YIELD AND YIELD COMPONENTS OF MAIZE/RICE MIXTURE AS INFLUENCED BY NITROGEN AND PHOSPHORUS FERTILIZATION.

BY

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A Thesis submitted to Ahmadu Bello University-Post-graduate School, in partial fulfilment of the requirements for the degree of Master of Science in Agronomy.

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MARCH, 1993

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous applic tion for a higher degree.

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CERTIFICATION

This thesis entitled "YIELD AND YIELD COMPONENTS OF MAIZE/RICE MIXTURE AS INFLUENCED BY NITROGEN AND PHOSPHORUS FERTILIZATION" By James M. KOMBIOK meets the regulations governing the degree of Master of Science in Agronomy of Ahmadu Bello University, Zaria and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my parents and previous and present teachers for making me what I am today.

MEANING OF SOME ABREVIATIONS

1.	DAP	-	Days after planting
2.	N.S	-	Not significant
3.	DMRT	-	Duncan's Multiple Range Test
4.	LSD	-	Least significance difference
5.	/ha	-	Per hectare
6.	N	-	Nitrogen
7.	P	-	Phosphorus
8.	gm	-	Grammes
9.	ppm	-	Parts per million
10.	cm	-	Centimeter.
11.	kg/N/ha	-	Kilogramme nitrogen per hectare
12.	kg/P/ha	-	Kilogramme phosphorus per hectare
13.	LAI	-	Leaf area index.

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ABSTRACT

A field experiment was conducted at Samaru farm of the Institute for Agricultural Research in 1990 and 1992 wet seasons with the objective of studying the effect of N and P on the yield and yield components of maize and rice under mixed cropping.

Factorial combinations of four levels of N (0, 60,120 and 180kgN/ha) and three levels of P (0, 13.2 and 26.4kgP/ha) were laid out in a randomised complete block design with four replications.

The results revealed that the grain yield of maize and rice were significantly influenced by N and P. In 1990, maize grain yield increased significantly upto 13.2kgP/ha at 0 and 60kgN/ha. There was no effect of P at 120 and 180kgN/ha. For rice, grain yield at 0 and 60kgN/ha was not influenced by P whereas, application of 26.4kgP/ha significantly increased grain yield at 120 and l80kgN/ha. In 1992 application of 13.2kgP/ha at each level of N significantly increased maize and rice grain yields. The highest grain yields were obtained at 120kgN/ha with 13.2kgP/ha suggesting that this fertilizer rate could be recommended for the mixture.

Yield components of maize such as cobs per square metre increased significantly with levels of N and P but there were; no signifleant changes in shelling percentage and hundred grain weight of maize. The number of panicles per square metre, number of tillers per plant and number of filled grains por panicle were the yield components of rice that responded to Increased N and P. While threshing percentage and thousand grain weight were not affected. Other plant characters of

both crops which were positively influenced by N and P were LAI, plant height and plant dry matter.

There was highly significant and positive correlation between maize grain yield and yield component such as cobs per square metre (r = 0.586, r = 0.558) in 1990 and 1992 respectively. In rice however, grain yield was found to be significantly and positively associated with components of yield such as panicles per square metre (r= 0.915, r = 0.910) and number of tillers per plant (r = 0.851, r = O.850) in 1990 and 1992 respectively.

Percent crude protein in plant leaves at maturity increased with the application of N alone but not with P. While percent P in leaves was significantly increased with both N and P.

Percent N in the soil at Crop maturity increased significantly with N upto 180kgN/ha but was not affected by P. Similarly P content in soil was significantly and positively influenced by P but not with N application.

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CHAPTER 1

INTRODUCTION

Mixed cropping, the system of growing two or more crop species simultaneously on the same piece of land at the same time is persistent among small scale farmers (Andrews and Kassam, 1976; Willey, 1979).

Growing crops in mixtures was a world-wide practice before the advent of mechanised agriculture. In U.S.A for example, Thatcher (1925) reported that 57% of the soyabean hecterage in Ohio State was grown mixed with maize. Similarily, between 1923 and 1926, about 60% of the soyabean grown in Illinois State was also mixed with maize (Hackleman et al., 1928). The practice however has now virtually disappeared in the more developed countries of Europe and America mainly due to mechanisation but it remains the dominant cropping system in the developing countries of the tropics and sub-tropics including Nigeria (Norman, 1974). In the surveys conducted in the former Zaria Province of Nigeria, Norman (1974 and 1975) revealed that, about 82% of the land grown to crops was under mixed cropping system because of the numerous advantages associated with this system.

Some of the advantages derived from mixed cropping by peasant farmers include precautions against uncertainty and income stability (Abalu, 1977), total productivity per unit area is increased (Rahat and Singh, 1979) and a reduction of pest and disease infestations (Anon; 1977).

Production of maize in the savanna areas of Nigeria is expanding. Apart from the fact that, the savanna environment has proved suitable for the production of the crop, major reasons for popularising maize as a grain crop in these areas where sorghum and millet are normally grown include its higher yields of about two or three times than the average experimental yield of sorghum and millet. Yields of about 8 - 10 tons/ha have been obtained for maize as against 4 - 5tons/ha for improved millet and long-season sorghum (Kowal and Kassam, 1978). Maize ears are protected by husk against insect and bird damage.

Both maize and rice have become important in the Nigerian goal for food sufficiency (Olu and Adepetu, 1984) and mixed cropping involving cereal/cereal continues to be dominant and important system in northern Nigeria (Fisher, 1979).

Recent work on maize/rice mixture showed that alternating one ridge of maize with five rows of rice proved promising in producing component crop yields that are comparable to sole crop of maize and rice (Anon, 1990) but, no extensive studies have been conducted on rates of fertilizers on maize/rice mixture in this ecological zone. Farmers therefore rely on rates of fertilizers meant for sole crops. This necessitates the studies on nitrogen and phosphorus levels that give maximum yield and efficiencies in the inter-crop system.

This study was therefore undertaken to:-

(i) determine the effect of nitrogen and phosphorus on the yield and yield components of maize/rice mixture;

(ii) determine the effect of N and P on the contents of nitrogen and phosphorus in the leaves of maize and rice and the residual status of N and P in the soil at crop maturity.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Effect of nitrogen and phosphorus on maize/rice mixture.

Information is very scanty on nitrogen and phosphorus for cereal/cereal mixture especially maize/rice mixture in the northern Guinea Savanna ecological zone of Nigeria, in contrast to sole maize and sole rice.

Moura and Lodi (1983) evaluated inter-cropping maize with rice in relation to grain yield and land use. Using both traditional and the recommended practices, they observed that, increasing levels up to 120kgN/ha and phosphorus upto 60kgP_2O_5/ha increased maize and rice grain yields significantly in pure stands and in the inter-crop respectively.

In another trial on the effect of plant arrangement and levels of fertilizer application, grain yield of sole rice as well as the inter-crop increased significantly with increasing levels of nitrogen upto 120kgN/ha (Anon, 1986).

2.2 Effect of nitrogen and phosphorus on sole maize.

2.2.1 Effect of nitrogen on sole maize.

Increasing levels of nitrogen increases grain yield but may not have significant effect on some

plant characters. Reyes et al; (1972) observed that plant height of maize was not affected when levels of nitrogen was increased from 0 - 200kgN/ha. In separate experiments, Paranbhakaran et al., (1973) and Ologunde, (1974) observed significant increases in grain yield of maize upto 120kgN/ha but further increases after this level never showed any significant increase in grain yield.

In the savanna ecological zone of Nigeria, 65kgN/ha applied to maize could give high yields, however, with hybrid maize the rate should be doubled (Jones, 1974). The optimum nitrogen rate was observed to be 120kgN/ha when a study was carried out by Balasubramania and Mokwunye (1976) where grain yield of maize was rather depressed at 180kgN/ha.

Jobim (1976) observed increase in maize grain yield from 2.7tons/ha to 4.5tons/ha when N was increased from 60 - 100kgN/ha. Increasing nitrogen from 0 - 15kgN/ha did not show any significant increase in grain yield but when it was increased above this level (0 - 15kgN/ha), significant higher grain yields were obtained. El-sharkey (1976) working with two levels of nitrogen (70 and 140kgN/ha) in Libya, found the least grain yield from plots with 70kgN/ha application.

Generally, increasing levels of nitrogen application to maize results in corresponding increases in grain yield to a maximum after which further increases in nitrogen may not give a corresponding significant yield increase. Roy and Singh (1984) and Ologunde and Ogunlela (1985) observed a significant increase in grain yield of maize only upto 120kgN/ha after which there was no significant increase in yield.

2.2.2 Effect of phosphorus on sole maize

Increasing levels of phosphorus applied to maize in the presence of nitrogen increases grain yield and some attributes of yield significantly (Lonhard-Bory and Nemeth, 1989). Leaf area index in particular was observed to increase by 18 - 24% when phosphorus was increased from 0 - 60kgP_2O_5/ha.

A linear response to phosphorus application and a highly significant and positive interaction was observed when McPhilips (1989) applied two levels of phosphorus (32.5 and 65kgP_2O_5/ha) and three levels of nitrogen (78, 136 and 190kgN/ha) to maize.

Sun et al; (1989) studied the effect of nitrogen and phosphorus on the extent of lodging and yield of maize and observed that, lodging in plots where nitrogen was applied alone was 58.8% as against

56.4% in plots with both nitrogen and phosphorus applied. On the other hand, on phosphorus applied plots with no nitrogen, the lodging was as low as 43.8% but grain yield was significantly higher in nitrogen or phosphorus alone than in the checks.

2.3 Effect of nitrogen and phosphorus on sole rice

2.3.1 Effect of nitrogen on sole rice.

Different rates of nitrogen have variable effect on rice yield and yield components, Chang (1968) observed that although increase in grain yield was obtained when rates of nitrogen increased from zero upto 136kgN/ha, the effect on a 1000 grain weight was not significant. Saisong et al (1970) noted that the effect of nitrogen application on yield components differ from character to character. The most important characters to be affected were concluded to be the number of panicles per metre square followed by the number of filled grains per panicle.

With proper management such as good water supply, frequent weeding and pest and disease control, high grain yield of about 4.8tons/ha was obtained with heavy nitrogen applications to rice (Tanaka, 1970). It was also noticed that periods at which nitrogen produces its fertilising effect on rice are mainly the early growth stage and panicle initiation stage and this makes split application more efficient (Chang, 1976).

Different varieties of rice respond differently to nitrogen. In a trial involving thrde varieties of rice and four levels of nitrogen (0, 40, 80 and 120kgN/ha), it was observed that ITA 235 grain yield decreased with increasing levels of nitrogen, Faro 15 remained constant but ITA 117 increased with nitrogen levels upto 120kgN/ha after which no significant grain yield was observed (Anon. 1979).

Grain yield, number of tillers per plant and number of panicles per unit area of rice were observed to increase linearly with increasing levels of nitrogen (Nossa and Vergara, 1980). The increase in panicle number and tillers when levels of nitrogen were increased has also been reported (Anon, 1983). The grain yield and tiller number of early maturing ITA 257 increased as rate increased upto 180kgN/ha. The percent lodged plants in the same experiment was higher in the higher levels (90 and 120kgN/ha) and moderate (26%) at lower rates (30kgN/ha).

Balasubramanian(1984) observed an increase in plant height, number of panicles per hill and grain yield at 120kgN/ha when urea (46%N) was applied 50% at sowing, 25% at tillering and the last 25% at panicle initiation. Increasing levels of nitrogen above 180kgN/ha however increased number of tillers, grains per unit area but lodging was also significantly increased (Munda, 1989).

2.3.2 Effect of phosphorus on sole rice.

Comparing nitrogen and phosphorus in a series of experiments, Walker (1972) observed a significant increase in grain yield only when phosphorus was applied and worked into the soil on plots with the highest level of nitrogen (180kgN/ha).

The relationship between grain yield and number of panicles per metre square and the amount of phosphorus applied was highly significant and positive (Matsushina, 1976).

Varieties of rice with longer and wider leaf sheaths are more responsive to phosphorus when nitrogen is not lacking than varieties with shorter and narrower leaf sheaths (Lee and Bin, 1988). Sharma and Miltra (1989) obtained paddy yields of about 4.3tons/ha for Jaya (wider leaf Sheaths) as against 3.5tons/ha for Ratra cultivar (narrow leaf sheaths) when 90kgP_2O_5 was applied.

2.4 The importance and availability of nitrogen and phsophorus and their effect on nitrogen and phosphorus in the soil.

Nitrogen and phosphorus are both essential for plant growth and deficiency of either will limit plants growth. Results obtained by Nye (1952) under savanna conditions in northern Ghana suggested

that the interactions between nitrogen and phosphorus would be high and positive where the effect of individual elements in the soil were high. An adequate supply of phosphorus tended to counteract the delay in maturity caused by excess nitrogen application (Eguchi et al, 1958).

Nitrogen is directly involved in phosphorus metabolism and the amount of nitrogen required by plant in the soil depends to some extent on the level of available phosphorus (Grunes 1959). Nitrogen is a constituent of chlorophyll, plant proteins and amino acids. Addition of nitrogen to the soil aids the synthesis of these compounds which in turn aid plant growth while poor development and stunted growth are pronounced signs of nitrogen starvation. The growth of plant was found to be highly correlated to the amount of nitrogen absorbed (Gasser and Williams, 1967).

