2 g/pot). The effect of phosphorus on this variety was, however, similar to that on Padma. The highest yield of 47.9g/pot was obtained for a phosphorus application of 25 kg P_2O_5/ha and the lowest (34.3g/pot) for an application of 50 kg P_2O_5/ha. The differences were also statistically significant. In both varieties P_2O_5 application above 25 kg P_2O_5/ha gave no response. On the contrary, phosphorus at high levels tended to decrease the yield of grain.

2. Yield of straw

The yield of straw was not significantly influenced by either calcium or phosphorus. However, the results in Table IV reveal that the highest yield (34.2 g/pot) in variety Padma was obtained for a calcium application of 1000 kg CaO/ha and the lowest (30.9g/pot) for the calcium level of 500 kg CaO/ha. As for phosphorus the highest yield (33.2 g/pot) for this variety was obtained for an application of 100 kg P_2O_5/ha and the lowest (32.1 g/pot) for an application of 50 kg P_2O_5/ha. In the case of Jaya the highest yield (47.3g/pot) was obtained at the calcium application rate of 1000 kg

CaO/ha and the lowest (41.3g/pot) at 500 kg CaO/ha. As regards the effect of phosphorus the highest yield (45.6g/pot) was obtained for the treatment 25 kg P_2O_5/ha and the lowest (42.9g/pot) for 50 kg P_2O_5/ha.

3. Grain-straw ratio

The grain-straw ratio was not significantly influenced by the various treatments. Of the different levels of calcium tried the rate of 2000 kg CaO/ha produced the highest ratio of 1.18 followed by 1.10, for no calcium, 1.06 for 1000 kg CaO/ha and 1.01 for 500 kg CaO/ha in variety Padma. Among the different levels of phosphorus tried an application of 25 kg P_2O_5/ha induced the highest grain-straw ratio of 1.22, whereas the lowest ratio of 1.01 was obtained for the no phosphorus treatment.

In variety Jaya the grain-straw ratio was found to increase steadily with increasing levels of calcium application. For the no calcium treatment the ratio was 0.86 which increased to 0.95, 1.01 and 1.20 respectively, when calcium was applied at the rates of 500, 1000 and 2000 kg CaO/ha. The effect of phosphorus on this ratio was not so regular. The highest ratio of 1.13 was recorded for a phosphorus application of 25 kg P_2O_5/ha and the lowest for an application of 50 kg P_2O_5/ha.

4. Weight of thousand grains

This character was significantly influenced by treatment in both varieties. In variety Padma the highest weight of 20.8 g for 1000 grains was obtained for a calcium application of 2000 kg CaO/ha and the lowest weight of 19.6 g for 1000 grains was for a calcium application of 500 kg CaO/ha. In the case of phosphorus the weight of grain increased steadily with increasing rates of phosphorus application. Thus the 1000 grain weight increased from 18.2 g for the no phosphorus treatment to 21.9 g for an application of 100 kg P_2O_5/ha through 19.6 g for 25 kg P_2O_5/ha and 20.8 g for 50 kg P_2O_5/ha.

In variety Jaya the weight of grain increased progressively with increased application of calcium. The weight of thousand grains was 19.3 g for the no calcium treatment which increased to 20.0 g for an application of 500 kg CaO/ha, to 21.2 g for 1000 kg CaO/ha and to 22.5 g for 2000 kg CaO/ha. The highest weight of 23.7 g for 1000 grains was obtained for the phosphorus application of 100 kg P_2O_5/ha and the lowest weight of 17.1 g for the no phosphorus treatment.

TABLE IV

Influence of different levels of lime and phosphorus on yield characters of rice, variety - Padma

Levels of lime kg/ha	Levels of P_2O_5 kg/ha	Yield characters			
		Wt.of grain g/pot	Wt.of straw g/pot	Grain-straw ratio	Wt. of 1000 grains g
0	0	31.8	31.8	1.00	18.6
	25	37.1	35.1	1.05	18.5
	50	38.6	29.3	1.31	21.0
	100	34.8	32.7	1.06	21.8
	Mean	35.8	32.2	1.10	20.0
500	0	29.9	33.0	0.94	16.8
	25	33.2	29.3	1.16	19.8
	50	26.5	25.3	0.94	20.7
	100	32.4	32.8	0.99	21.3
	Mean	30.5	30.9	1.01	19.6
1000	0	36.7	33.2	1.06	18.5
	25	39.6	33.3	1.17	19.5
	50	32.9	36.3	0.90	20.8
	100	36.3	34.0	1.05	22.2
	Mean	35.7	34.2	1.06	20.2
2000	0	37.0	34.0	1.08	19.2
	25	48.2	33.5	1.45	20.5
	50	32.2	35.0	0.97	20.8
	100	40.3	33.2	1.21	22.6
	Mean	40.4	33.8	1.18	20.8
All levels	0	33.8	33.0	1.01	18.2
	25	39.7	32.8	1.22	19.6
	50	32.6	32.1	1.03	20.8
	100	35.9	33.2	1.08	21.9
C.D.at 5% level		N.S.	N.S.	N.S.	0.715

TABLE V

Influence of different levels of lime and phosphorus on yield characters of rice, variety - Jaya

Levels of lime kg/ha	Levels of P_2O_5 kg/ha	Yield characters			
		Wt. of grain g/pot	Wt. of straw g/pot	Grain-straw ratio	Wt. of 1000 grains g
0	0	38.3	40.5	0.95	16.7
	25	48.2	54.2	0.90	20.8
	50	32.5	49.5	0.62	19.0
	100	41.3	42.0	0.98	20.6
	Mean	40.8	46.3	0.86	19.3
500	0	31.6	37.7	0.85	18.7
	25	40.3	46.5	0.88	20.5
	50	37.3	38.5	0.97	18.3
	100	47.5	42.7	1.11	22.7
	Mean	39.2	41.3	0.95	20.0
1000	0	44.6	46.3	0.97	14.0
	25	56.5	45.3	1.32	26.3
	50	36.6	43.2	0.87	20.4
	100	48.5	54.5	0.88	24.1
	Mean	50.8	47.3	1.01	21.2
2000	0	49.8	48.2	1.04	19.2
	25	46.5	36.3	1.40	23.3
	50	30.0	42.8	0.72	19.9
	100	46.8	38.8	1.20	27.3
	Mean	43.3	41.5	1.09	22.5
All levels	0	41.1	43.2	0.95	17.1
	25	47.9	45.6	1.13	22.7
	50	34.3	42.9	0.83	19.4
	100	46.0	44.5	1.04	23.7
C.D. at 5% level		8.64	N.S.	N.S.	3.68

However, for an application of 50 kg P_2O_5/ha the thousand grain weight was 19.4 g as compared to 22.7 g for a lower level of phosphorus application viz., 25 kg P_2O_5/ha.

C. MINERAL COMPOSITION OF PLANT

Data relating to the mineral composition of plants for the various treatments of calcium and phosphorus are given in Tables VI to IX.

1. Nitrogen

In variety Padma the level of nitrogen in grain is seen to be significantly influenced by the various treatments. Of the different rates of calcium tried an application of 1000 kg CaO/ha has given the maximum level (0.716 per cent) of nitrogen in the grain, and an application of 500 kg CaO/ha has given the minimum (0.660 per cent). Of the different levels of phosphorus used, the rate of 50 kg P_2O_5/ha has produced the highest level of nitrogen in the grain (0.698 per cent) whereas the lowest level (0.670 per cent) was obtained for, no phosphorus treatment. In the straw the level of nitrogen was not influenced by calcium application. However, the highest value of nitrogen

(0.707 per cent) was obtained for a calcium application of 1000 kg CaO/ha and the lowest value (0.637 per cent) for the no calcium treatment. As regards phosphorus the maximum level of 0.747 per cent nitrogen in the straw was obtained for a phosphorus application of 100 kg P_2O_5/ha and the minimum of 0.604 per cent nitrogen for an application of 50 kg P_2O_5/ha.

In variety Jaya the levels of nitrogen in both the grain and straw were influenced significantly by the various levels of calcium applied. As the level of calcium was increased from 0 to 2000 kg CaO/ha the nitrogen content also increased progressively from 0.736 per cent to 0.789 per cent in the grain and from 0.670 per cent to 0.723 per cent in the straw. Similarly the rate of phosphorus application also influenced the level of nitrogen in the grain. The highest level of nitrogen in the grain (0.847 per cent) was obtained for a phosphorus application of 100 kg P_2O_5/ha and the lowest value (0.684 per cent) was for the no phosphorus treatment. But in straw though the maximum nitrogen level (0.751 per cent) was secured at the highest rate of phosphorus application (100 kg P_2O_5/ha) the minimum value (0.665 per cent) was for an application of 50 kg P_2O_5/ha.

2. Phosphorus

The P_2O_5 contents of both grain and straw in the two varieties were influenced significantly by the treatments and their combinations.

In variety Padma (Table VI) it was seen that as the level of calcium was increased from 0 to 1000 kg CaO/ha there was a corresponding increase in the P_2O_5 content of the grain from 0.335 per cent to 0.439 per cent. Of the various rates of phosphorus tried the highest dose viz., 100 kg P_2O_5/ha resulted in the highest P_2O_5 content (0.458 per cent) in the grain, while the lowest P_2O_5 (0.311 per cent) was obtained for an application of 25 kg P_2O_5/ha. But the results in Table VII showing the composition of straw reveal that the level of phosphorus in straw was practically unaffected by the various calcium and phosphorus treatments.

The influence of the various treatments of calcium on the phosphorus content of the grain and straw in variety Jaya was similar to that in Padma. Of the various rates of calcium tried an application at the rate of 1000 kg CaO/ha produced the highest level of P_2O_5 in the grain (0.481 per cent).

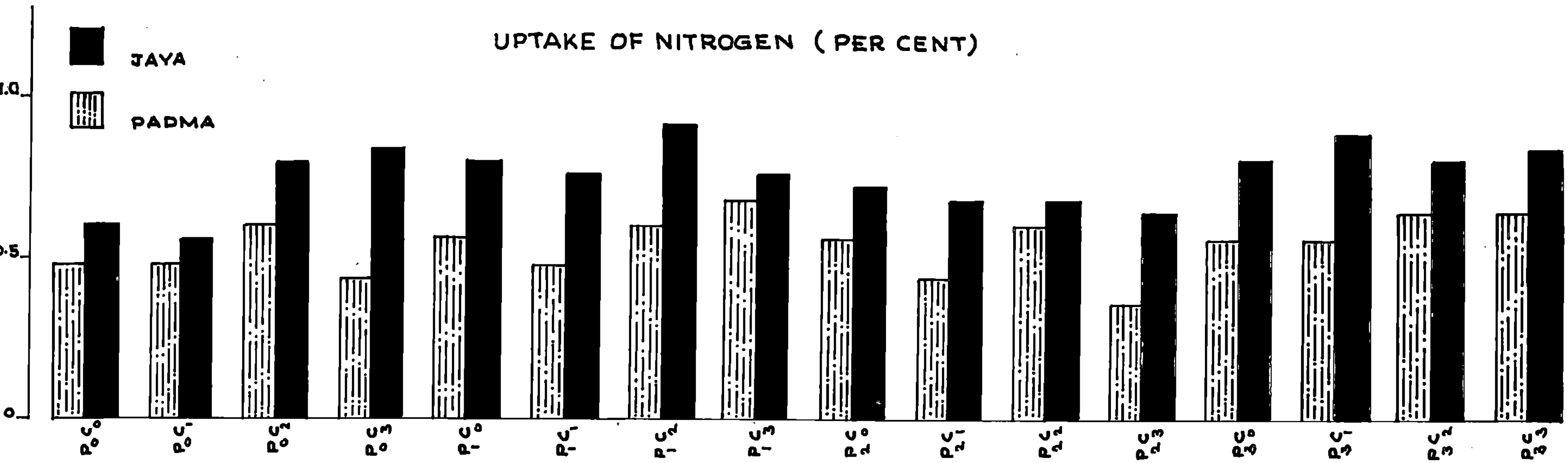

UPTAKE OF NITROGEN (PER CENT)
JAYA
PADMA

FIG: 2a

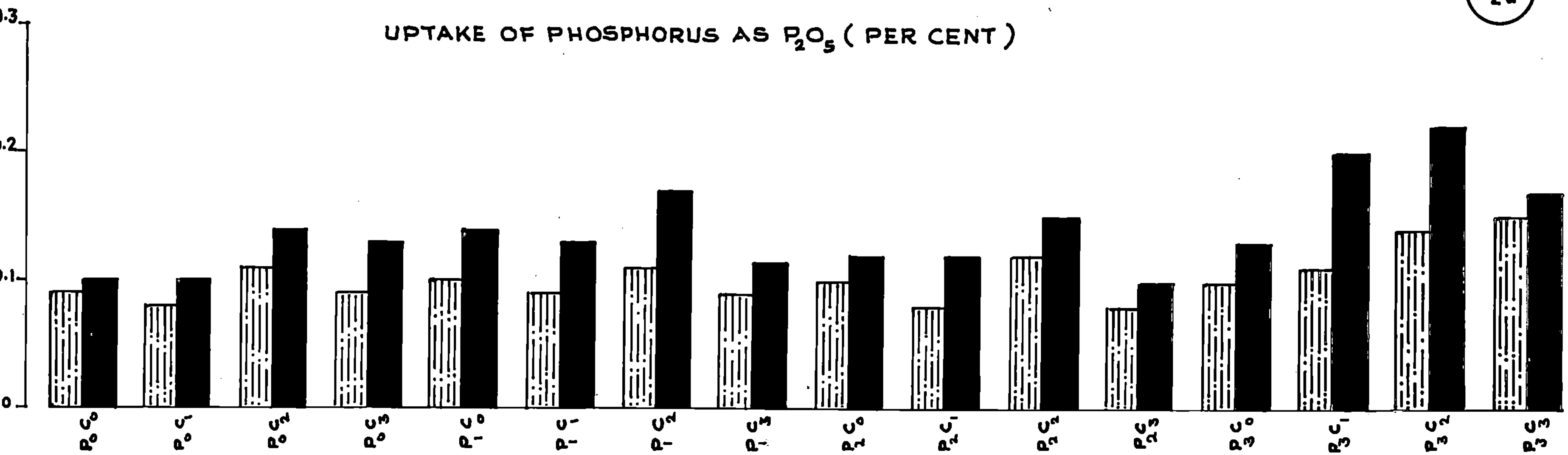

UPTAKE OF PHOSPHORUS AS P_2O_5 (PER CENT)

FIG: 2b

The phosphorus content tended to decrease both at the lower and higher levels of calcium application. However, the application of phosphorus resulted in a progressive increase in the P_2O_5 content of the grain from 0.332 per cent to 0.497 per cent with increased application of this element from 0 to 100 kg P_2O_5/ha. The influence of calcium and phosphorus application on the P_2O_5 content of straw in Jaya was similar to that in Padma.

3. Potassium

Reference to Tables VI and VII shows that the level of K_2O in the grain in variety Padma was influenced significantly by phosphorus and in the straw by calcium. The K_2O content of grain tended to decrease with increase in the rise of calcium application although the differences were not significant. Thus the highest value of 0.446 per cent K_2O in the grain was obtained for the no calcium treatment and the lowest value (0.420 per cent) was secured at the 2000 kg CaO/ha level. As regards the influence of phosphorus the highest level of 0.456 per cent K_2O in the grain was obtained for the no phosphorus treatment which decreased to 0.390 per cent when the phosphorus application was raised to 50 kg P_2O_5/ha. Thereafter, the K_2O content showed a slight increase when the rate of P_2O_5 application was increased to 100 kg P_2O_5/ha. The effect of calcium on K_2O content of straw was significant, the relationship being reciprocal. The effect of phosphorus, though not significant, was also found to be similar.

In variety Jaya the K_2O content of grain was influenced significantly by calcium. With increased levels of calcium application there was a decrease in the percentage of this element in the grain. The effect of phosphorus was not, however, significant. In the straw also the effects of calcium and phosphorus on the K_2O content were similar to those in the grain.

4. <u>Calcium</u>

A perusal of the Tables VI to IX reveals that the CaO content of the grain of variety Padma was not significantly influenced by the different treatments. However, the highest level of CaO (0.719 per cent) was noted for a calcium application of 2000 kg CaO/ha and the lowest (0.588 per cent) for the no calcium treatment. No regularity was noted for the effect of phosphorus on the CaO content of the grain. The effect of calcium and phosphorus on the CaO content of the straw was also similar. The highest CaO content (1.033 per cent) was obtained for the highest level of calcium application and the lowest value (0.845 per cent) was secured for the no calcium treatment. As regards the influence of phosphorus the highest level of CaO in the straw was obtained for an application of 25 kg P_2O_5/ha and the lowest level (0.856 per cent) for the no phosphorus treatment.

In variety Jaya also calcium and phosphorus had no significant influence on the CaO content of grain. The level of CaO in the grain from plants grown in the unlimed soil was even higher than that in plants grown on soils limed to different levels. As regards phosphorus the maximum level of CaO (0.878 per cent) in the grain was obtained for a phosphorus application of 25 kg P_2O_5/ha and the lowest (0.786 per cent) was for an application of 50 kg P_2O_5/ha. A similar trend was noticed for the CaO content of the straw of variety Jaya for the various treatments of calcium and phosphorus.