Brady (1974) observed that nitrogen tends primarily to encourage above ground vegetative growth and inparts to leaves green colour (chlorophyll) for photosynthesis. Excess nitrogen in the soil however leads to luxury uptake by plants with resultant vegetative growth while its difficiency was observed to cause the yellowing of foliage and poor grain yields (Asher and Lee, 1981).

In a series of experiments over three years on the nitrogen content of the soil, Stabetorp and Lyngstad (1988) observed higher significant residual amounts of nitrogen from plots with 160kgN/ha than that with 120kgN/ha.

Although the amount of total phosphorus in an average soil compares favourably with that of other minerals, its availability to plants is very low (Pierre et al; 1974). This is because most of the phosphorus present in the soil easily reverts to less available forms but its availability and efficiency is observed to be enhanced if the nitrogen status of the soil is not very low (Brady, 1974). He further identified early flowering, seed formation, crop maturation and the strength of cereals to be some of the functions of phosphorus while bluish-green to purple tints on older leaves are apparent phosphorus deficiency.

A high supply of soil phosphorus results in a low percentage of phosphorus from fertilizer. On the other hand under conditions where phosphorus in the soil is very deficient the percent phosphorus from fertilizer will be high and at the same time, high grain yield and dry matter responses would be expected but contrary to this, no yield response would be observed (Anon 1984).

Phosphorus application to soils increases available phosphorus several times as it was shown by Ivanov and Dimitrov (1989) that the available phosphorus status was lower at 120kgP_2O_5/ha than at 180kgP_2O_5/ha plots after crop maturity. Long term annual application of phosphorus in the soil was also studied by Condron and Goh (1989). The results revealed that increases in soil in-organic and organic phosphorus occurred in response to continued phosphorus addition although in-organic phosphorus decreased with time following cessation of phosphorus fertilizer application.

2.5 Effect of nitrogen and phosphorus on the contents of nitrogen and in crop plants.

The contents of nitrogen and phosphorus in crop plants vary according to the supply of nitrogen and phosphorus to the plant, genetic characteristics of the crop planting rate and weather conditions Pierre et al; (1974). They observed least efficient way of application of fertilizer when it was broadcasted and left on the surface of the soil.

When field and plant tissue tests were conducted for nitrogen and phosphorus in Sudan, Osman et al; (1977) noted that rice did not respond to phosphorus as nitrogen. As early as the seedling stage, there was an optimum accumulation in the leaf blade of 1300ppm of nitrogen but the accumulation of phosphorus was not significant.

Nitrogen uptake by maize is observed to increase with incfeasing levels of nitrogen. Jokela and Randall (1989) observed significant nitrogen uptake by maize in USA upto the highest rate of 225kgN/ha application.

Crop plants however make good use of phosphorus more at vigorous vegetative growth stage. It was therefore concluded that maximum utilization of phosphorus resulting to higher grain yield and dry matter would be obtained when phosphorus is applied before 30 days after planting (Seartz and Sterges, 1965).

A positive interaction of nitrogen and phosphorus was observed when Bayo (1979) conducted two separate experiments on Paddy field fertilization. Increasing the rates of phosphorus upto 90kgP_2O_5/ha increased the uptake of phosphorus significantly.

When maize was grown in pots of podzottic soil increasing phosphorus levels upto 768mgP/pot was observed by Zia, (1988) to increase tissue concentration to a maximum corresponding to the highest rate of phosphorus.

CHAPTER 3.

3.0 MATERIALS AND METHODS

3.1 Experimental Location

A field trial was conducted at the Institute for Agricultural Research farm, Samaru (11° 11'N, 07° 38'E, 680m above sea level) in the northern Guinea Savanna ecological zone of Nigeria during 1990 and 1992 wet seasons. Rainfall, evapo-transpiration data for 1990 and 1992 are shown in appendices A and B.

3.2 Treatments and Experimental Design

The treatments were composed of all possible combinations of four levels of nitrogen (0, 60, 120 and 180kgN/ha) and three levels of phosphorus (0, 13.2 and 26.4kgP/ha) in a randomised complete block design with four replications. The gross plot size was $40.5M^2$ ($8.1 \times 5.0M^2$) and a net plot size of $27.0M^2$ ($5.0M \times 5.4M$).

3.3 Land Preparation

The site was disc-ploughed and ridged at 90cm apart by a tractor mounted ridger. Every other ridge was then flattened, levelled and raked to a fine tilth. A composite soil sample was taken at random by means of soil auger for physio-chemical properties determination (Appendix C). This was done before planting in both years.

3.4 Planting and Planting Materials

Maize (cv: TZBSR) a late maturing variety (120 days), resistant to streak with white grains (Anon, 1975) and rice (cv: ITA 257) an early maturing variety (90 - 100 days), blast resistant and low shattering (Anon, 1981) were used in this trial.

Maize was planted on the 18th June, 1990 and 30th June, 1992 respectively at 1.8m by 0.2m. This was thinned to two plants per hill two weeks after planting to maintain a population of 55,555 plants per hectare.

Rice on the other hand was planted on the 19th, June 1990 and 2nd July, 1992 respectively at six seeds per hill at 30cm by 30cm which was also later thinned to two plants per hill to meet a population of 222,222 plants per hectare.

There was one ridge of maize alternating five rows of rice on flat.

3.5 Fertilizer application

Fertilizer application was by band placement with half the amount of urea (as source of nitrogen) applied two weeks after planting and the second dose seven weeks after planting. Single superphosphate served as the source of phosphorus and this was applied as a single dose at two weeks after planting and covered with soil.

3.6 Weed control

Five hoe-weeding operations were carried out at two, four, six, nine and twelve weeks after planting.

3.7 Harvesting

Maize was harvested by hand on the 15th October, 1990 and 21st October 1992 respectively while rice was harvested using a sickle on the 6th October, 1990 and 7th October, 1992 respectively.

3.8.0 Data Collection

3.8.1 Plant shoot height

Five plants each were chosen at random outside the net plot for both maize and rice and their heights determined by measuring from ground level to the last leaf ar tassel or panicle respectively, the average height per plant of maize and rice was then recorded per plot. This was done at 30, 60 and 90 days after planting.

3.8.2 Plant dry matter.

The five plants each of maize and rice used for height determination above (3.8.1) were cut at ground level and oven dried and the average dry weight per plant determined on a sensitive balance in the laboratory also at 30, 60 and 90 days after planting.

3.8.3 Leaf area index (LAI) at maturity

An area of one square metre was taken in each plot for leaf area index for maize and rice separately. The length and brendth of maize and rice of each leaf of five randomly selected maize and rice plants were measured and multiplied by a factor of 0.8 for maize and 0.7 for rice respectively (Watson 1952). The leaf areas were then averaged per plant of maize and rice and multiplied by the number of each crop plants in the square metre, ($1m^2$). The total leaf areas per each plant were then divided by the land area of one square metre.

3.8.4 Number of days to 50% tasselling of maize and 50% panicle initiation in rice.

Number of days from planting to when maize and rice attained 50% tassels and 50% panicles respectively were recorded.

3.8.5 Ear height

Five maize plants per plot were used for ear height determination. The height was taken from the ground level to the node at which the top most ear was attached and average height per ear recorded.

These plants were tagged and subsequently used for cob length, ear diameter, cob diameter and kernel depth determinations.

3.8.6 Number of cobs of maize per square metre.

The number of cobs in each net plot was counted prior to harvest and converted to per metre basis.

3.8.7- Number of panicles of rice per square metre.

The number of panicles harvested from each net plot was physically counted and recorded during harvesting.

3.8.8 Cob length of maize.

The length of five cobs harvested from the five plants used for ear height determination (3.8.5) were measured and average length per cob recorded.

3.8.9 Ear diameter of maize

The diameter per every ear from the cobs used for cob length above (3.8.8) was taken and average diameter recorded to represent ear diameter.

3.8.10 Cob diameter of maize

After shelling the five ears measured for ear diameter above (3.8.8) their cob diameters were also measured and average per cob recorded.

3.8.11 Kernel depth of maize

Kernel depth was obtained by substracting the cob diameter from the ear diameter found above.

3.8.12 Number of tillers per rice plant.

The number of tillers produced per plant of rice was counted. This was done by counting the number of plants per hill at random for five hills and the average per hill recorded.

3.8.13 Shelling percentage of maize.

The shelling percentage of maize was calculated as follows:-

$$\text{Shelling percentage (\%)} = \frac{\text{Grain weight after shelling}}{\text{cob weight (unshelled)}} \times 100$$

3.8.14 Threshing percentage of rice

$$\text{Threshing percentage (\%)} = \frac{\text{Grain weight after threshing}}{\text{panicle weight (unthreshed)}} \times 100$$

3.8.15 Number of filled grains per panicle and percentage unfilled grains.

The number of filled grains and percentage unfilled grains were determined by a method devised by Gomez (1972) as follows:-

(i) Number of filled grains;

$$= \frac{f}{w} \times \frac{W + w}{P}$$

(ii) Percentage unfilled grains;

$$= \frac{U + u}{f(Wxw)/_{w} + U + u} \times 100$$

Where:

P = number of all panicles per square metre

f = filled grains from two main rice plants (not tillers) harvested from one square metre

u = the number of unfilled grains from the two main plants.

w = the weight of filled grains from the two main plants above

U = the number of unfilled grains from the rest of the plants in the square metre

W = The weight of filled grains from the square metre area.

3.8..16 Grain weight

Grain samples of maize and rice were collected from each net plot and hundred grain weight of maize and thousand grain weight of rice were taken respectively.

3.8.17 Grain yield

The harvested cobs of maize and panicles of rice from the net plots were shelled and threshed respectively, sun dried and winnowed. The grains were then weighed before converting each crop yield into per hectare basis.

3.8.18 Nutrient analysis

Contents of nitrogen and phosphorus were determined in all the leaves of maize and rice at maturity and their residue in the soil also determined after crop maturity by Soil Science Department of the Faculty of Agriculture, Ahmadu Bello University, Zaria. Percent N in leaves of maize and rice was converted into crude protein content by multiplying by 6.25.

3.8.19 Data analysis

Analysis of variance was done to test the treatment effect for significance using F-test as described by Cox and Cochran (1967). The effect of nitrogen and phosphorus and their interactions were compared using LSD and DMRT at 5% level of probability respectively.

A simple correlation was also done for some selected characters of both maize and rice separately to test their degree of association.

CHAPTER 4

4.0 RESULTS

4.1 Effect of N and P levels on grain yield, shelling percentage, number of cobs per square metre and 100-grain weight of maize.

4.1.1 Grain yield of maize

Maize grain yield increased significantly in both years as levels of nitrogen increased (Table 1). In 1990 however, the increase in grain yield of maize was significant upto the highest level of nitrogen (180kgN/ha) while in 1992, yield advantage beyond 120kgN/ha was not significant.

The effect of phosphorus levels on maize yield showed that, there was no significant increase in grain yield of maize beyond 13.2kgP/ha in both years (Table 1).

There was interaction of nitrogen and phosphorus on maize grain yield with increasing levels of N and P in both years (Tables 2 and 3). In 1990, at N levels of 0 and 60kgN/ha there was a significant decreasing effect on grain yield as levels of phosphorus increased while at 120 and 180kgN/ha there was no significant effect on grain yield observed with increasing phosphorus levels (Table 2). On the other hand, at all the levels of phosphorus, increasing levels of nitrogen significantly influenced grain yield to the highest level of nitrogen.

Table 1: Effect of N and P on maize grain yield (kg/ha)+ shelling percentage (%)+, cobs per square metre and hundred grain weight+ (1990 and 1992).

	Grain yield (kg/ha)		Shelling percent	Cobs (No/M^2)		100-grain weight (g)	
Treatments	1990	1992	1992	1990	1992	1990	1992
N-levels(kg/ha)							
0	485d	590c	76.00	6.58b	3.21b	21.60	15.14c
60	3053c	3167b	76.04	7.58a	7.71a	22.28	16.70c
120	3267b	4827a	76.56	8.17a	7.93a	22.28	19.06b
180	4063a	4835a	76.00	8.75a	8.38a	22.41	20.97a
SE +	44	38	0.61	0.33	0.32	0.54	0.51
LSD (0.05)	133	114	NS	0.98	0.96	NS	1.53
P-levels (kg/ha)							
0	2829b	2834b	75.85	6.94c	6.68b	21.97	18.12
13.2	2986a	3130a	76.14	7.63b	7.84a	23.48	17.95
26.4	3085a	3100a	76.47	8.75a	8.21a	21.35	19.60
SE ±	39	38	0.53	0.32	0.30	0.41	0.22
LSD (0.05)	116	113	NS	0.96	0.92	1.20	NS
Interaction							
N x P	**	**	NS	**	**	NS	NS

+ For a factor, means followed by similar letter in a column are not statistically significant at 5% level of probability (LSD).

* Significant at 5% level of probability

** Significant at 1% level of probability

NS = Not significant.

Table 2: Interaction of N and P levels on grain yield (kg/ha)+ of maize (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	303e	485d	666d
60	2786c	3162b	3211b
120	3209b	3228b	3362b
180	4018a	4068a	4102a

+ Means followed by similar letter in both row and column are not significantly different at 5% level of probability (DMRT).