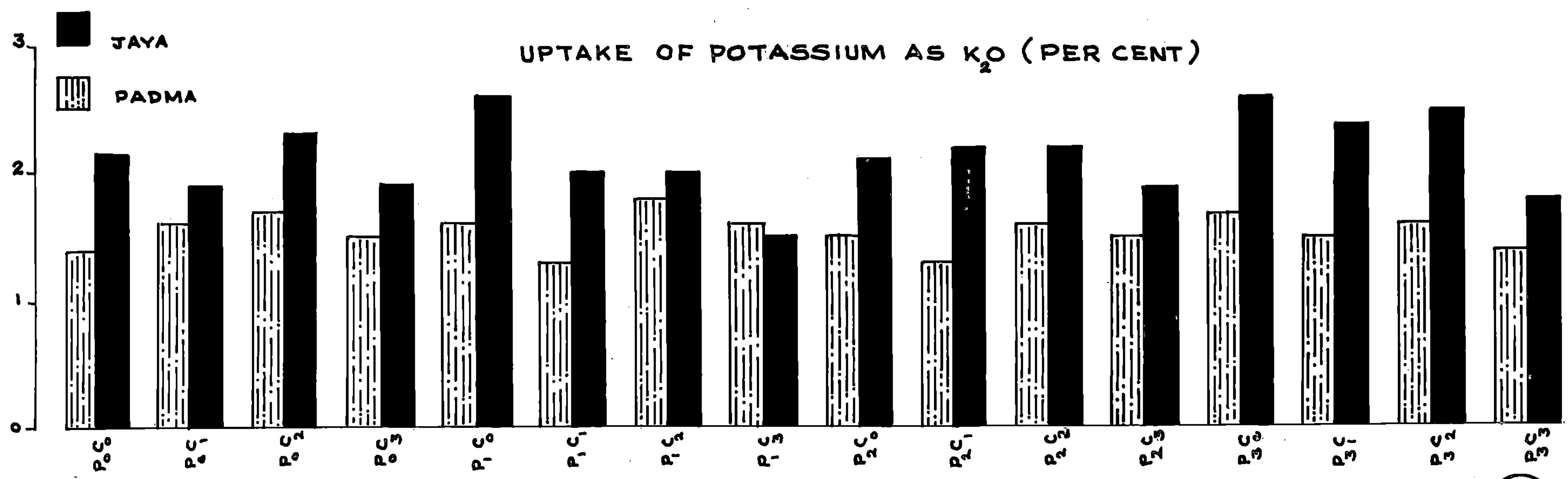


FIG: 3a

UPTAKE OF CALCIUM AS CaO (PER CENT)

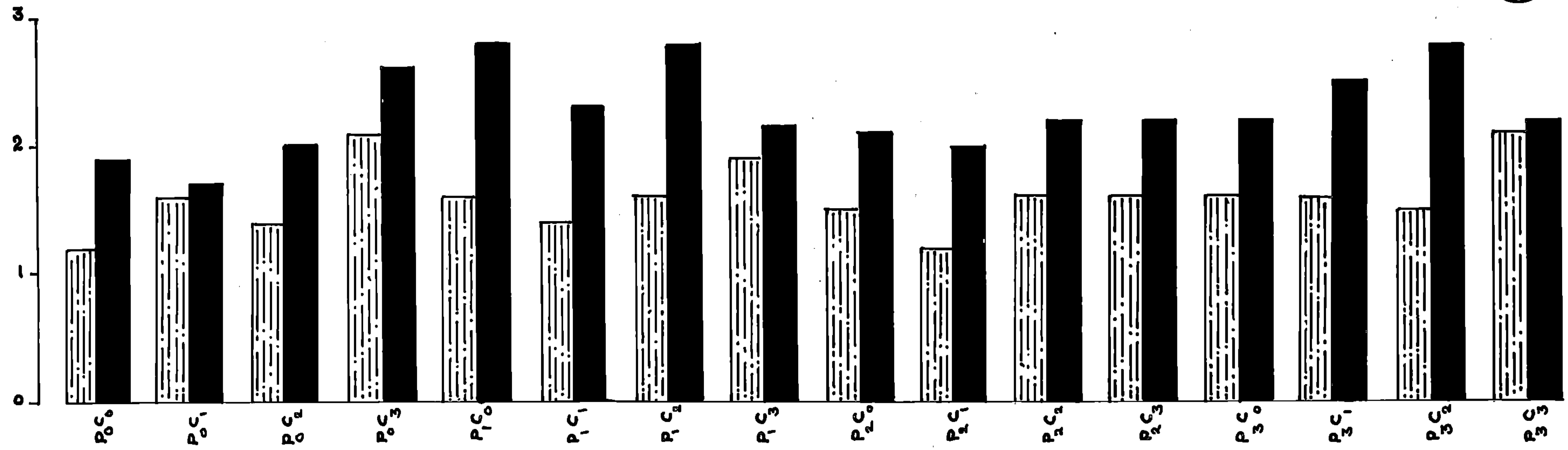


FIG: 3b

5. Magnesium

The MgO content of grain in variety Padma (Table VI and VII) was significantly influenced by the calcium and phosphorus treatments. The highest level of MgO (0.154 per cent) was recorded for the highest level of calcium applied and the lowest MgO content (0.139 per cent) was noted for the 0 level of calcium application and this difference was significant. As regards the influence of phosphorus it was noted that the content of MgO showed a tendency to decrease with increased levels of phosphorus application. Data in Table VII show that in variety Padma increased application of calcium resulted in increased levels of MgO in the straw. As regards the effect of phosphorus it was seen that the highest MgO content (0.190 per cent) in the straw of this variety was obtained for a phosphorus application of 50 kg P_2O_5/ha and the lowest value (0.155 per cent) for the 0 level of phosphorus application.

The data in Tables VIII and IX reveal a similar trend for the influence of calcium and phosphorus on the MgO content of grain and straw in variety Jaya. Thus the highest value of MgO content (0.245 per cent) was noticed for the 2000 kg CaO/ha level and the lowest value (0.199 per cent) for the 500 kg CaO/ha level. As regards the effect of phosphorus it was noted that the highest MgO level (0.239 per cent) in the grain was obtained for the no phosphorus treatment and the lowest level (0.205 per cent) for the phosphorus application of 25 kg P_2O_5/ha. The effect of the various treatments on the MgO content of straw in variety Jaya was not statistically significant. However, the highest MgO content (0.163 per cent) was noted for a calcium application of 2000 kg CaO/ha and the lowest level (0.142 per cent) was obtained for the no lime treatment. The effect of phosphorus treatment on the MgO content of straw in Jaya was also not significant. However, the highest MgO content (0.163 per cent) was obtained for a phosphorus application of 25 kg P_2O_5/ha, the MgO content of straw for the other phosphorus treatments being less than this figure.

TABLE VI

Influence of different levels of lime and phosphorus composition of rice variety - Padma Grain

Levels of lime kg/ha	Levels of P_2O_5 kg/ha	Composition of plant material - Grain (oven - dry basis) per cent N	P_2O_5	K_2O	CaO	MgO
0	0	0.619	0.339	0.464	0.485	0.131
	25	0.664	0.312	0.464	0.560	0.146
	50	0.684	0.344	0.424	0.635	0.135
	100	0.693	0.345	0.432	0.672	0.140
	Mean	0.665	0.335	0.446	0.588	0.139
500	0	0.637	0.348	0.472	0.896	0.165
	25	0.661	0.347	0.424	0.635	0.163
	50	0.668	0.352	0.395	0.411	0.126
	100	0.655	0.440	0.416	0.597	0.149
	Mean	0.660	0.371	0.427	0.634	0.151
1000	0	0.745	0.405	0.472	0.485	0.149
	25	0.657	0.353	0.432	0.523	0.168
	50	0.752	0.476	0.336	0.635	0.140
	100	0.709	0.523	0.464	0.560	0.131
	Mean	0.716	0.439	0.426	0.551	0.147
2000	0	0.684	0.319	0.396	0.846	0.224
	25	0.749	0.234	0.440	0.635	0.154
	50	0.654	0.317	0.408	0.616	0.133
	100	0.673	0.526	0.424	0.788	0.121
	Mean	0.694	0.354	0.420	0.719	0.154
All levels	0	0.670	0.355	0.456	0.663	0.162
	25	0.683	0.311	0.440	0.588	0.158
	50	0.698	0.377	0.390	0.570	0.134
	100	0.683	0.458	0.434	0.654	0.135
C.D. at 5% level		0.026	0.163	0.076	N.S.	0.028

TABLE VII

Influence of different levels of lime and phosphorus on composition of rice variety - Padma Straw