Table 3: Interaction of N and P levels on the grain yield (kg/ha)+ of maize (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	537j	870i	363k
60	2667h	3630f	3204g
120	4444d	6093a	3944e
180	3689f	5926b	4889c

+ Means followed by similar letter in both row and column are not significantly different at 5% level of probability (DMRT).

In 1992 however, at all the levels of nitrogen, grain yield of maize increased upto 13.2kgP/ha and decreased significantly in each case with further increases (Table 3). Similarily, at all the levels of phosphorus increasing levels of nitrogen significantly influenced grain yield in each case upto 120kgN/ha with the highest grain yield obtained when nitrogen and phosphorus increased upto 120kgN/ha and 13.2kgP/ha respectively.

4.1.2 Shelling percentage of maize.

Result obtained in 1992 on maize shelling percentage (the only year the variable was taken) revealed that, neither increasing levels of nitrogen, phosphorus nor their interactions significantly influenced the shelling percentage of maize (Table 1).

4.1.3 Number of cobs per square metre.

Number of cobs per square metre increased significantly as the level of nitrogen increased but only upto 60kgN/ha in both years (Table 1).

In 1990, phosphorus significantly influenced the number of cobs per square metre to the highest level of phosphorus (26.4kgP/ha) while in 1992, increase in the number of cobs per square metre beyond 13.2kgP/ha was not significant (Table 1).

In 1990 the interaction of nitrogen and phosphorus on cob number showed that, at all the levels of nitrogen except at 180kgN/ha there was no significant

influence on cob number with increasing levels of phosphorus. However at 180kgN/ha, cob number increased when phosphorus level increased to 13.2kgP/ha beyond which there was no significant effect (Table 4).

Except at the highest level of phosphorus, where cob number increased significantly upto 60KgN/ha, increasing levels of nitrogen upto 120kgN/ha had no significant influence on cob number at the other levels of phosphorus.

However in 1992, increasing level of nitrogen significantly influenced cob number at 13.2kgP/ha and 26.4kg/ha but not at plots without phosphorus (Table 5). While with increasing level of phosphorus, cob number was only significantly influenced at 60kgN/ha.

4.1.4 Hundred grain weight of maize.

Hundred grain weight of maize was not significantly affected by levels of nitrogen in 1990 but in 1992, there was a significant increase in hundred grain weight upto 180kgN/ha with 60kgN/ha at par with the plots without nitrogen (Table 1).

In both years, increasing levels of phosphorus had no significant influence on hundred grain weight on maize (Table 1).

There was also no interqction of nitrogen and phosphorus on hundred grain weight of maize in both years.

Table 4: Interaction of N and P levels on number of cobs (No/M^2)+ of maize (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	6.00b	6.00b	7.50b
60	6.50b	8.00ab	8.25a
120	7.75ab	7.75ab	9.00a
180	7.50b	8.75a	10.00a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

Table 5: Interaction of N and P levels on the number cobs (No/M^2)+ (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	7.00b	7.00b	8.75b
60	7.50b	9.00b	9.25a
120	8.75ab	8.75ab	10.00a
180	8.50ab	9.75a	11.00a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

4.2 Effect of N and P on ear height and leaf area index of maize at maturity.

4.2.1 Ear height of maize.

The results obtained in both years on ear height showed that in 1990, ear height was influenced by nitrogen level upto 120kgN/ha after which there was no significant increase, while in 1992, there was rather a significant decrease in ear height beyond 120kgN/ha (Table 6).

In 1990 it was observed that, increasing level of phosphorus did not significantly affect ear height. Contrary to this in 1992, there was a significant effect on ear height upto the highest level of phosphorus (Table 6).

There was no interaction of nitrogen and phosphorus on ear height in 1990 but in 1992, the interaction of N and P on ear height is presented in Table 7. Ear height significantly increased at all levels of nitrogen upto the highest level of phosphorus except at the check, (without phosphorus) where the increment was upto 13.2kgP/ha. In a similar manner, ear height was significantly influenced at all levels of phosphorus with increasing levels of nitrogen.

4.2.2 Leaf area index of maize

Leaf area index of maize was observed to be positively influenced by levels of nitrogen in both years (Table 6). Increasing nitrogen to 180kgN/ha gave

Table 6: Effect of N and P levels on the ear height (cm)+ and LAI of maize+ (1990 and 1992).

	Ear height		Leaf Area Index	
Treatments	1990	1992	1990	1992
N-levels(kg/ha)				
0	59.18b	66.13d	2.98d	3.60d
60	63.87b	87.63c	3.59c	5.39c
120	73.12a	94.38a	3.62b	6.33a
180	81.70a	89.56b	4.34a	5.52b
SE ±	3.14	1.07	0.10	0.05
LSD (0.05)	9.05	3.06	0.28	0.14
P-levels (kg/ha)				
0	74.78	77.41c	3.58b	4.92b
13.2	72.76	83.00b	4.58a	5.36a
26.4	70.85	92.86a	4.65a	5.35a
SE ±	0.89	0.93	0.08	0.04
LSD (0.05)	NS	2.65	0.25	0.12
Interaction				
N x P	NS	*	*	**

+ For a factor, means followed by similar letter in a column are not significantly different at 5% level of probability (LSD).

* Significant at 5% level of probability

** Significant at 1% level of probability

NS = Not significant.

Table 7: Interaction effect of N and P levels on ear height of maize (cm)+ (1992)

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	62.25	70.25e	65.88f
60	78.38d	85.15c	99.38b
120	85.75c	88.75c	108.63a
180	83.28cd	87.88c	97.56b

+Means followed by the similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

corresponding significant increase in leaf area index in 1990 but in 1992, there was a significant decrease in leaf area index beyond 120kgN/ha.

The effect of phosphorus on leaf area index in both years showed that increasing phosphorus level beyond 13.2kgP/ha did not significantly affect the variable (Table 6).

The results obtained in both years indicated that there was a highly significant interaction effect of nitrogen and phosphorus on leaf area index (Tables 8 and 9).

In 1990, at lower levels of nitrogen (0 and 60kgN/ha) there was interaction effect on leaf area index with increasing levels of phosphorus, but at higher levels of 120kgN/ha and 180kgN/ha, there was no interaction effect observed (Table 8). Increasing levels of nitrogen on the other hand showed a significant influence on leaf area index at every level of phosphorus upto the highest level of nitrogen.

On the contrary in 1992, there was no interaction observed at the lower levels of nitrogen (0 and 60kgN/ha) with increasing levels of phosphorus (Table 9). However at 120 and 180kgN/ha, there was a significant decrease in leaf area index upto to 26.4kgP/ha with the values at 13.2kgP/ha being at par with the check (without phosphorus). Also at all the levels of phosphorus, there was significant influence on leaf area index with increasing levels of nitrogen upto 120kgN/ha except at 26.4kgP/ha where positive response was observed upto 180kgN/ha.

Table 8: Interaction effects of N and P levels on LAI+ of maize at maturity (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	2.17d	2.94c	3.83b
60	2.82c	3.83b	4.13b
120	3.12b	3.58b	4.15b
180	4.21a	4.36a	4.47a

+ Means followed by similar letter in both row and column are not significantly different at 5% level of probability (DMRT).

Table 9: Interaction effect of N and P levels on LAI+ of maize at maturity (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	4.39de	4.49de	2.93e
60	5.02d	5.06d	5.09d
120	6.75a	6.73a	5.51c
180	4.51de	5.17d	6.87a

+ Means followed by similar letter are not significantly different at 5% level of probability (DMRT).

4.3 Effect of N and P on maize shoot height at 30, 60 and 90 days after planting

Except at 30 days after planting where significant increase in maize shoot height was observed when nitrogen was increased a level beyond the check, there were significant taller maize plants upto 120kgN/ha at 60 and 90 days after planting in both years (Table 10).

Maize shoot height was significantly influenced by increasing level of phosphorus upto 26.4kgP/ha at 30 days after planting in both years (Table 10). However at 60 and 90 days after planting, there was no significant effect observed beyond 13.2kgP/ha in both years.

There was significant interaction on maize shoot height at all the stages of sampling in both years (Tables 11, 12, 13, 14, 15 and 16).

In 1990 at 30 DAP plots without phosphorus and plots fertilized with 26.4kgP/ha had significant effect on maize shoot height only when nitrogen was raised a level above the control (without N) in each case with higher maize shoot at 26.4kgP/ha than plots without phosphorus (Table 11). While at 13.2kgP/ha, shoot height responded positively upto 120kgN/ha. However increasing levels of phosphorus on the other hand, at lower levels of nitrogen (0 and 60kgN/ha) showed significant effect but at higher levels of nitrogen (120 and 180kgN/ha) there was no significant increase in shoot height beyond 13.2kgP/ha.

At 30 DAP in 1992 there was significant effect of phosphorus at all the levels except at the control (0kgP/ha) with increasing levels of nitrogen with the tallest maize shoot height obtained at 60kgN/ha and 26.4kgP/ha respectively (Table 12). On the contrary, there was interaction effect at all the levels of nitrogen except at 120kgN/ha with levels of phosphorus.

In 1990 at 60 DAP, maize at all levels of phosphorus showed that there was interaction with levels of nitrogen on maize shoot height (Table 13). Increasing levels of phosphorus at all levels of nitrogen also showed significant maize shoot height with significantly taller shoot height at 180kgN/ha as phosphorus levels increased from 13.2 to 26.4kgP/ha than other levels of nitrogen. There was no interaction of N and P on maize shoot height at plots without phosphorus fertilization in 1992 at 60 DAP with levels of nitrogen but plots with 13.2 and 26.4kgP/ha showed significant effect only when nitrogen was raised to 60kgN/ha (Table 14). Increasing levels of phosphorus however positively affected maize shoot height at all levels of N except at 180kgN/ha.

There was interaction of phosphorus (at all levels) on maize shoot height in 1990 at 90 DAP with increasing levels of nitrogen (Table 15). Similarily at all levels of nitrogen except at 180kgN/ha, there was a significant increasing effect on maize shoot height with levels of phosphorus. In 1992 regardless of the

level of phosphorus at 90 DAP there was interaction on maize shoot height only when nitrogen level was raised above the control (Table 16). While at lower levels of nitrogen at 90 DAP showed interaction on shoot height, there was no effect at higher levels (120 and 180kgN/ha) as levels of phosphorus increased.

Table 10: Effect of N and P levels on plant shoot height (cm)+ at 30, 60 and 90 DAP (1990 and 1992).

	Plant shoot height					
	30		60		90	
Treatments	1990	1992	1990	1992	1990	1992
N-(kg/ha)						
0	27.38b	39.38b	104.55c	94.83c	109.25c	185.83c
60	39.56a	48.61a	145.00b	183.17b	156.88b	225.85b
120	40.18a	47.63a	175.38a	188.58a	189.25a	237.00a
180	40.56a	46.89a	189.18a	198.08a	200.03a	243.42a
SE ±	0.34	0.89	3.95	4.88	4.63	5.79
LSD (0.05)	1.12	2.56	12.75	12.49	14.79	12.25
P-(kg/ha)						
0	33.38c	41.95c	134.07b	148.81b	142.30b	210.25b
13.2	38.13b	43.87b	157.85a	169.06a	162.59a	222.69a
26.4	39.25a	51.05a	167.16a	180.63a	171.65a	235.88a
SE ±	0.33	0.78	3.82	3.76	3.73	3.68
LSD (0.05)	1.02	2.22	12.37	12.16	12.14	11.95
Interaction						
N x P	**	**	**	**	**	**

+ For a factor, means followed by same letter in the similar in a column are not significantly at 5% level of probability (LSD).

* Significant at 5% level of probability

** Significant at 1% level of probability.

Table 11: Interaction effect of N and P levels on maize shoot hight (cm)+ at 30 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	25.88f	27.25c	29.00d
60	35.50c	41.18b	42.00a
120	35.88c	41.70a	42.95a
180	36.75c	42.37a	43.06a

+Means followed by similar letter in both row and column are not significantly different at 5% level of probability using DMRT.

Table 12: Interaction effect of N and P levels on maize shoot height (cm)+ at 30 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	34.00d	35.47d	48.66b
60	44.94c	45.78bc	55.12a
120	46.38bc	46.75bc	49.75b
180	42.50c	47.47b	50.69b

+Means followed by similar letter(s) in row and column significantly different at 5% level of probability (DMRT).

Table 13: Interaction of N and P levels (kg/ha) on maize shoot height (cm)+ at 60 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	77.13g	114.13f	125.38e
60	125.88e	142.63d	166.50c
120	165.50c	175.13b	176.50b
180	167.75c	199.53a	200.25a

+Means followed by similar letter(s) in the same row and column are not significantly different at 5% level probability using DMRT.

Table 14: Interaction effect of N and P levels (kg/ha) on maize shoot height (cm)+ at 60 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	61.75d	105.75c	117.00c
60	172.50b	181.75b	195.25a
120	177.00b	186.50ab	202.25a
180	184.00ab	202.25a	208.00a

+ Means followed by similar letter(s) in the same row and column are not significantly different at 5% level of probability (DMRT).

Table 15: Interaction of N and P levels on maize shoot height (cm)+ at 90 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	83.38g	115.88f	128.50e
60	144.38d	154.75d	171.50c
120	149.00d	177.50c	181.25b
180	192.45ab	202.25a	205.38a

+ Means followed by similar letter(s) in both the same row and column are not significantly different at 5% level of probability using DMRT.

Table 16: Interaction of N and P levels on shoot height(cm)+ at 90 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	171.50c	185.50c	200.50b
60	205.50b	221.50ab	251.50a
120	228.50ab	241.50a	241.00a
180	235.50ab	242.25a	252.50a

+ Means followed by similar letter(s) in both the same row and column are not significantly different at 5% level of probability using DMRT.

4.4 Effect of N and P on maize dry matter at 30, 60 and 90 Days after planting.

At 30 and 90 DAP in both years, maize dry matter was observed to increase significantly but not beyond 120kgN/ha, while at 60 DAP there was a significant influence upto 180kgN/ha (Table 17).

The effect of phosphorus on dry matter of maize in both years showed that at 30 and 90 DAP there was significant effect only when phosphorus level increased upto 13.2kgP/ha while at 60 DAP significantly higher dry matter was observed upto 26.4kgP/ha (Table 17).

At all the stages of sampling for dry matter in both years, there was highly and significant effect of nitrogen and phosphorus interaction on maize dry matter (Tables 18, 19, 20, 21, 22 and 23).

The interaction of nitrogen and phosphorus showed that at 30 DAP in 1990, all the levels of phosphorus positively influenced plant dry matter (Table 18). Similarily, there was interaction at all the levels of nitrogen only when phosphorus level was raised to 13.2kgP/ha. In 1992, plots with no phosphorus eventhough showed significant increase in dry matter, it was not consistent with levels of nitrogen. However plots fertilised with 13.2 and 26.4kgP/ha showed a consistent increase in dry matter with the highest dry matter obtained at 180kgN/ha (Table 19).

In 1990 at 60 DAP there was interaction of phosphorus with nitrogen at all levels (Table 20). While increasing phosphorus level beyond 13.2kgP/ha did not significantly affect plant dry matter at all the levels of nitrogen except at plots without nitrogen (control). There was also interaction of phosphorus in 1992 at 60 DAP with levels of nitrogen on maize dry matter (Table 21). The highest dry matter was achieved at 180kgN/ha when phosphorus level was raised to 26.4kgP/ha.

At the final stage of sampling in 1990 (90 DAP) at all the levels of nitrogen, there was observed a significant increase in dry matter with increasing levels of phosphorus upto 26.4kgP/ha except at 180kgN/ha where beyond 13.2kgP/ha was not significant (Table 22). At 0kgP/ha and 26.4kgP/ha in 1992 there was positive influence on dry matter upto 120kgN/ha while at 13.2kgP/ha a rather decreasing effect was observed beyond 60kgN/ha (Table 23).

Table 17: Effect of N and P levels on the dry matter (g/plant)+ of maize at 30, 60 and 90 DAP (1990 and 1992)

	Days after planting					
	30		60		90	
Treatments	1990	1992	1990	1992	1990	1992
N-(kg/ha)						
0	3.86c	2.28c	24.77d	32.96d	80.91c	77.98c
60	7.02b	3.17b	59.58c	57.37c	171.56b	198.89b
120	7.86a	3.75b	77.81b	64.50b	216.23a	247.50a
180	7.89a	3.59b	103.95a	73.85a	228.72a	265.60a
SE ±	0.08	0.22	0.63	0.70	9.19	9.23
LSD (0.05)	0.25	0.64	1.38	2.10	27.54	27.69
P-(kg/ha)						
0	5.19b	2.36b	53.09c	48.01c	148.79b	171.53b
13.2	7.12a	3.74a	66.88b	59.18b	193.00a	219.29a
26.4	7.31a	3.74a	79.61a	64.31a	201.28a	201.71a
SE ±	0.07	0.22	0.61	0.61	9.16	9.06
LSD (0.05)	0.21	0.65	1.34	1.73	27.47	27.18
Interaction						
N x P	**	**	**	**	**	*

+ For a factor, means followed by similar letter in a column are not significantly different at 5% level of probability.

* Significant at 5% level of probability

** Significant at 1% level of probability.

Table 18: Interaction of N and P levels on dry matter (g/plant)+ of maize plants at 30 DAP (1990).

N-(kg/ha)	Phosphorus (kg/ha)		
	0	13.2	26.4
0	3.50f	4.01e	4.07e
60	4.80d	7.87b	8.08b
120	6.20c	7.91b	8.05b
180	6.30c	8.67a	8.72a

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability using DMRT.

Table 19: Interaction of N and P levels on dry matter (g/plant)+ of maize plants at 30 DAP (1992).

N-(kg/ha)	Phosphorus (kg/ha)		
	0	13.2	26.4
0	1.65j	2.04i	3.16d
60	2.87e	2.77f	3.87b
120	2.29h	2.93e	3.12d
180	2.64g	3.22c	4.89a

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability using DMRT.

Table 20: Interaction effects of N and P level on dry matter (g/plant)+ of maize at 60 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	13.14L	22.84k	28.36j
60	53.62i	57.65g	67.48g
120	64.59g	77.81c	91.03c
180	81.05d	119.23a	120.59a

+Means followed by similar letter in both row and column are not significantly different at 5% level of probability using DMRT.

Table 21: Interaction effect of N and P levels on dry matter (g/plant)+ of maize at 60 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	13.46i	43.618	41.80h
60	57.00e	61.07d	54.04c
120	56.92e	60.57de	76.81b
180	64.67d	71.49c	85.40a

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability using DMRT.

Table 22: Interaction effect of N and P levels on dry matter (g/plant)+of maize at 90 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	73.43h	87.43g	91.88f
60	134.06e	165.92d	214.72b
120	192.30g	204.43b	251.96a
180	195.38bc	244.22a	246.48a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability using DMRT.

Table 23: Interaction effects of N and P levels on dry matter (g/plant) +of maize at 90 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	82.92e	94.03e	57.63f
60	162.12c	316.96a	264.60b
120	310.01a	173.38c	313.14a
180	131.71d	292.61ab	171.47c

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability using DMRT.

4.5 Effect of N and P on cob length ear diameter, cob diameter and kernel depth of maize.

With the exception of cob length which was significantly influenced by levels of nitrogen upto the highest level of 180kgN/ha, ear diameter, cob diameter and kernel depth were all not affected by level of nitrogen (Table 24).

Increasing levels of phosphorus had no significant effect on these variables (cob length, ear diameter, cob diameter and kernel depth) in 1992 the only year the variables were taken (Table 24).

There was also no interaction effect of nitrogen and phosphorus on these variables.

Table 24: Effect of N and P on the cob length+, ear diameter+ cob diameter+ and kernel depth+ of maize (1992).

Treatments	Cob length (cm)	Ear diameter (cm)	Cob diameter (cm)	Kernel depth (cm)
N-level (kg/ha)				
0	10.17d	4.18	2.52	1.64
60	14.52c	4.41	2.66	1.68
120	15.90b	4.39	2.70	1.71
180	16.07a	4.53	2.70	1.68
SE ±	0.34	0.06	0.06	0.05
LSD (0.05)	0.10	NS	NS	NS
P-level (kg/ha)				
0	14.09	4.36	2.58	1.70
13	14.17	4.36	2.64	1.72
26	14.23	4.42	2.72	1.68
SE ±	0.17	0.05	0.05	0.02
LSD (0.05)	NS	NS	NS	NS
Interaction				
N x P	NS	NS	NS	NS

+ For a factor, means followed by similar letter in a column are not statistically significant at 5% level of probability.

4.6 Effect of N and P on percent lodged plant and number of days to 50% tasselling of maize.

4.6.1 Percent lodged maize plants.

The results obtained on percent lodged plants of maize in both years showed that, neither increasing levels of nitrogen, phosphorus nor their interactions had effect on the number plants lodged prior to harvesting (Table 25).

4.6.2 Number of days to 50% tasselling in maize.

The number of days to tasselling significantly increased with increasing levels of nitrogen in 1990 with no significant difference between the number of days to tasselling at 60 and 120kgN/ha (Table 25). However in 1992, there was a significant effect on the number of days to tasselling only when nitrogen increased beyond 120kgN/ha.

The effect of phosphorus and the interaction of nitrogen and phosphorus on the number of days to tasselling was not significant (Table 25).

Table 25: Effect of N and P levels on the percent lodged plants+ and number of days to 50% tasselling+ of maize (1990 and 1992).

	Percent lodged maize plants(%)		No of days to 50% tasselling of maize	
Treatments	1990	1992	1990	1992
N-(kg/ha)				
0	11.68	2.95	58.92c	63.75b
60	11.77	2.75	62.50b	63.00b
120	12.28	2.62	63.25b	63.58b
180	12.41	2.62	66.08a	66.58a
SE ±	0.48	0.18	0.69	0.58
LSD (0.05)	NS	NS	1.98	1.66
P-(kg/ha)				
0	12.10	1.14	62.00	64.94
13.2	12.24	1.31	63.06	65.13
26.4	11.96	2.07	63.00	65.13
SE ±	0.49	0.15	0.78	0.50
LSD (0.05)	NS	NS	NS	NS
Interaction				
N x P	NS	NS	NS	NS

+ For a factor, means followed by same letter in a colum are not statistically different at 5% level of probability.

NS = Not significant.

4.7 Effect of N and P on rice grain yield, threshing percentage, number of panicles per metre square and thousand grain weight.

4.7.1 Grain yield of rice.

Grain yield of rice was significantly influenced by levels of nitrogen fertilization in both years (Table 26). The application of nitrogen upto 180kgN/ha in 1990 gave significant increases while in 1992 there was no yield response beyond 120kgN/ha.

There was a significant increase in grain yield of rice with phosphorus application not beyond 13.2kgP/ha in both years (Table 26).

There was no interaction of nitrogen and phosphorus on rice grain yield at 0 and 60kgN/ha levels of nitrogen in 1990 (Table 27). On the contrary, at levels of 120 and 180kgN/ha, there was observed interaction with increasing levels of phosphorus. Similarily at 0kgP/ha, there was no influence with increasing levels of nitrogen while at 13.2kgP/ha there was effect when a level was raised above the control (no nitrogen). At 26.4kgP/ha however, there was corresponding effect upto the highest level of nitrogen. In 1992, at all the levels of phosphorus except at 13.2kgP/ha where there was significant decreasing effect, there was no effect beyong 120kgN/ha (Table 28).

Table 26: Effect of N and P levels on grain yield+, threshing percent+, panicles/M2+ and 100 grain weight+ of rice (1990 and 1992).

	Grain yield (kg/ha)		Threshing percentage (%)	Panicles(No/M^2)		1000 grain weight (g)	
Treatments	1990	1992	1992	1990	1992	1990	1992
N-levels(kg/ha)							
0	742d	930c	69.00	83.33d	42.83d	29.98	30.16
60	1608c	1836b	69.77	122.75c	90.00c	30.03	30.61
120	1666b	2328a	69.23	133.92b	183.33b	30.06	30.63
180	2206a	2416a	69.81	168.75a	194.00a	30.02	30.24
SE ±	64	36	0.65	4.34	3.95	0.52	0.54
LSD (0.05)	184	105	NS	13.87	12.92	NS	NS
P-levels(kg/ha)							
0	328c	1755b	70.13	109.81b	117.13b	29.32	30.50
13.2	1949a	1941a	68.64	130.00a	132.00a	29.77	29.80
26.4	1654b	1937a	69.58	141.75a	133.50a	30.06	30.03
SE ±	55	34	0.56	4.16	3.65	0.50	0.52
LSD (0.05)	159	103	NS	13.35	11.85	NS	NS
Interaction							
N x P	**	**	NS	**	**	NS	NS

+ For a factor, means followed by same letter in a column are not statistically significant at 5% of probability.

* Significant at 5% level of probability
** Significant at 1% level of probability
NS = Not significant.

Table 27: Interaction of N and P level on grain yield (kg/ha)+of rice (1990).

N-(kg/ha)	Phosphorus (kg/ha)		
	0	13.2	26.4
0	715c	776c	733c
60	1677bc	1796b	1633b
120	1234c	1679bc	1904b
180	1684bc	2181b	2749a

+ Means followed by similar letter(s) in the same row and column are not significantly different at 5% (DMRT).

Table 28: Interaction of N and P levels on grain yield (kg/ha)+ of rice (1992).

N-(kg/ha)	Phosphorus (kg/ha)		
	0	13.2	26.4
0	1013e	848f	929e
60	1656d	2152c	1702d
120	2162c	2990a	2112c
180	2053c	2710b	2205c

+Means followed by similar letter in the same row column are not significantly different at 5% level of probability (DMRT).

The interaction of N and P on rice grain yield also showed that with increasing levels of phosphorus there was interaction only upto 13.2kgP/ha at all the levels of nitrogen.

4.7.2 Threshing percentage of rice.

Threshing percentage was not affected by neither increasing levels of nitrogen, phosphorus nor their interactions in 1992, the only year the parameter was taken (Table 26).

4.7.3 Number of panicles per square metre.

The number of panicles was significantly influenced by levels of nitrogen in a similar manner in both years (Table 26). In each year there was a significant response to nitrogen to the highest level of 180kgN/ha).

Increasing phosphorus beyond 13.2kgP/ha had no significant effect on panicle number per square metre in both years (Table 26).