Levels of lime kg/ha	Levels of P_2O_5 kg/ha	Composition of plant material - straw (oven - dry basis) per cent N	P_2O_5	K_2O	CaO	MgO
0	0	0.605	0.150	1.048	0.709	0.163
	25	0.641	0.162	0.976	0.900	0.174
	50	0.651	0.165	1.168	0.908	0.155
	100	0.653	0.169	1.240	0.863	0.149
	Mean	0.637	0.161	1.108	0.845	0.161
500	0	0.619	0.130	1.216	0.858	0.149
	25	0.628	0.161	0.968	0.979	0.205
	50	0.655	0.141	1.176	0.975	0.201
	100	0.773	0.163	1.151	1.053	0.159
	Mean	0.669	0.140	1.127	0.964	0.178
1000	0	0.692	0.141	1.208	0.971	0.131
	25	0.652	0.163	1.255	1.016	0.196
	50	0.687	0.131	1.200	0.904	0.201
	100	0.800	0.149	1.088	0.904	0.191
	Mean	0.707	0.146	1.188	0.944	0.179
2000	0	0.638	0.146	1.090	0.902	0.189
	25	0.603	0.159	0.928	1.087	0.182
	50	0.640	0.139	0.852	0.896	0.245
	100	0.763	0.142	0.966	1.157	0.219
	Mean	0.665	0.147	0.950	1.033	0.207
All levels	0	0.638	0.141	1.145	0.856	0.155
	25	0.631	0.161	1.032	0.995	0.157
	50	0.604	0.144	1.028	0.923	0.190
	100	0.747	0.156	1.105	0.994	0.180
C.D. at 5% level		N.S.	0.007	0.240	0.163	0.003

TABLE VIII

Influence of different levels of lime and phosphorus on composition of rice variety - Jaya Grain

Levels of lime kg/ha	Levels of P_2O_5 kg/ha	Composition of plant material - grain (oven-dry basis) per cent N	P_2O_5	K_2O	CaO	MgO
0	0	0.632	0.262	0.680	0.784	0.163
	25	0.651	0.337	0.664	0.896	0.252
	50	0.814	0.307	0.708	0.784	0.245
	100	0.873	0.353	0.696	0.859	0.229
	Mean	0.736	0.316	0.688	0.835	0.220
500	0	0.667	0.349	0.552	0.713	0.285
	25	0.760	0.388	0.520	0.863	0.173
	50	0.820	0.406	0.608	0.863	0.163
	100	0.845	0.551	0.536	0.784	0.174
	Mean	0.773	0.423	0.554	0.805	0.199
1000	0	0.723	0.390	0.498	0.635	0.214
	25	0.791	0.399	0.536	0.933	0.187
	50	0.767	0.509	0.520	0.859	0.247
	100	0.843	0.627	0.472	0.784	0.219
	Mean	0.781	0.481	0.507	0.803	0.217
2000	0	0.714	0.327	0.432	0.821	0.294
	25	0.795	0.350	0.416	0.821	0.210
	50	0.821	0.345	0.440	0.900	0.201
	100	0.827	0.458	0.472	0.751	0.275
	Mean	0.789	0.443	0.440	0.823	0.245
All levels	0	0.684	0.332	0.541	0.805	0.239
	25	0.749	0.376	0.534	0.878	0.205
	50	0.804	0.400	0.556	0.786	0.211
	100	0.847	0.497	0.544	0.794	0.225
C.D. at 5% level		0.028	0.035	0.098	N.S.	0.005

TABLE IX

Influence of different levels of lime and phosphorus on composition of rice variety - Jaya Straw

Levels of lime kg/ha	Levels of P_2O_5 kg/ha	Composition of plant material - Straw (oven-dry basis)				
		per cent				
		N	P_2O_5	K_2O	CaO	MgO
0	0	0.632	0.140	1.392	0.859	0.121
	25	0.672	0.162	1.000	0.979	0.168
	50	0.640	0.171	0.920	0.902	0.133
	100	0.727	0.172	1.011	0.904	0.145
	Mean	0.670	0.160	1.269	0.911	0.142
500	0	0.659	0.141	1.320	0.908	0.146
	25	0.696	0.161	0.984	0.904	0.154
	50	0.664	0.160	1.360	0.900	0.193
	100	0.745	0.169	1.256	1.087	0.146
	Mean	0.891	0.158	1.230	0.949	0.161
1000	0	0.711	0.141	1.144	0.896	0.153
	25	0.736	0.150	0.840	0.900	0.145
	50	0.663	0.151	1.232	0.979	0.146
	100	0.752	0.162	1.103	1.016	0.154
	Mean	0.715	0.151	1.080	0.947	0.150
2000	0	0.699	0.134	0.928	0.979	0.159
	25	0.729	0.159	0.824	1.045	0.187
	50	0.684	0.143	1.039	1.049	0.146
	100	0.779	0.161	0.968	0.979	0.159
	Mean	0.723	0.151	0.940	1.013	0.163
All levels	0	0.675	0.139	1.196	0.910	0.146
	25	0.708	0.158	0.912	1.040	0.163
	50	0.665	0.155	1.241	0.882	0.158
	100	0.751	0.166	1.168	0.995	0.152
C.D. at 5% level		0.017	0.006	0.108	N.S.	N.S.

UPTAKE OF MAGNESIUM AS MgO (PER CENT)

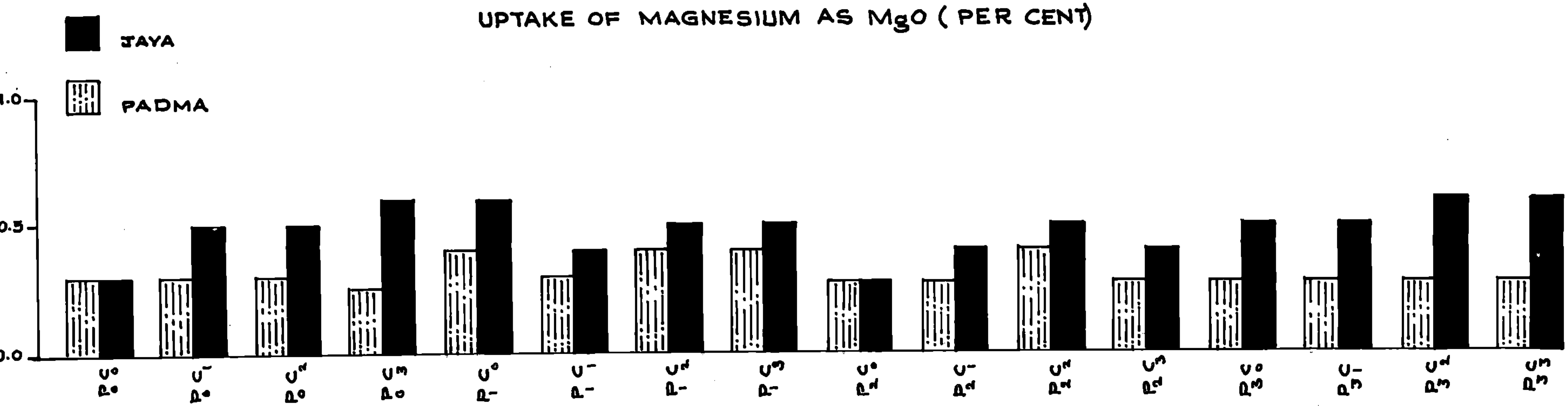


FIG: 4a

GRAIN-STRAW RATIO

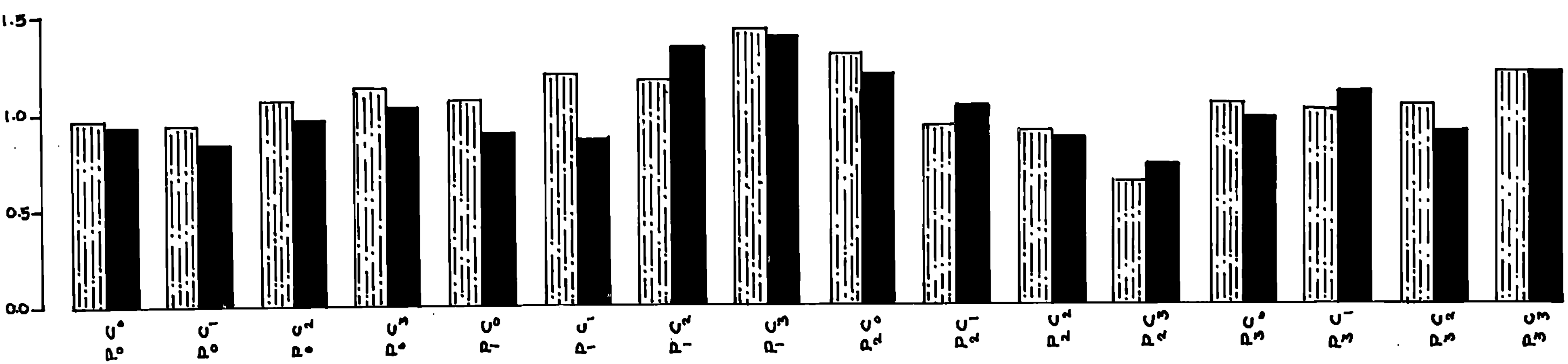


FIG: 4a

D. UPTAKE OF NUTRIENTS

The data for the total uptake of the different nutrients (calculated as so many g/pot) by rice as influenced by the various treatments are furnished in Tables X and XI.

1. Uptake of Nitrogen

It is observed from Table X that the uptake of nitrogen by variety Padma was not influenced by the different levels of calcium or phosphorus tried. But of the different levels of calcium applied, the highest level of 2000 kg CaO/ha resulted in the maximum uptake of nitrogen (0.505 g/pot) followed in order by the treatments 1000 kg CaO/ha (0.499 g/pot) 0 kg CaO/ha (0.444 g/pot) and 500 kg CaO/ha (0.412 g/pot). As regards the different levels of phosphorus tried an application of 100 kg P_2O_5/ha resulted in the maximum uptake of nitrogen (0.496 g/pot) and the 0 level in the minimum (0.432 g/pot).

In variety Jaya (Table XI) also the same trend was maintained. The highest uptake of nitrogen

(0.704 g/pot) was obtained for the 1000 kg CaO/ha level and the lowest value (0.592 g/pot) for the application of 500 kg CaO/ha. As regards the influence of phosphorus on the uptake of nitrogen it was noticed that the maximum uptake (0.723 g/pot) was for an application of 100 kg P_2O_5/ha and the lowest (0.560 g/pot) was for an application of 50 kg P_2O_5/ha.

2. Uptake of phosphorus

Table X reveals that the uptake of P_2O_5 by variety Padma was significantly influenced by liming. The maximum uptake (0.205 g/pot) was obtained for the application of 1000 kg CaO/ha and the lowest (0.159 g/pot) for the application of 500 kg CaO/ha. The effect of phosphorus application on the uptake of P_2O_5 by variety Padma was not significant although the uptake tended to increase slightly with increased applications of this element.

In variety Jaya (Table XI) the uptake of P_2O_5 was significantly influenced by the different treatments. Of the different levels of calcium tried the highest uptake of P_2O_5 (0.294 g/pot) was obtained for a calcium application of 1000 kg CaO/ha and the lowest (0.204 g/pot) was secured at the liming rate of 0 kg CaO/ha. As regards the influence of phosphorus the maximum P_2O_5 uptake (0.300 g/pot) was for a phosphorus application of 100 kg P_2O_5/ha and the lowest (0.197 g/pot) was for the no phosphorus treatment.

3. Uptake of potassium

The data in Tables X and XI reveal that the total uptake of K_2O by the two varieties was not influenced by the different treatments of calcium and phosphorus. However, the general trend was for the uptake of K_2O to decrease with increased applications of these elements.

4. Uptake of calcium

The data in Table X indicate that the uptake of CaO by variety Padma was influenced significantly by calcium treatment. The highest uptake of CaO (0.637 g/pot) was recorded at the highest level of calcium application viz., 2000 kg CaO/ha, which was significantly higher than the uptake at the 500 kg

CaO/ha level (0.482 g/pot). As regards phosphorus the highest uptake of CaO (0.564 g/pot) was obtained at a phosphorus application of 100 kg P_2O_5/ha which was not significantly different from the uptake at the other levels of phosphorus application.

In variety Jaya the application of calcium and phosphorus was found to have no significant effect on the uptake of CaO by the plants.

5. Uptake of magnesium

The uptake of MgO was influenced significantly by the application of calcium and phosphorus in variety Padma. The maximum uptake (0.131 g/pot) was obtained at the liming rate of 2000 kg CaO/ha and the lowest (0.101 g/pot) for a liming rate of 500 kg CaO/ha which was not significantly different from the uptake of MgO at the other two rates of lime application. As regards the effect of phosphorus, the highest uptake of MgO was secured at a phosphorus application 25 kg P_2O_5/ha and the lowest (0.106 g/pot) at the 0 rate of phosphorus application which was not significantly different from the values for the other two rates.

TABLE X

Influence of different levels of lime and phosphorus on uptake of nutrients by rice variety - Padma

Level of lime kg/ha	Level of P_2O_5 kg/ha	Uptake of nutrients g/pot				
		N	P_2O_5	K_2O	CaO	MgO
0	0	0.390	0.156	0.483	0.380	0.094
	25	0.477	0.176	0.525	0.532	0.118
	50	0.455	0.181	0.508	0.511	0.097
	100	0.455	0.175	0.555	0.519	0.097
	Mean	0.444	0.172	0.517	0.485	0.102
500	0	0.396	0.148	0.539	0.533	0.101
	25	0.403	0.162	0.437	0.479	0.114
	50	0.369	0.133	0.446	0.385	0.090
	100	0.475	0.196	0.511	0.531	0.101
	Mean	0.412	0.159	0.491	0.482	0.101
1000	0	0.484	0.151	0.567	0.482	0.095
	25	0.489	0.194	0.589	0.544	0.132
	50	0.497	0.203	0.539	0.535	0.119
	100	0.562	0.240	0.542	0.498	0.113
	Mean	0.499	0.205	0.559	0.514	0.115
2000	0	0.470	0.168	0.517	0.618	0.146
	25	0.565	0.164	0.524	0.658	0.133
	50	0.420	0.100	0.417	0.516	0.128
	100	0.524	0.259	0.481	0.711	0.121
	Mean	0.505	0.190	0.488	0.637	0.131
All levels	0	0.432	0.163	0.527	0.493	0.106
	25	0.484	0.174	0.519	0.553	0.124
	50	0.436	0.168	0.443	0.484	0.107
	100	0.496	0.213	0.522	0.564	0.108
C.D. at 5% level		N.S.	0.108	N.S.	0.116	0.016

TABLE XI

Influence of different levels of lime and phosphorus on uptake of nutrients by rice variety - Jaya

Level of lime kg/ha	Level of P_2O_5 kg/ha	Uptake of nutrients g/pot				
		N	P_2O_5	K_2O	CaO	MgO
0	0	0.498	0.157	0.821	0.650	0.109
	25	0.677	0.249	0.863	0.989	0.214
	50	0.581	0.184	0.915	0.701	0.145
	100	0.667	0.218	0.853	0.737	0.121
	Mean	0.608	0.204	0.858	0.766	0.157
500	0	0.458	0.163	0.642	0.592	0.147
	25	0.629	0.229	0.667	0.764	0.140
	50	0.563	0.206	0.739	0.665	0.132
	100	0.718	0.334	0.788	0.831	0.149
	Mean	0.592	0.233	0.709	0.704	0.142
1000	0	0.652	0.239	0.753	0.667	0.165
	25	0.779	0.295	0.686	0.946	0.168
	50	0.567	0.253	0.722	0.726	0.161
	100	0.819	0.392	0.837	0.927	0.191
	Mean	0.704	0.294	0.748	0.815	0.171
2000	0	0.693	0.227	0.629	0.879	0.206
	25	0.634	0.219	0.492	0.742	0.171
	50	0.539	0.165	0.625	0.722	0.124
	100	0.689	0.277	0.589	0.737	0.189
	Mean	0.639	0.222	0.584	0.770	0.173
All levels	0	0.575	0.197	0.711	0.689	0.157
	25	0.680	0.248	0.677	0.851	0.174
	50	0.560	0.203	0.674	0.705	0.140
	100	0.723	0.305	0.766	0.808	0.171
C.D. at 5% level		N.S.	0.172	N.S.	N.S.	N.S.