There was interaction of nitrogen and phosphorus on panicle number in both years (Tables 29 and 30). In 1990 there was a significant effect on panicle number at all the levels of phosphorus with increasing levels of nitrogen (Table 29). On the other hand, increasing levels of phosphorus resulted into non-significant effect beyond 13.2kgP/ha at 0kgN/ha and 120kgN/ha while at 180kgN/ha and 60kgN/ha the increase was upto 26.4kgP/ha.

Table 29: Interaction of N and P levels on the number of panicles/m^{2+} (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	53.00f	97.25e	99.75e
60	106.25e	122.00d	140.00c
120	120.25d	138.50c	143.00c
180	159.75b	162.25b	80.25a

+ Means followed by similar letter(s) in the same row and column are not significantly different at 5% (DMRT).

Table 30: Interaction effect of N and P levels on the number of panicle/m^{2+} (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	27.50j	56.00h	45.00i
60	72.00g	108.00e	90.00f
120	180.00c	172.00d	198.00a
180	189.00b	192.00b	201.00a

+ Means followed by similar letter in the same row and column are not significantly different at 5% level of probability (DMRT).

The interaction of N and P on panicle number in 1992 showed that, increasing levels of nitrogen significantly affected panicle number at all the levels of phosphorus. However, the highest phosphorus level of 26.4kgP/ha had effect on the variable beyond 120kgN/ha (Table 30).

5.7.4 Thousand grain weight of rice.

There was no change in 1000-seed weight with changes in both nitrogen and phosphorus levels (Table 26). The interaction between nitrogen and phosphorus on 1000-seed weight also did not attain any level of significance.

4.8 Effect of N and P on LAI, percent lodged plants, number of tillers per plant and number of days to 50% panicle initiation.

4.8.1 Leaf area index (LAI) of rice.

Leaf area index was significantly influenced by levels of nitrogen upto 180kgN/ha in 1990 but beyond 120kgN/ha in 1992 gave rather significantly lower leaf area index (Table 31).

Significantly higher leaf area index was observed at the highest level of phosphorus (26.4kgP/ha) in 1990 but increasing phosphorus level above 13.2kgP/ha in 1992 never gave significantly lower leaf area index (Table 31).

The interaction of nitrogen and phosphorus on leaf area index of rice in 1990 showed that at levels of 0 and 13.2kgP/ha, phosphorus (0 and 13.2kgP/ha) there was significant influence only upto 120kgN/ha while at 26.4kgP/ha, significant increase was observed upto 180kgN/ha. On the other hand, increasing levels of phosphorus did not influence leaf area index at all levels at nitrogen except at 180kgN/ha (Table 32).

In 1992, there was interaction at all levels of phosphorus with increasing levels of nitrogen on LAI (Table 33). There was equally interaction when phosphorus increased at all levels of nitrogen.

Table 31: Effect of N and P levels on LAI+, percent lodged plant (%)+ number of tillers per plant+ and number of days to 50% panicle initiation+ of rice (1990 and 1992).

	Leaf area index		Percent lodged plants		Number of tillers/ plant		Days to panicle initiation	
Treatments	1990	1992	1990	1992	1990	1992	1990	1992
N-levels(kg/ha)								
0	1.40d	1.40d	1.00d	0.05	3.58d	2.83d	68.83d	70.25
60	2.85c	2.10c	1.17c	0.19	5.83c	4.75c	72.92c	71.00
120	3.45b	3.27a	1.78b	0.05	7.92b	9.42b	74.17b	71.42
180	4.36a	2.86b	1.98a	0.05	9.92a	10.75a	76.50a	70.00
SE ±	0.04	0.035	0.02	0.04	0.42	0.42	0.55	0.62
LSD (0.05)	0.12	0.11	0.46	NS	1.20	1.21	1.58	NS
P-levels(kg/ha)								
0	2.73c	2.07b	1.85	0.04	6.50b	5.94b	72.00b	69.63
13.2	2.93b	2.74a	1.67	0.08	7.13a	7.44a	73.12a	70.06
26.4	3.96a	2.76a	1.69	0.10	7.44a	7.44a	74.18a	71.06
SE ±	0.04	0.033	0.019	0.035	0.36	0.36	0.49	0.54
LSD (0.05)	0.10	0.10	NS	NS	1.04	1.04	1.37	NS
Interaction								
N x P	**	**	NS	NS	**	**	**	NS

+ For a factor, means followed by same letter in the same treatment group is not statistically different at 5% level probability.

* Significant at 5% level. ** Significant at 1% level

NS = Not signifixant.

Table 32: Interaction of N and P levels on LAI+ of rice at maturity (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	1.05e	1.45e	1.70e
60	2.75d	2.80d	2.99d
120	3.15c	3.30c	3.85c
180	3.96c	4.20b	4.91a

+ Means followed by similar letter(s) in the same row and column are not significantly different at 5% level probability.

Table 33: Interaction of N and P levels on LAI+ of rice at maturity (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	1.71g	1.13j	1.36i
60	2.83d	1.89f	1.58h
120	3.22c	4.82a	2.57d
180	2.53d	3.55b	2.51de

+Means followed by similar letter(s) in the same row and column are not significantly different at 5% level of probability (DMRT).

4.8.2 Percent lodged plants of rice.

The application of levels of nitrogen resulted in significantly higher percent lodged rice plants up to the highest level of nitrogen in 1990 but in 1992, there was no significant increase observed (Table 31).

There was no change in the percent lodged rice plants with changes in phosphorus levels in both years (Table 31). The interaction between nitrogen and phosphorus levels on percent lodged plants of rice was also not significant in both years.

4.8.3 Number of tillers per plant.

There was a significant increasing number of tillers produced by rice plants due to levels of nitrogen application in both years (Table 31).

In both years however, increasing levels of phosphorus application to rice beyond 13.2kgP/ha never gave any significant influence on the number of tillers produced per plant (Table 31).

In 1990, there was interaction of N and P on tiller number at 0 and 26.4kgP/ha only when N level higher than the control (no nitrogen) was raised; while at 13.2kgP/ha, there was observed a significant increase upto 180kgN/ha with no difference in the number of tillers per plant at 60 and 120kgN/ha. There was no interaction effect of nitrogen on number of tillers at all levels of nitrogen with increasing levels of phosphorus except at 180kgN/ha (Table 34).

Table 34: Interaction of N and P on the number of tillers/plant+of rice (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	3.25c	3.50c	3.50c
60	4.50b	5.25b	5.50b
120	5.50b	5.75b	6.00b
180	6.25b	9.25a	10.75a

+Means followed by similar(s) in the same row and column are not significantly different at 5% level of probability using (DMRT).

Table 35: Interaction effect of N and P levels on the number of tillers/plant+of rice (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	2.50c	3.00c	3.00c
60	4.25b	5.25b	4.75b
120	7.50b	9.75a	11.00a
180	7.90b	11.75a	11.00a

+Means followed by similar letter in the same row and column are not significantly different at 5% level of probability using DMRT.

There was interaction at all levels of phosphorus with N upto 120kgN/ha in 1992 (Table 35). On the contrary, there was no interaction at the lower levels of nitrogen with levels of phosphorus. At 120 and 180kgN/ha however, the interaction was observed only when phosphorus level increased above the control (without phosphorus).

4.8.4 Days to 50% panicle initiation.

The results obtained for the number of days to panicle initiation showed that, the application of nitrogen in 1990 significantly increased the number of days to panicle initiation while in 1992, there was no significant change observed (Table 31).

Changing levels of phosphorus application to rice did not significantly change the number of days to panicle initiation in both years (Table 31).

There was observed interaction of nitrogen and phosphorus on number of days to panicle initiation in 1990 but not in 1992 (Table 36). There was a similar trend of interaction on the number of days at all levels of phosphorus with levels of nitrogen with each level of P responding positively upto 180kgN/ha and with no significant difference between days at 60kgN/ha and 120kgN/ha. However with increasing levels of phosphorus, there was no interaction at 0, 60 and 180kgN/ha except at 120kgN/ha where a change was observed when phosphorus level increased from 13.2kgP/ha to 26.4kgP/ha.

Table 36: Interaction of N and P levels on the number of days+to panicle initiation (1990).

N-(kg/ha)	Phosphorus (kg/ha) 0	13.2	26.4
0	67.50c	68.25c	70.75c
60	71.60b	73.50b	73.25b
120	73.50b	74.00b	75.00a
180	75.50a	76.75a	77.25a

+ Means followed by similar letter in the same row and column are not significantly different at 5% level of probability using DMRT.

4.9 Effect of N and P on rice shoot height at 30, 60 and 90 DAP

Rice shoot height at all the stages of sampling in 1990 was significantly influenced by levels of nitrogen upto 180kgN/ha (Table 37). However in 1992, the results showed a different trend of response of plant height to nitrogen. At 30 DAP, rice shoot height increased significantly only when N level was raised above the check (without nitrogen) and reduced significantly with further increases. At 60 DAP, rice shoot height responded positively to nitrogen up to 180kgN/ha but with no significant difference in plant height between 60 and 120kgN/ha. Sampling at 90 DAP, it was observed that, rice shoot height did not attain any level of significance when nitrogen was raised beyond 120kgN/ha.

The response of rice shoot height to phosphorus showed a similar significant increases at all the stages of sampling upto 26.4kgP/ha except at 90 DAP in 1992 where no significance in shoot height was observed (Table 37).

Interaction of N and P on rice shoot height was observed at all the levels of phosphorus with increasing levels of nitrogen at 30 DAP in 1990 (Table 38). However there was no significant change observed on rice shoot height with increasing levels of phosphorus at N levels of 0 and 60kgN/ha . In 1992, there was

Table 37: Effects of N and P levels on rice shoot height (cm)+ at 30, 60 and 90 DAP 1990 and 1992).

	Days After Planting					
	30		60		90	
Treatments	1990	1992	1990	1992	1990	1992
N-levels(kg/ha)						
0	20.70d	29.55c	56.42d	57.50c	80.29d	82.92c
60	33.50c	41.30a	74.13c	81.25b	100.71c	101.85b
120	39.38b	35.58b	81.84b	81.58b	103.07b	113.00a
180	43.58a	36.79b	84.49a	83.92a	106.03a	115.67a
SE ±	0.69	0.80	0.83	0.67	0.90	1.09
LSD (0.05)	1.99	2.29	2.38	1.71	2.62	3.12
P-levels (kg/ha)						
0	33.49c	33.08b	71.56c	69.25c	93.86c	102.19
13.2	36.81b	34.43b	74.47b	76.81b	98.33b	104.63
26.4	38.73a	39.91a	76.65a	82.13a	100.39a	103.25
SE ±	0.59	0.69	0.72	0.72	0.79	0.94
LSD (0.05)	1.72	1.98	2.06	1.66	2.27	NS
Interaction						
N x P	**	**	**	**	**	**

+ For a factor, means followed by same letter(s) in a column, are not statistically significant at 5% level of probability.

* Significant at 5% level of probability

** Significant at 1% level of probability.

Table 38: Interaction of N and P levels on rice shoot height (cm)+ at 30 DAP (1990).

N-(kg/ha)	Phosphorus (kg/ha) 0	13.2	26.4
0	26.88e	28.50e	28.75e
60	32.38d	33.50d	34.63d
120	36.50d	40.25c	42.00c
180	38.20b	45.00a	47.56a

+Means followed by similar letter in both row and column are not significantly different at 5% level of probability using DMRT.

Table 39: Interaction of N and P levels on rice shoot height (cm)+ at 30 DAP (1992).

N-(kg/ha)	Phosphorus (kg/ha) 0	13.2	26.4
0	25.00d	26.28d	27.38b
60	38.63ab	41.25a	44.03a
120	35.38b	35.96b	36.31ab
180	35.31b	35.13b	41.94a

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability using DMRT.

significant influence on shoot height at all the levels of phosphorus only when nitrogen was raised a level above the check (without N) (Table 39). At higher levels of phosphorus (13.2 and 26.4kgP/ha) these changes in rice shoot height did not attain any level of significance upto the highest level of nitrogen. In contrast, there was interaction only at 0 and 180kgN/ha with levels of phosphorus.

There was interaction of N and P on rice shoot height at all the levels of phosphorus with levels of nitrogen at 60 DAP in 1990 (Table 40). On the contrary, significant effect of N on rice shoot height with increasing levels of phosphorus was only at higher N levels of 120 and 180kgN/ha. There was also significant changes at all levels of phosphorus in 1992 with increasing levels of nitrogen. At the highest level of phosphorus of 26.4kgP/ha, significantly taller rice shoot than other levels at 60 DAP was observed. Eventhough there was interaction of N and P observed on shoot height at all levels of phosphorus not beyond 13.2kgP/ha at 180kgN/ha.

At 90 DAP in 1990, despite the fact that interaction observed at all the levels of phosphorus with levels of nitrogen on rice shoot not upto the highest level of nitrogen (Table 42). At 13.2 and 26.4kgP/ha, there

Table 40: Interaction of N and P level on rice shoot height (cm)+ at 60 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	54.06e	56.67e	58.53e
60	72.46d	74.68d	75.25d
120	79.63c	81.38c	84.53b
180	80.11b	85.6a	88.2a

+Means followed by similar letter(s) in the same row and column are not significantly different at 5% level using DMRT.

Table 41: Interaction of N and P levels on rice shoot height (cm)+ at 60 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	45.00e	60.00d	67.50c
60	76.25bc	81.50b	85.00a
120	77.50bc	80.50b	86.75a
180	78.25b	85.25a	88.25a

+Means followed by similar letter(s) in the same row and column are not significantly different at 5% level of probability using DMRT.

Table 42: Interaction of N and P levels on rice shoot height (cm) +at 90 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	79.50c	80.29c	81.09c
60	94.33b	102.32eb	105.48a
120	98.39b	104.21a	106.63a
180	103.25ab	106.48a	108.35a

+Means followed by similar letter(s) in the same row and column are not significantly different at 5% level of probability using DMRT.

Table 43: Interaction of N and P levels on rice shoot height (cm)+ at 90 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	73.75f	88.50e	86.50e
60	96.00d	103.50c	106.00c
120	121.00a	110.50b	107.50c
180	118.00a	116.00ab	113.00ab

+Means followed by similar letter(s) in the same row and column are not significantly different at 5% level of probability using DMRT.

was no interaction on rice shoot height beyond 120kgN/ha, while at check (without phosphours), the increase was significant only when nitrogen was raised upto 60kgN/ha. There was no interaction of nitrogen and phosphorus on rice shoot height at 0 and 180kgN/ha with increasing levels of phosphorus. The interaction table of nitrogen and phosphorus on rice shoot height at 90 DAP in 1992 is presented in Table 43.

4.10 Effect of N and P on rice dry matter at 30, 60 and 90 DAP

There was no influence observed on rice dry matter at 30 DAP in both years neither by increasing levels of nitrogen, phosphorus nor their interactions (Table 44). However at 60 and 90 DAP in both years, similar significant increases in rice dry matter was observed by increasing nitrogen level upto 180kgN/ha.

The change in rice dry matter was significant at 60 and 90 DAP, in both years upto the highest level of phosphorus (Table 44).

The interaction of nitrogen and phosphorus at 60 DAP in 1990 showed that, change in rice dry matter at zero level of phosphorus did not exceed 60kgN/ha while at 13.2kgP/ha, rice dry matter increased significantly upto 120kgN/ha but there was an inconsistent change at 26.4kgP/ha with increasing levels of nitrogen (Table 45). There was also interaction of N and P at all levels of nitrogen with increasing levels of phosphorus upto 26.4kgP/ha except at 120kgN/ha where there was no effect beyond 13.2kgP/ha. At 60 DAP in 1992, interaction of nitrogen and phosphorus on rice dry matter was observed at all levels of phosphorus with levels of nitrogen and also at all levels of nitrogen with increasing levels of phosphorus (Table 46).

Table 44: Effect of N and P levels on dry matter (g/plant)+ 30, 60 and 90 DAP (1990 and 1992).

	Days After Planting					
	30		60		90	
Treatment	1990	1992	1990	1992	1990	1992
N-(kg/ha)						
0	0.53	0.99	4.58d	2.28d	6.50d	5.49d
60	1.33	1.18	9.59c	5.26c	14.77c	11.98c
120	1.36	1.21	10.40b	6.93b	15.42b	16.69b
180	1.34	1.29	11.15a	8.52a	18.53a	14.23a
SE ±	0.32	0.19	0.04	0.035	0.23	0.24
LSD (0.05)	NS	NS	0.11	0.10	0.66	0.69
P-(kg/ha)						
0	0.95	1.10	7.52c	4.88c	10.39c	13.47c
13.2	1.10	1.18	8.28b	5.84b	12.39b	13.94b
26.4	1.59	1.23	9.51a	6.54a	14.52a	14.07a
SE ±	0.28	0.17	0.034	0.029	0.20	0.21
LSD (0.05)	NS	NS	0.07	0.09	0.58	0.60
Interaction						
N x P	NS	NS	**	**	**	**

+ For a factor, means followed by same letter in a column are not statistically different, at 5% level of probability.

* Significant at 5% level of probability
** Significant at 1% level of probability
NS = Not significant.

Table 45: Interaction of N and P levels on the day matter (g/plant) [+] of rice dry matter at 60 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	4.23bg	4.49ef	4.98e
60	8.58d	9.06c	11.44a
120	8.55d	9.50b	10.15b
180	8.70d	10.05b	11.47a

[+] Means followed by similar letter in both row and column are not significantly different at 5% using DMRT.

Table 46: Interaction effects of N and P levels on the dry matter (g/plant) [+] of rice dry matter at 60 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	2.06cj	2.34j	2.45h
60	2.82cg	5.20bf	5.78e
120	5.17bf	7.09d	8.54b
180	7.47c	8.71b	9.60a

[+] Means followed by similar letter(s) in both row and column are not significantly different at 5% using DMRT.

The interaction of nitrogen and phosphorus at 90 DAP in 1990 showed that at all levels of phosphorus, rice dry matter significantly increased with increasing levels of nitrogen (Table 47). At all the levels of nitrogen except the check, (without nitrogen) there was interaction on rice dry matter with levels of phosphorus. In 1992, the interaction of nitrogen and phosphorus on rice dry matter at 90 DAP presented in Table 48 showed that at all the levels of nitrogen, there was significant increasing effect on rice dry matter with increasing levels of phosphorus.

Table 47: Interaction effect of N and P levels on dry matter (g/plant)+ of rice dry matter at 90 DAP (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	5.95bf	6.25f	7.32f
60	12.23d	14.75c	15.55b
120	11.45e	16.45a	15.66b
180	11.92e	12.20d	16.54a

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

Table 48: Interaction effect of N and P levels on dry matter (g/plant)+ of rice at 90 DAP (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	5.01h	6.76g	4.65i
60	13.0be	14.25d	8.63f
120	23.63b	9.06e	17.38c
180	12.16d	8.88e	21.65a

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

14.11 The effect of N and P on percent unfilled grains and number of filled grains per panicle of rice.

4.11.1 Percent unfilled rice grains.

The effect of application of nitrogen on percent unfilled grains of rice showed that, there was no significant difference between the check (without nitrogen) and all the levels of nitrogen except at 180kgN/ha in 1990 (Table 49). In 1992, no significant change was also observed on percent unfilled grains with nitrogen application.

There was no change in the percent unfilled grains observed when phosphorus was applied in 1990 but in 1992, there was a significant increase in percent unfilled grain upto 13.2kgP/ha beyond which there was a significant reduction (Table 49).

There was interaction of nitrogen and phosphorus on percent unfilled grains only in 1992 (Table 50). Except at check, (without phosphorus) the other levels of phosphorus showed that increasing levels of nitrogen upto 120kgN/ha did not affect percent unfilled grains at plots with 13.2kgP/ha fertilization, while at the highest level of phosphorus (26.4kgP/ha) percent unfilled grains decreased significantly only when nitrogen was raised a level above 60kgN/ha. There was interaction of N and P observed on percent unfilled grains at all levels of nitrogen except at check (without nitrogen) with increasing levels of phosphorus.

Table 49: The effects of N and P levels on percent (%) unfilled grains (%)+ and number of filled grains per panicle+ of rice (1990 and 1992).

	Percent unfilled grains (%)		Number of filled grains/panicle	
Treatments	1990	1992	1990	1992
N-levels(kg/ha)				
0	12.79b	19.38	52.68b	33.47b
60	14.80b	19.13	66.90a	39.45a
120	13.66b	18.18	63.09a	37.60a
180	20.02a	18.13	49.49b	14.90c
SE ±	0.45	0.55	1.45	0.88
LSD (0.05)	1.29	NS	4.19	2.62
P-levels (kg/ha)				
0	16.82	17.40c	56.28b	31.25b
13.2	15.05	20.80a	65.94a	34.75a
26.4	14.99	18.67b	51.92c	23.05c
SE ±	0.43	0.48	1.26	0.76
LSD (0.05)	NS	1.42	3.63	2.24
Interaction				
N x P	NS	*	**	**

+ For a factor, means followed by similar letter in a column are not statistically significant at 5% level probability.

NS = Not significant
* = Significant at 5% level of probability
** = Significant at 1% level of probability.

Table 50: Interaction of N and P levels on percent (%) unfilled grains of rice at maturity (1992). +

N-levels(kg/ha)	Phosphorus level (kg/ha) 0	13.2	26.4
0	22.64a	20.50a	18.01ab
60	15.00d	23.98a	18.40ab
120	17.41c	20.72a	16.41c
180	14.54d	18.00b	21.85a

+ Means followed by similar letter(s) in the same row and column are not significantly different at 5% level of probability (DMRT).

4.11.2 Number of filled grains per panicle.

The observation made on the number of filled grains per panicle as affected by nitrogen application in both years was similar (Table 49). Increasing nitrogen level beyond 120kgN/ha significantly reduced the number of filled grains per panicle while there was no significant difference in filled grains per panicle between 60 and 120kgN/ha in both years.

Phosphorus level beyond 13.2kgP/ha reduced the number of filled grains per panicle significantly in both years (Table 49).

The interaction of nitrogen and phosphorus on the number of filled grains in 1990 revealed that at all levels of phosphorus; increasing nitrogen beyond 60kgN/ha attained no level of significance while upto 180kgN/ha rather reduced filled grains significantly (Table 51).

There was significant effect on filled grains per panicle at all levels of nitrogen except the check (without nitrogen) with levels of phosphorus. In 1992 while the highest level of phosphorus rather decreased filled grains significantly with levels of N, there was an increase upto 60kgN/ha at 0 and 13.2kgP/ha (Table 52). Similarly at all levels of nitrogen filled grains were significantly reduced except at 180kgN/ha where no interaction was observed with levels of P.

Table 51: Interaction of N and P levels on the number of filled grains/panicle +(1990).

	Phosphorus levels (kg/ha)		
N-levels(kg/ha)	0	13.2	26.4
0	41.01d	43.64d	43.40d
60	72.29a	69.79a	58.60b
120	69.34a	69.91a	57.90b
180	49.47d	52.32c	47.60c

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

Table 52: Interaction effect of N and P levels on the number of filled grains panicle +(1992).

	Phosphorus levels (kg/ha)		
N-levels(kg/ha)	0	13.2	26.4
0	37.81b	25.92c	36.69b
60	50.01a	39.42b	28.92c
120	21.12d	16.45e	15.24e
180	16.09e	17.25e	14.37e

+Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

4.12 Effect of N and P on Crude Protein content and percent phosphorus in the leaves of maize and rice at maturity.

4.12.1 Crude Protein content in maize leaves at maturity.

The application of nitrogen significantly influenced crude protein content in maize leaves only when it was raised upto 120kgN/ha in both years (Table 53).

There was no significant effect on crude protein in maize leaves with the application of phosphorus in both years (Table 53).

In 1990, the interaction of nitrogen and phosphorus on the crude protein in maize leaves showed similar significant increasing crude protein content at all P levels with levels of nitrogen while there was no interaction observed at all levels of nitrogen with levels of phosphorus (Table 54). In 1992 however, there was significant and positive change in crude protein in maize leaves at all levels of phosphorus with increasing levels of nitrogen but only upto 120kgN/ha (Table 55). On the other hand, except at 120 and 180kgN/ha where there was no interaction observed, other nitrogen levels showed significant increasing effect with levels of phosphorus.

4.12.2 Crude protein content in rice leaves at maturity.

In 1990, the effect of application of nitrogen on crude protein content in rice leaves was observed upto 120kgN/ha while in 1992, only when a level above the check (without nitrogen) was applied (Table 53).

Table 53: Effect of N and P levels on percent crude protein (%)+ and percent phosphorus (%)+ in maize and rice leaves at maturity (1990 and 1992).

	Percent crude protein (%)				Percent P (%)			
	Maize leaves		Rice leaves		Maize leaves		Rice leaves	
Treatments	1990	1992	1990	1992	1990	1992	1990	1992
N(kg/ha)								
0	7.88b	9.88b	5.56c	5.31b	0.21b	0.16c	0.17c	0.17b
60	11.06b	9.94b	11.25b	8.38a	0.21b	0.15b	0.17b	0.17b
120	15.44a	13.75a	16.38a	9.38a	0.23a	0.15b	0.16b	0.23a
180	17.31a	16.63a	17.50a	9.88a	0.24a	0.21a	0.18a	0.23a
SE ±	2.25	1.38	1.19	1.06	0.004	0.003	0.004	0.004
LSD (0.05)	6.00	3.44	3.44	3.00	0.010	0.11	0.011	0.011
P-(kg/ha)								
0	13.81	13.19	12.44c	9.06	0.20c	0.17b	0.16c	0.15c
13.2	14.63	12.44	16.50a	8.75	0.24b	0.18a	0.18b	0.21a
26.4	15.13	12.25	13.00b	8.94	0.26a	0.18a	0.21a	0.19b
SE ±	1.93	1.37	1.00	0.94	0.003	0.003	0.003	0.003
LSD(0.05)	NS	NS	2.94	NS	0.010	0.010	0.011	0.011
Interaction								
N x P	*	*	**	*	**	**	**	**

+ For a factor, means followed by similar letter(s) in a column are not statistically significant at 5% level of probability.