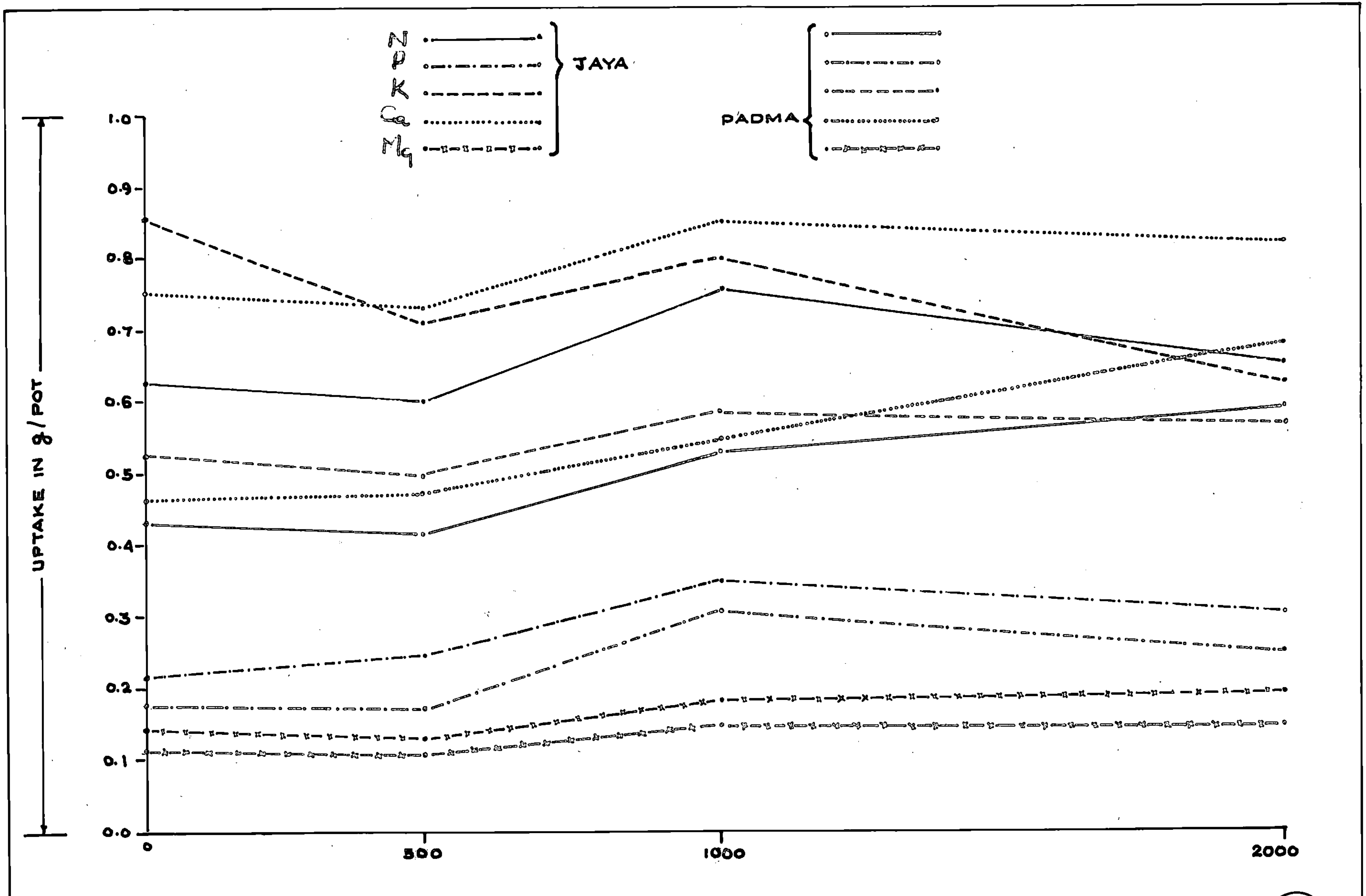

N
P
K
Ca
Mg
JAYA
PADMA
UPTAKE IN g/POT
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
500
1000
2000
LEVELS OF CALCIUM IN Kg/Ha

FIG: 6

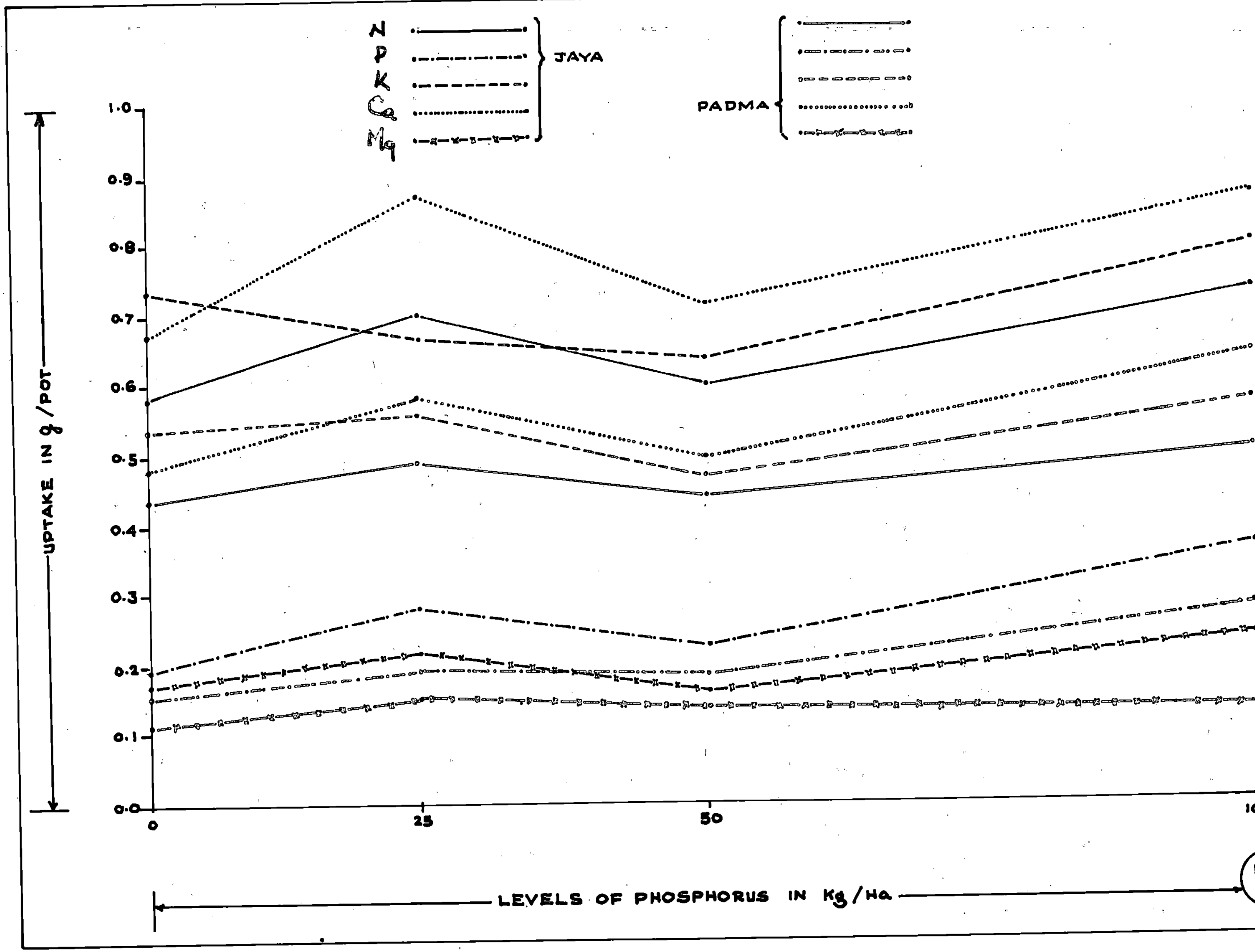

N
P
K
Ca
Mg
JAYA
PADMA
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
UPTAKE IN g /POT
0
25
50
100
LEVELS OF PHOSPHORUS IN Kg /Ha

FIG 5

TABLE XII

Cation content of rice for different levels of lime and phosphorus variety - Padma grain

Level of calcium kg/ha	Level of P_2O_5 kg/ha	me /100 g			
		K_2O	CaO	MgO	Total
0	0	9.8	17.2	6.6	33.6
	25	9.8	20.0	7.4	37.2
	50	9.0	22.8	6.8	38.6
	100	9.2	24.0	7.0	40.2
500	0	10.0	32.0	8.2	50.2
	25	9.0	22.8	8.2	40.0
	50	8.4	14.8	6.4	29.6
	100	8.8	21.4	7.4	38.2
1000	0	10.0	17.2	7.4	34.6
	25	9.2	18.8	8.2	36.2
	50	7.2	22.8	7.0	37.0
	100	9.8	20.0	6.6	36.4
2000	0	8.4	30.2	11.2	49.8
	25	9.2	22.8	7.6	39.6
	50	8.8	22.0	6.8	37.6
	100	9.0	28.0	6.0	43.0

TABLE XIII

Cation content of rice for different levels of lime and phosphorus variety - Padma straw

Level of calcium kg/ha	Level of P_2O_5 kg/ha	me /100 g			
		K_2O	CaO	MgO	Total
0	0	22.2	25.2	8.2	55.6
	25	20.8	32.0	8.6	61.4
	50	24.8	32.2	7.8	64.8
	100	26.4	30.8	7.4	64.6
500	0	26.4	30.0	7.4	63.8
	25	20.8	34.8	10.2	65.8
	50	24.8	34.6	10.0	69.4
	100	24.2	37.6	8.0	69.8
1000	0	26.2	34.6	6.6	67.4
	25	26.6	36.2	9.8	72.6
	50	25.4	32.0	10.0	67.4
	100	22.2	32.0	9.6	63.8
2000	0	22.2	32.0	9.4	63.6
	25	19.8	34.4	9.2	63.4
	50	18.0	32.0	12.2	62.2
	100	20.8	40.0	10.8	71.6

TABLE XIV

Cation content of rice for different levels of lime and phosphorus variety - Jaya grain

Level of calcium kg/ha	Level of P_2O_5 kg/ha	me /100 g			
		K_2O	CaO	MgO	Total
0	0	14.4	28.0	8.2	50.6
	25	14.0	32.0	12.6	58.6
	50	15.0	28.0	12.2	55.2
	100	14.8	31.4	11.4	57.6
500	0	11.0	26.8	14.2	52.0
	25	10.6	31.0	8.8	50.4
	50	13.0	31.0	8.2	52.2
	100	10.8	28.0	8.6	47.4
1000	0	10.6	22.8	10.6	44.0
	25	10.8	33.2	9.4	53.4
	50	10.6	31.4	12.4	54.4
	100	10.0	28.0	11.0	49.0
2000	0	9.6	30.8	14.6	55.0
	25	9.0	30.8	10.4	50.2
	50	9.6	32.2	10.0	51.8
	100	10.0	27.8	13.8	51.6

TABLE XV

Cation content of rice for different levels of lime and phosphorus variety - Jaya straw

Level of calcium kg/ha	Level of P_2O_5 kg/ha	me /100 g			
		K_2O	CaO	MgO	Total
0	0	29.6	30.6	6.0	66.2
	25	21.2	35.0	8.4	64.6
	50	19.4	32.6	6.6	58.6
	100	21.4	32.6	7.2	61.2
500	0	28.0	32.8	7.2	68.0
	25	20.8	32.6	7.6	61.0
	50	28.2	32.4	9.6	70.2
	100	26.8	38.8	7.2	72.8
1000	0	24.2	32.4	7.6	64.2
	25	18.0	32.4	7.2	57.6
	50	26.6	35.0	7.2	68.8
	100	24.0	38.0	7.6	69.6
2000	0	19.4	35.0	8.0	62.4
	25	17.6	37.8	9.4	64.8
	50	21.2	37.8	7.2	66.2
	100	20.0	35.0	8.0	63.0

In variety Jaya, however, the effect of calcium and phosphorus on the total uptake of MgO was not statistically significant.

E. CATION EQUIVALENCE IN RICE

The cation content of the plants expressed as milli equivalents per 100 g of plant material is presented in Tables XII - XV.

The average values for grain and straw in variety Padma were 38.2 and 65.4 me/100 g, while the values for variety Jaya were 52.1 and 64.9 me/100 g.

DISCUSSION

DISCUSSION

In the present study an attempt has been made to evaluate the response of two high yielding varieties of rice viz., Padma and Jaya to graded doses of calcium and phosphorus. The effect of the various treatments on the uptake of N, P_2O_5, K_2O, CaO and MgO has also been studied in detail. The results are discussed in relation to the effect of the various treatments on the growth and yield characters observed, as well as the chemical composition of the grain and straw.

Of the different growth characters studied only the length of earhead was significantly influenced by the different levels of calcium and phosphorus. Tiller number, number of productive tillers and the height of plants were practically unaffected by the application of these elements. This finding is in agreement with the results reported by Srinivasulu and Pawar (1965) Muliyar (1965) and Laker (1967).

However, the application of phosphorus at 25 kg P_2O_5/ha resulted in a slight increase in the number of tillers as compared to the no phosphorus treatment, which was in conformity with the finding of Takajima <u>et al</u> (1959).

Though the length of earhead is generally recognised as a varietal character (Chamy, 1960) which is seldom influenced by fertilization the application of calcium and phosphorus has revealed significant influence on this character in the present study. This would mean that some of the genetic plant characters are susceptible to variations within certain limits under different systems of management.

The influence of calcium and phosphorus on the yield characters has been somewhat anomalous. However, it was generally seen that the beneficial effect of liming was a maximum at the level 1000 kg CaO/ha or half the lime requirement. When the liming rate was increased to full lime requirement or 2000 kg CaO/ha the yield characters were adversely affected. This is in accordance with the view expressed by Mehlich and co-workers (1952) according to whom the soils of the tropics and sub-tropics need be limed to partial saturation only for the best results. The clays in these soils are of the kaolinitic type, which when limed to full saturation, may exert an adverse effect on crop yields. Reduced yields at higher levels of calcium application have been reported by Pierre et al (1935) and Mandal et al (1955).

The effect of phosphorus on the yield characters has not been significant except on the weight of 1000 grains. However, the application of this element at the rate of 25 kg P_2O_5/ha has given the highest yield in both the varieties. Higher rates of application have resulted in slightly reduced yields which might be due to the supression of some of the soluble micronutrients by the formation of less soluble phosphates. A similar finding has been reported by Verma (1960). The effect of calcium and phosphorus on the yield of straw, as well as the grain-straw ratio has also not been significant. This was only to be expected because the contributory factors determining the straw yield such as the height of plants and number of tillers were not affected by the various treatments.

The only significant effect which the application of calcium and phosphorus had on yield characters was its beneficial influence on the weight of 1000 grains. This character was found to increase with increased rates of calcium and phosphorus application. It is to be concluded that these elements help to produce more plumpy and better-filled grains, resulting in increased 1000 grain weight as reported by Muliyar (1965) and Volke and Inostroza (1967).

Treatement of calcium and phosphorus has influenced the composition of grain and straw in the two varieties to different extents. While the nitrogen content of the grain in variety Padma is influenced significantly by the various treatments, their effect on the nitrogen content of straw has not been significant. But in variety Jaya the nitrogen contents of both grain and straw are significantly influenced by calcium and phosphorus. Though the total uptake of this element is not significantly affected by treatment the trend was for an increased uptake of nitrogen with increased rates of calcium and phosphorus application. This result indicates that calcium and phosphorus application can help in better utilization of nitrogen by plants as reported by Eorlan and Militescu (1966).

The calcium and phosphorus treatments have significantly influenced the content of P_2O_5 in the grain and straw in both varieties. Efficient utilization of applied phosphorus as a result of liming has been reported by many workers. The beneficial effect of lime is attributed to different factors such as correcting the soil acidity, remedying nutrient deficiencies and combating of the toxic effects of certain cations. The results obtained in this study do not throw any additional light on the exact manner in which lime functions in acid soils but the evidence from this investigation tends to favour the existing theories. Calcium at higher rates of application is known to repress the availability of added phosphorus and this has been borne out by the results of the present study. The repressing effect of high doses of calcium on absorption of added phosphorus by plants is generally attributed to the reversion of readily soluble phosphates to less soluble calcium phosphates. The increased level, as well as uptake, of phosphorus by the plants for increased rates of phosphorus application is only to be expected and is in accordance with the results reported by Rai et al (1963) Fujiwara (1964) Singh and Pancholy (1967) and Naphade (1969).

In variety Padma the effect of calcium on the K_2O content was significant in the straw but not in the grain. In both cases the relationship, however, was found to be reciprocal. The effect of phosphorus application was also similar.

But in Jaya the effect of calcium on K_2O content of both grain and straw was significant with a reciprocal calcium-potassium relationship. The effect of phosphorus on K_2O content, however, was not significant though it showed a similar trend. The total uptake of K_2O was also found to decrease with increased rates of calcium and phosphorus application. According to Reiteimer (1951) when soils are limed the availability of ions such as K^+ and $PO_4^{\equiv}$ is generally affected though there is little agreement as to the magnitude or even the direction of the effect, which, in many case is not very considerable. In the present study, however, calcium has maintained a definite reciprocal relationship to the uptake of K_2O by the rice plant.

The increased rates of calcium application has resulted in a higher level of this element in the grain and straw in variety Padma though the differences were not significant. The same trend was obtained for the total uptake of CaO also. In variety Jaya the level of calcium in the grain was slightly higher in the unlimed than in the limed soil though the difference was not significant. The results would indicate that once a minimum level of calcium in the soil is assured its uptake by the rice plant is independent of the total quantity applied.

The inverse relationship between magnesium and calcium,as well as the linear relationship between phosphorus and magnesium in plant nutrition are generally well accepted. Though these relationships have to some extent been detected in the present study the effect of calcium and phosphorus on the absorption of MgO has not always been uniform. The complex nature of the interactions between the various elements taking place in the soil under conditions of heavy liming and phosphorus application might be responsible for discrepancies noted.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

A pot culture experiment was carried out to study the influence of different levels of calcium and phosphorus on the growth, yield, composition and uptake of nutrients by two varieties of rice, Padma and Jaya. The soil used was collected from the kayal lands of the Agricultural College, Vellayani and had a lime requirement of 2000 kg CaO/ha. The levels of calcium studied were 0, 500, 1000 and 2000 kg CaO/ha and the doses of phosphorus were 0, 25, 50 and 100 kg P_2O_5/ha. A completely randomized design with 32 treatments and 3 replications was used for the experiment. The results are summarised below.

1. Of the different growth characters studied only the length of earhead was significantly influenced by the different levels of calcium and phosphorus. Tiller number, number of productive tillers and height of plants were practically unaffected by the application of these elements in both varieties.

2. The influence of calcium and phosphorus on the

yield characters was somewhat anomalous. However, the beneficial effect of calcium was generally a maximum at the level 1000 kg CaO/ha or at half the lime requirement.

3. The only significant effect which the application of calcium and phosphorus had on yield characters was its beneficial influence on the weight of 1000 grains in both varieties.

4. Treatment of calcium and phosphorus influenced the composition of grain and straw in the two varieties to different extents.

(a) In Padma, the nitrogen content of grain, and not of straw, was influenced significantly by treatment, while in Jaya the nitrogen content of both grain and straw were affected. A general increased trend in the uptake of nitrogen was noticed in both varieties with increased levels of calcium and phosphorus application.

(b) The uptake of P_2O_5 was influenced significantly by the different treatments in both varieties.

(c) The total uptake of K_2O was found to decrease with increased rates of calcium and phosphorus application indicating thereby a reciprocal calcium-potassium relationship.