* Significant at 5% level of probability

** Significant at 1% level of probability.

Table 54: Interaction of N and P on percent crude protein content (%)+ in maize leaves at maturity (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	8.44d	7.81d	7.38d
60	10.31c	11.13c	11.81c
120	14.06b	16.00b	16.31b
180	22.44a	23.44a	24.94a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

Table 55: Interaction effects of N and P on percent crude protein content (%)+ in maize leaves at maturity (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	11.63b	10.25b	7.69d
60	11.81b	8.31d	9.63c
120	16.13a	13.81a	17.50a
180	19.50a	16.19a	16.25a

+ Means followed by similar letter in both row and column are not significantly different at 5% level of probability (DMRT).

Crude protein content in rice leaves in 1990 increased significantly with increasing levels of phosphorus upto 13.2kgP/ha and reduced with further increases of phosphorus (Table 53). There was however no influence of phosphorus observed on the crude protein content in leaves of rice in 1992.

There was interaction of N and P on crude protein content in the leaves of rice at all levels of phosphorus with levels of nitrogen only upto 120kgN/ha in 1990 (Table 56). However there was no interaction observed on crude protein content in rice at all levels of nitrogen with levels of phosphorus. Interaction of N and P was also observed in 1992 at all levels of phosphorus only when nitrogen was raised a level above the check (Table 57). No interaction was observed when all nitrogen levels were considered against increasing phosphorus levels.

4.12.3 Percent of phosphorus in maize leaves at maturity.

The percent phosphorus in maize leaves significantly increased only when nitrogen level was raised upto 120kgN/ha in 1990 while in 1992 significant difference in percent phosphorus was recorded only at a level above 120kgN/ha (Table 53).

With phosphorus application however, there was no significant difference in percent phosphorus in maize leaves between the check (without phosphorus) and 13.2kgP/ha in 1990 but increasing phosphorus a level above the check in 1992 resulted in significantly higher percent phosphorus in maize leaves (Table 53). The interaction of nitrogen and phosphorus on percent phosphorus in maize leaves are presented in Tables 58 and 59.

Table 56: Interaction of N and P levels on percent crude protein content (%)+ in rice leaves at maturity (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	6.13c	5.88c	5.56c
60	10.56b	11.31b	12.00b
120	16.81a	16.19a	16.94a
180	16.00a	17.50a	18.06a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

Table 57: Interaction of N and P levels on percent crude protein content (%)+ in rice leaves at maturity (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	6.19b	5.06b	4.75b
60	9.56a	7.81a	7.94a
120	10.56a	11.81a	11.63a
180	10.00a	10.38	9.25a

+ Means followed by similar letter(s) in the same row column are not significantly different at 5% level on probability using (DMRT).

4.12.4 Percent phosphorus in rice leaves at maturity

The results obtained on the percent phosphorus in rice leaves in both years showed a similar trend (Table 53). There was significant positive influence of nitrogen on the percent phosphorus in rice leaves only when nitrogen was increased upto 180kgN/ha in both years.

There was also significant increase in percent phosphorus in rice leaves upto the highest level of phosphorus (26.4kgP/ha) in 1990 but in 1992, the percent phosphorus increased significantly only upto 13.2kgP/ha and reduced drastically with further increases of phosphorus (Table 53).

There was positive and significant effect of nitrogen and phosphorus interaction on percent phosphorus in rice leaves in both years (Tables 60 and 61).

Table 58: Interaction of N and P levels on percent(%)+ phosphorus in maize leaves at maturity (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	0.20c	0.23b	0.21bc
60	0.19d	0.23b	0.24b
120	0.20c	0.25a	0.25a
180	0.209/4c	0.25a	0.25a

+ Means followed by similar letter in both row and column are not significantly different at 5% level of probability using DMRT.

Table 59: Interaction of N and P levels on percent (%)+ phosphorus in maize leaves at maturity (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	0.09i	0.24c	0.02e
60	0.21d	0.11h	0.14f
120	0.13g	0.28a	0.19e
180	0.19e	0.25b	0.26b

+ Means followed by similar letter in both row and column are not significantly different at 5% level of probability using DMRT.

Table 60: Interaction effects of N and P levels on percent (%)+ phosphorus in leaves of rice at maturity (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	0.14d	0.17b	0.20a
60	0.15c	0.15c	0.19a
120	0.14d	0.17b	0.18b
180	0.20a	0.12d	0.21a

+ Means followed by similar letter(s) in both row and column not significantly different at 5% level of probability using DMRT.

Table 61: Interaction effect of N and P levels on percent (%)+ phosphorus in leaves of rice at maturity (1992).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	0.16bc	0.22a	0.18b
60	0.15b	0.12d	0.17b
120	0.15bc	0.17b	0.14bc
180	0.21a	0.20a	0.22a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of proability using DMRT.

4.13 Effect of N and P on percent nitrogen and content of phosphorus in the soil at crop maturity.

4.13.1 Percent N in the soil at crop maturity.

Percent nitrogen in the soil at crop maturity was significantly increased with increasing level of nitrogen application in 1990 (Table 62). In 1992 however, there was a positive influence on percent nitrogen in the soil with nitrogens application but with no significant difference between 60 and 120kgN/ha.

In both years increasing levels of phosphorus had no effect on effect on percent nitrogen in the soil (Table 62).

There was also no interaction of N and P on the percent N at crop maturity in both years.

4.13.2 Content of phosphorus in the soil at crop maturity.

No significant effect was observed on the content of phosphorus in the soil with the application of levels of nitrogen in both years (Table 62).

However the application of levels of phosphorus resulted in corresponding significant increase in the content of phosphorus in the soil upto 26.4kgP/ha in both years (Table 62).

The interaction of nitrogen and phosphorus on the content of phosphorus in the soil in both years are presented in Table 63 and 64.

Table 62: Effect of N and P levels on the percent nitrogen and content of phosphorus in the soil after maturity (1990 and 1992).

	Percentage nitrogen (%)+ in the soil after crop maturity		Phosphorus content (ppm)+ in the soil the soil the soil at crop maturity.	
	1990	1992	1990	1992
N-(kg/ha)				
0	0.021d	0.030c	10.69	9.75
60	0.027c	0.051b	10.44	9.50
120	0.039b	0.052b	10.89	10.06
180	0.058a	0.062a	10.99	9.10
SE +	0.004	0.005	0.19	0.18
LSD (0.05)	0.012	0.015	NS	NS
P-(kg/ha)				
0	0.035	0.050	8.86c	6.56c
13.2	0.036	0.059	10.82b	8.85b
26.4	0.038	0.045	11.83a	10.89a
SE ±	0.07	0.004	0.17	0.16
LSD(0.05)	NS	NS	0.41	0.45
Interaction				
N x P	NS	NS	**	**

+ For a factor means followed by similar letter in the same group of treatments are not significantly different at 5% level of probability.

* Significant at 5% level of probability
** Significant at 1% level of probability
NS = Not significant.

Table 63: Interaction effect of N and P levels percent phosphorus (%)+ in the soil at crop maturity (1990).

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	9.45c	10.36b	10.29b
60	7.16c	11.32a	12.84a
120	11.27a	9.30c	12.11a
180	7.58c	10.30c	12.11a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability using DMRT.

Table 64: Interaction effect of N and P level on percent phosphorus (%)+ in the soil at crop maturity for 1992.

	Phosphorus (kg/ha)		
N-(kg/ha)	0	13.2	26.4
0	7.32bc	10.40a	8.53b
60	5.07d	9.68b	10.75a
120	10.47a	9.58b	10.11a
180	11.37a	9.58b	10.18a

+ Means followed by similar letter(s) in both row and column are not significantly different at 5% level of probability (DMRT).

4.14 Association among plant characters.

4.14.1 Correlation among plant characters of maize.

Observations made on the correlation between maize grain yield and plant characters of maize in both years were similar (Tables 65 and 66). Maize grain yield was highly associated with leaf area index, number of cobs per square meter hundred grain weight and stand count at harvest. Other maize characters that were highly, significant and positively correlated with grain yield were plant dry matter at 90 DAP, plant shoot height at 90 DAP, percent nitrogen in the soil and percent nitrogen in maize leaves at maturity in both years. However, some of the plant characters such as content of phosphorus in the soil was not significant and percent lodged plant was negatively associated with grain yield of maize.

Also, number of cobs per square metre was found to be significantly and positively correlated with stand count, hundred grain weight, leaf area index, percent nitrogen in soil and in leaves of maize in both years.

Table 6.5: Simple correlation coefficients between some selected variables and yield of maize as affected by N and P levels. (1990 wet season).

	1	2	3	4	5	6	7	8	9	10	11	12
1.	.1											
2.	.911**	1										
3.	.181	.047	1									
4.	.740**	.787**	-.06	1								
5.	.808**	.862**	-.051	.936**	1							
6.	.160	.205	.386**	.125	.085	1						
7.	.735**	.767**	.183	.665**	.715**	.402**	1					
8.	.602**	.595**	.080	.382**	.500**	.855**	.586**	1				
9.	.115	.142	.195	.016	.068	.147	.242	.32*	1			
10.	.688**	.815**	.033	.776**	.840**	.800**	.775**	.500**	.22	1		
11.	.151	.124	.098	.111	.007	.245	.408**	.535**	.155	.129	1	
12.	.066	.088	-.180	.46	.095	-.086	.167	.195	.310**	.087	.228	1

1. Plant dry matter at maturity; 2. Plant height at maturity; 3. Conc. of P in the soil after harvest;
4. Percent N in the soil after harvest; 5. Percent N in maize plant; 6. Conc. of P in maize; 7. Grain yield/ha;
8. No of cobs/m^2; 9. Stand count at harvest; 10. LAI; 11. Weight per 100 grains; 12. Percent lodged plants.

* Significant at 5%; ** Significant 1% r= 0.284 and 0.368 at 5% and 1% prespectively. DF = n-2 48-2 = 46

Table 66: Simple correlation coefficients between some selected variables and grain yield of maize as affected by N and P levels (1992 wet season).

	1	2	3	4	5	6	7	8	9	10	11	12
1.	1											
2.	.902**	1										
3.	.176	.038	1									
4.	.726*	.776**	-.052	1								
5.	.801**	.856*	-.0 53	.932**	1							
6.	.154	.200	.376**	.22	.076	1						
7.	.728**	.750**	..172	.660**	.710**	.411**	1					
8.	.598**	.581**	.081	.375**	.500**	.846**	.558*	1				
9.	.101	.135	.189	.012	.053	.138	.255	.306*	1			
10.	.680**	.810**	.036	.765*	.840	.800**	.768**	.505*	.225	1		
11.	.149	.122	.088	.101	.005	.444**	.206	.515**	.150	.115	1	
12.	.061	.078	-176	.033	.091	-.065	.150	.180	.318*	.086	.222	1

KEY:

1. Plant dry matter at maturity; 2. Plant shoot height at maturity; 3. Conc. of P in soil; 4. Percent N in the soil 5. Percent N in maize; 6. Conc. of P in maize; 7. Grain yield/ha; 8. Number of cobs/m^2; 9. Stand count; 10. Lai; 11. Weight per 100 grains; 12. Percent lodged plants

* Significant at 5% ** Significant at 1%; = 0.284 and 0.368 at 5% and 1% respectively DF = 46

4.14.2 Correlation among plant characters of rice.

In both years, except thousand grain weight of rice and content of phosphorus in the soil, all the characters selected were all highly significant and positively correlated with grain yield of rice (Table 67 and 68). The number of panicles per square metre was also observed to be highly associated with percent nitrogen in the soil and in rice leaves at maturity, leaf area index, number of tillers per plant and phosphorus content in the soil in both years. Number of tillers too per plant of rice was found to be highly significantly correlated with leaf area index, percent nitrogen in the soil and in the leaves in rice plant but was not significantly associated with thousand grain weight of rice.

Table 67: Simple correlation coefficients betwwe some selected variables and yield of rice as affected by N and P levels (1990 wet season).

1	1	2	3	4	5	6	7	8	8	10	11	12
1.	1											
2.	.876**	1										
3.	.641**	.802**	1									
4.	.759**	.883**	.841**	1								
5.	.298*	.414**	.537**	.413**	1							
6.	.750**	.788	-.08	.935**	.125	1						
7.	.183	.049	.195	-.052	.388**	.425**	1					
8.	.243	-.03	.180	.246	.263	.098	.129	1				
9.	.766**	.886**	.875**	.936**	.636**	.776**	.0.33	.269	1			
10.	.756**	.911**	.874**	.935**	.523**	.665**	.183	.273	.960**	1		
11.	.576**	.715**	.806**	.843**	.631**	.825**	.245	.261	.880**	.851**	1	
12.	.716**	.845**	.844**	.848**	.746**	.681**	.233	.328	.943**	.915**	.837**	1

KEY:

1. Plant dry matter at maturity; 2. Plant shoot height at maturity; 3. Stand count at harvest; 4. Percent N in Rice; 5. P conc. in rice; 6. Percent N in the soil after crop maturity; 7. Conc. of P in the soil after crop maturity; 8. Weight per 1000 grains; 9. LAI; 10. Grain yield per ha; 11. Number of tiller/plant; 12. Number of panicles/m^2

* Significant at 5% level of probability; ** Significant at 1% level of probability;
r= 0.284 and 0.368 at 5 and 1% respectively.

Table 68: Simple correlation coefficients between some selected variables and grain yield of rice as affected by N and P levels (1992 wet season).