(d) A general inverse relationship between magnesium and calcium, as well as a linear relationship between phosphorus and magnesium have been noted in the present study. The effect of calcium and phosphorus on the absorption of MgO was not always uniform.

5. The total content of cations in the two varieties was found to be more or less a constant irrespective of the treatments, though variety Jaya recorded a higher content of cations as compared to Padma.

6. Variety Jaya excelled variety Padma in all the growth and yield characters studied as well as in the utilization of the plant nutrients.

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APPENDICES

APPENDIX I

Summary of statistical analysis-growth characters of rice Variety - Padma

Source	Df	Number of tillers (varia nce)	Produc tive tillers (varia nce)	Height of plants (varia nce)	Length of earhead (varia nce)
Total	45	..	..	..	..
Treatment	15	2.722	2.17	11.87	10.83**
P	3	..	..	..	20.16**
C	3	..	..	..	8.37**
P x C	9	..	..	..	8.53**
Error	30	2.01	1.53	16.66	0.42

** Significant at 1% level

APPENDIX II

Summary of statistical analysis-growth characters of rice Variety-Jaya

Source	Df	Number of tillers (variance)	Productive tillers (variance)	Height of plants (variance)	Length of earhead (variance)
Total	46	..	..	..	..
Treatment	15	4.009	2.09	68.4	12.01**
P	3	..	..	..	31.23**
C	3	..	..	..	12.58**
P x C	9	..	..	..	5.42*
Error	31	3.76	1.15	162.9	0.78

* Significant at 5% level

** " at 1% "

APPENDIX III

Summary of statistical analysis-yield characters of rice variety - Padma

Source	Df	Yield of grain (variance)	Yield of straw (variance)	Grain-straw ratio (variance)	Weight 1000 grains (variance)
Total	45	..	..	..	..
Treatment	15	75.20	13.17	0.1316	7.26**
P	3	..	..	..	30.41**
C	3	..	..	0.4113	3.17*
P x C	9	..	..	..	0.91*
Error	30	64.51	26.2	0.0481	0.18

* Significant at 5% level

** " at 1% "

APPENDIX IV

Summary of statistical analysis
Yield character of rice
variety - Jaya

Source	Df	Yield of grain (variance)	Yield of straw (variance)	Grain-straw ratio (variance)	Weight of 1000 grains (variance)
Total	46	..	..	..	..
Treatment	15	161.35	88.09	0.085	28.83*
P	3	421.49	..	..	110.88**
C	3	..	..	..	23.14*
P x C	9	..	..	..	3.36
Error	31	109.39	74.55	0.081	4.96

* Significant at 5% level
** " at 1% "

APPENDIX V

Summary of statistical analysis
chemical composition of rice - grain
variety - Padma

source	Df	Per cent Nitrogen (variance)	Per cent P_2O_5 (variance)	Per cent K_2O (variance)	Per cent CaO (variance)	Per cent MgO (variance)
Total	45	..	..	..	..	..
Treatment	15	0.0046**	0.0188**	0.0037	0.0473	0.0014*
P	3	0.0014**	0.0454**	0.0090*	..	0.0026
C	3	0.0081**	0.244**	0.0014	..	0.0005
P x C	9	0.0044**	0.0081**	0.0050	..	0.0013*
Error	30	0.0002	0.0003	0.0021	0.0482	0.0004

* Significant at 5% level
** " at 1% "

APPENDIX VI

Summary of statistical analysis
chemical composition of rice - Straw
variety - Padma

Source	Df	percent Nitrogen (varia nce)	percent P_2O_5 (varia nce)	percent K_2O (varia nce)	percent CaO (varia nce)	percent MgO (varia nce)
Total	46	..	..	..	..	..
Treatment	15	0.0046	0.0004**	0.0444	0.033	0.0024*
P	3	..	0.0010**	..	0.050*	0.0035*
C	3	..	0.0006**	0.1090*	0.067*	0.0039*
P x C	9	..	0.0002**	..	0.016	0.0015*
Error	31	0.0034	0.00001	0.0199	0.009	0.0004

* Significant at 5% level

** " at 1% "

APPENDIX VII

Summary of statistical analysis, chemical composition of rice - Grain - variety - Jaya

Source	Df	Percent N (variance)	Percent P_2O_5 (variance)	Percent K_2O (variance)	Percent CaO (variance)	Percent MgO (variance)
Total	45	..	..	..	..	..
Treatment	15	0.0163**	0.0269**	0.0263	0.024	0.0061**
P	3	0.0594**	0.0607**	..	..	0.0027**
C	3	0.0062**	0.0584**	0.1250**	..	0.0042**
P x C	9	0.0053**	0.0051**	..	..	0.0079**
Error	30	0.0003	0.0004	0.0035	..	0.0002

** Significant at 1% level.

APPENDIX VIII

Summary of statistical analysis, chemical composition of of rice - Straw Variety - Jaya

Source	Df	Percent N (variance)	Percent P_2O_5 (variance)	Percent K_2O (variance)	Percent CaO (variance)	Percent MgO (variance)
Total	46	..	..	..	..	..
Treatment	15	0.0052**	0.0004**	0.1127**	0.0138	0.0008
P	3	0.0176**	0.0012**	0.2582**	..	..
C	3	0.0066**	0.0003**	0.2665**	..	..
P x C	9	0.0007**	0.0005**	0.0128	..	..
Error	31	0.0001	0.00001	0.0047	0.1000	0.0009

** Significant at 1% level.

APPENDIX IX

Summary of statistical analysis, uptake of nutrients variety - Padma

Source	Df	Nitrogen g/pot (vari ance)	P_2O_5 g/pot (vari ance)	K_2O g/pot (vari ance)	CaO g/pot (vari ance)	MgO g/pot (vari ance)
Total	45	..	..	..	..	..
Treatment	15	0.0089	0.0031	0.0062	0.0208	0.0007**
P	3	..	..	..	..	0.0009**
C	3	..	0.0081	..	0.0562	0.0021**
P x C	9	..	..	..	..	0.0002*
Error	30	0.0062	0.0011	0.0085	0.0094	0.00006

* Significant at 5% level.

** " at 1% "

APPENDIX X

Summary of statistical analysis, Uptake of nutrients
Variety - Jaya

Source	Df	Nitrogen g/pot (variance)	P_2O_5 g/pot (variance)	K_2O g/pot (variance)	CaO g/pot (variance)	MgO g/pot (variance)
Total	46	..	..	..	..	..
Treatment	15	0.0262	0.0118*	0.0379	0.0393	0.0025
P	3	..	0.0296**	..	..	..
C	3	..	0.0182	..	..	..
P x C	9	..	0.0038	..	..	..
Error	31	0.0160	0.0024	0.0210	0.0240	0.0013

* Significant at 5% level
** " at 1% "

P L A T E S

PLATE I

Influence of calcium on the growth of rice

Variety - Padma

Pot No.	1	Calcium at	0	kg CaO/ha
"	2	"	500	"
"	3	"	1000	"
"	4	"	2000	"

PLATE II

Influence of calcium on the growth of rice

Variety - Jaya

Pot No.	17	Calcium at	0	kg CaO/ha
"	18	"	500	"
"	19	"	1000	"
"	20	"	2000	"


1
2
3
4


17
18
19
20

PLATE III

Influence of Calcium on the growth of rice
Variety - Padma

Pot No.1	Calcium at	0 kg CaO/ha	
" 2	"	500	"

PLATE IV

Influence of Calcium on the growth of rice
Variety - Jaya

Pot No. 17	Calcium at	0 kg CaO/ha	
" 18	"	500 kg	"


1
2


17
18

PLATE V

Influence of Calcium on the growth of rice
Variety - Padma

Pot No.1 Calcium at 0 kg CaO/ha
" 3 " 1000 "

PLATE VI

Influence of Calcium on the growth of rice
Variety - Jaya

Pot No. 17 Calcium at 0 kg CaO/ha
" 19 " 1000 "


1
3


17
19

PLATE VII

Influence of Calcium on the growth of rice
Variety - Padma

Pot No. 10 Calcium at 500 kg CaO/ha

" 11 " 1000 "

PLATE VIII

Influence of Calcium on the growth of rice
Variety - Jaya

Pot No. 27 Calcium at 500 kg CaO/ha

" 28 " 1000 "


10
11


27
28

PLATE IX

Influence of P_2O_5 on the growth of rice

Variety - Padma

Pot No.11 P_2O_5 at 50 kg / ha

" 15 " 100 "

PLATE No. X

Influence of P_2O_5 on the growth of rice variety - Jaya

Pot No. 23. P_2O_5 at 25 kg/ha

,, 25 ,, 50 kg/ha


11
15


23
25

PLATE XI

Influence of P_2O_5 on the growth of rice

Variety - Padma

Pot No.	1	P_2O_5	at	0 kg/ha
"	15	"		100 "

PLATE XII

Influence of P_2O_5 on the growth of rice

Variety - Jaya

Pot No.	17	P_2O_5	at	0 kg/ha
"	31	"		100 "


1
15


17
31