	1	2	3	4	5	6	7	8	9	10	11	12
1.	1											
2.	.766**	1										
3.	.625**	.735**	1									
4.	.732**	.830**	.820**	1								
5.	.250	.0415**	.526**	.430**	1							
6.	.730**	.768**	-.010	.915**	.123	1						
7.	.176	.036	.180	-.052	.489**	460**	1					
8.	.233	.033	.168	.246	.098	.264	.089	1				
9.	.686**	.865**	.865**	.931**	.628**	.765**	.32	.260	1			
10.	.730**	.900**	.845**	.932**	.506**	.656**	.179	.265	.930**	1		
11.	.560**	.706**	.801**	.823**	.625**	.815**	.213	.252	.865**	.850**	1	
12.	.705**	.826**	.833**	.826**	.728**	.636**	.225	.315	.940**	.910**	.817**	1

KEY:

1. Plant dry matter at maturity; 2. Plant shoot height at maturity; 3. Stand count; 4. Percent N; 5. P. conc. in rice. 6. Percent in the soil after crop maturity; 7. Conc. of P in the soil after crop maturity; 8. Weight per 100 grains. 9. LAI; 10. Grain yield/ha; 11. Number of tillers/plant; 12. Number of panicles/m^2.

** Significant at 1%; * Significant at 5%; r= 0.284 and 0.368 at 5% and 1% respectively.

CHAPTER 5

5. DISCUSSION

5.1 Effect of N and P on grain yield.

5.1.1. Maize grain yield.

Maize grain yield responded to N and P upto 120kgN/ha and 13.2kgP/ha respectively with yield depressing from further increases except in 1990 when it responded to N upto 180kgN/ha. This is similar to the findings of Balasubramanian and Mokwunye (1976) who observed increase in grain yield of maize with increased level of N upto 120kgN/ha with yield depressing with further increases to 180kgN/ha. Ologunde and Ogunlela (1984) reported that, the optimum N rate for maize lies between 100 and 150kgN/ha with yield depressing beyond 150kgN/ha. While Lonhard-Bony and Nemeth (1989) and McPhilips (1989) found significantly higher grain yields of maize at 13.2kgP/ha than at lower or higher rates of P.

5.1.2 Rice grain yield.

Rice grain yield increased significantly with N upto 180kgN/ha in 1990 but in 1992 there was no yield advantage beyond 120kgN/ha while 13.2kgP/ha was the optimum rate of P in both years.

Number of panicles per square metre, number of filled grains per panicle and number of tillers per plant increased significantly with levels of N and P. Saisong et al. (1970) identified these characters to be the three most important characters affected by N and P.

It could therefore be explained that the significant increase of grain yield of rice with levels of N and P was probably due to their positive effect on these characters. This confirms the findings of Nossa and Vergara (1980) that, the significant increase in grain yield in three upland varieties of rice was due to the increases of these characters with N and P.

The optimum rates of N and P for maize and rice production in mixture was observed to be 120kgN/ha and 13.2kgP/ha respectively. The much higher N response upto 180kgN/ha by both maize and rice in 1990 than in 1992 could be attributed in part to the very low level of N revealed from soil test (0.021%) before planting.

5.2 Other plant characters

5.2.1 Ear height of maize

The increase in ear height with levels of N and P was much expected since N enhances above ground vegetative growth and phosphorus is not lacking for vigorous root development to support plants in position (Garga et al; 1978). This is in accordance with the findings of Mohammed et al., (1978) that ear height increased significantly with the application of levels of N and P.

5.2.2 Days to 50% tasselling of maize

Number of days to tasselling increased significantly with levels of N but not with P. This is because N is known to delay the plant from reaching reproductive phase due to increased vegetative growth but P counteracts this delay (Eguchi et al; 1958). This confirms the reports made by Rathore et al; (1976) that, the number of days to tasselling increased significantly with N alone but was not affected by the addition of P.

5.2.3 Plant shoot height.

There were significant increases in both maize and rice shoot height with N and P since these are known to be among the most essential nutrient elements for plants growth and development (Brady, 1974). This observation on plant height agrees with Garga et al; (1978) who found significant increased plant height with N and P but disagrees with Reyes et al., (1972) who found no significant increase in plant height with N upto 200kgN/ha.

5.2.4 Plant dry matter.

Maize and rice dry matter increased significantly with levels of N and P at all stages of sampling except at 30 DAP when no significant increase was observed in rice. Rice roots have been found not to be well developed to utilise the available soil nutrients effectively before 30 DAP

(Brady, 1974). This is in agreement with the findings of Chang (1976) that, N produces its fertilising effect on rice plant not earlier than 30 DAP.

5.2.5 Grain weight.

There was no significant increase in hundred grain weight of maize and thousand grain weight of rice with levels of N and P. This result is in accordance with that of Chang (1968) and Matsushina (1976) who identified grain weight as one of the most important components of yield but no significant increase was observed with levels of N and P.

5.2.6 Percent lodged plants

There were no significant increases in percent lodged plants of maize and rice except in 1990 when there was significant increase in this character for rice with N alone but not with P.

The high level of P in the soil could have been the cause of the no significant increase in lodging percent. Brady (1974) noted that P gives strength to cereals and therefore prevents them from lodging. This agrees with the findings of Eguchi et al; (1958) that, lodging which is one of the effects of excess N is counteracted by adequate supply of P. Sun et al., (1989) also found higher percent lodging of plants from plots with higher levels of N without P than from plots with both N and P corresponding to 58.8% and 43.6% respectively.

5.2.7 Shelling percentage

Shelling percentage was neither affected by N nor P. This confirms the findings of Agboola and Kayode (1981) that the application of N and P had no effect on shelling percentage. But disagrees with that of Ologunde and Ogunlela (1984) who reported significant increases with lower rates of N and decreased at higher rates. Horrocks and Zuber (1970) however concluded that different response of N and P observed on shelling percentage could be attributed to the method used, location, cultivar and cultural practices.

5.2.8 Leaf area index (LAI)

There were significant increases in leaf area indices of maize and rice with N upto 120kgN/ha in 1992 after which there was a significant reduction with further increases. This is consistent with the observation by El-Hattab et al (1980) that, leaf area index of maize increased upto a point after which it reduced with further increases of N.

5.3 The effect of N and P on crude protein content and percent P in leaves of maize and rice at maturity.

The significant increase in crude protein content and percent P in leaves with N application and the increase in percent P with P application was much expected. This is because N in excess of plant requirement leads to luxury uptake of it by plants (Asher and Lee 1975), while the increase in percent P agrees with Terman et al (1977) who

reported increase in percent P with the application of N rates. Such increase in P uptake on addition of N however was observed by Duncan and Ohhrogge (1958) to be attributed to the increase in root growth in volume of fertilised soil. Many workers including Ologunde (1974), Kalia (1975), Osman et al (1977) and Bayo (1979) found similar significant increases in crude protein content plants with N application. Similarily Castro and Gomez (1990) also found percent P in leaves to be higher from plots with applied P than in leaves from plots without P fertilization.

5.4 Effect of N and P on the contents of N and P in the soil after crop maturity.

Increasing N levels significantly increased the percent N in the soil but had no effect on P content. Similarily, increasing levels of P also increased the content of P but not percent N. The significant increase in content of a particular element applied to soil is probably due to the fact that not all the amount can be taken up by plants due to leaching.

When the nutrients requirements of plants are met any further incfeases to the soil might be left unabsorbed. This might have probably been the case in this trial considering the 1992 soil analysis of 0.038% N and the high available P in both years with the level of N and P applied. This agrees with Stabetorp and Lyngstad (1988)

who reported significantly lower percent N in plots with 120kgN/ha than in plots with 180kgN/ha. Also, Ivanov and Dimitrov (1989) reported significantly and unecessarily higher residual contents of P in the soil from plots with 180kgP_2O_5/ha than from plots with 120kgP_2O_5/ha respectively.

5.5 Correlation studies

High positive correlation was observed between maize grain yield and number of cobs per square metre, leaf area index, dry matter and maize shoot height. Similarily, number of panicles per square metre, leaf area index of rice, number of tillers per plant, rice shoot height and rice dry matter were found to be significantly and positively associated with rice grain yield. This therefore indicates that, an increase in each of the above characters of maize and rice will lead to total increase in grain yield of these crops.

The significant and positive correlation between N and P in leaves of maize and rice and their respective grain yields in this study confirms the findings of Peck et al. (1969) and Walker and Peck (1974) that, there were highly significant correlation coefficients between grain yield of maize and the percent N and content of P in leaves.

CHAPTER 6.

6. SUMMARY AND CONCLUSION

A field experiment was conducted on Samaru Farm of the Institute for Agricultural Research, (11° 11'N, 07° 38'E, 680m above sea level) in the northern Guinea Savanna during the 1990 and 1992 wet seasons to investigate the effect on N and P on the yield and yield components of maize and rice in mixture.

There were twelve treatments obtained by factorial combinations of four levels of N (0, 60, 120 and 180kgN/ha) and three levels of P (0, 13.2 and 26.4kg/ha) laid out in a randomised complete block design with four replications.

The varieties of maize and rice used were TZBSR (late maturing, streak resistant with white grains) and ITA 257 (early maturing, blast resistant and low shattering) respectively.

Urea (46%N) was used as the source of nitrogen while single superphosphate (7.86%P) provided phosphorus.

The optimum rates of N and P for maize and rice grain yield production was observed to be 120kgN/ha and 13.2kgP/ha respectively.

Yield components of maize such as cobs per square metre increased significantly with levels of N and P, while shelling percentage was not affected by either of the elements. Hundred grain weight increased significantly with only N in 1992 but not with P.

Other plant characters of maize which were found to respond to N and P included plant height, plant dry matter and leaf area index. However, cob length increased significantly with N but not with P. Ear diameter, cob diameter and kernel depth were all not affected by either N or P.

Number of panicles per square metre, number of filled grains per panicle and number of tillers produced per plant were the yield components of rice which responded to both N and P. Threshing percentage and thousand grain weight of rice were however not influenced by N and P.

Rice plant characters which responded to N and P in the experiment are plant height, plant dry matter and leaf area index. Percent lodged rice plants and days to 50% panicle initiation were significantly influenced by N alone in 1990 but not by P.

Increasing levels of N significantly increased the percent crude protein upto 120kgN/ha and P content upto 180kgN/ha in both maize and rice leaves.

Levels of P did not affected percent crude protein in both crop leaves except in rice in 1990 but P content increased significantly upto 26.4kgP/ha.

Percent N in the soil increased significantly upto 180kgN/ha with N application but P content was not affected, while P application also increased P content significantly but had no effect on percent N.

There was highly significant and positive correlation between maize grain yield and maize plant characters such as cobs per square metre (r=.586, r=.558) and leaf area index at maturity (r=.715, r=.515) in 1990 and 1992 respectively.

Grain yield of rice was found to be significantly and positively associated with rice plant characters such as number of panicles per square metre (r=.915, r=.910) number of tillers per plant (r=.851, r=.850) and leaf area index of rice at maturity (r=.960, r=.930) in 1990 and 1992 respectively.

Based on these findings, 120kgN/ha and 13.2kgP/ha which are the recommended rates of N and P for maize production in this ecological zone, are also adequate for maizd and rice production in mixture.

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Appendix A: Total rainfall, maximum and minimum temperature relative humidity and sunshine hours at ten days intervals during the period of the experiment at Samaru in 1990.

Months	Days	Total rainfall (mm)	Max. $t^{o}C$	Min. $t^{o}C$	Rel. humidity (%)	Sunshine hourse
June	11-20	14.2	31.1	21.1	79.0	7.64
	21-30	73.2	28.8	19.3	81.2	6.14
July	1-10	67.8	29.4	20.93	78.9	6.52
	11-20	84.6	28.2	21.5	81.2	4.86
	21-31	69.5	28.5	21.9	81.0	6.2
August	1-10	103.2	28.4	19.4	81.9	6.2
	11-20	44.7	28.4	19.3	84.3	6.6
	21-31	101.4	29.9	19.8	78.3	7.4
Sept.	1-10	54.6	30.0	19.4	78.1	8.37
	11-20	14.7	30.3	19.7	74.6	6.58
	21-30	18.1	31.4	19.8	75.0	8.12
Oct.	1-10	-	32.3	20.6	71.7	7.88
	11-20	-	32.5	18.9	59.6	6.98
	21-31	-	32.7	17.8	51.0	10.19

Source: Samaru meteorological station.

Appendix B: Total rainfall, maximum and minimum temperature relative humidity and sunshine hours at ten days intervals during the period of the experiment at Samaru in 1992.

Months	Days	Total rainfall (mm)	Max. $t^{o}C$	Min. $t^{o}C$	Rel. humidity (%)	Sunshine hours
June	21-30	29.20	30.5	20.7	72.0	6.08
July	1-10	74.0	28.7	19.5	67.3	6.04
	11-20	130.9	28.1	17.9	82.4	6.69
	21-31	38.4	31.3	22.0	74.5	7.15
August	1-10	150.8	27.8	19.8	68.3	5.28
	11-20	56.2	53.6	20.4	73.3	5.39
	21-31	80.4	29.8	21.8	83.3	5.59
Sept.	1-10	72.9	28.6	17.9	81.6	5.31
	11-20	124.2	29.0	19.3	63.5	1.65
	21.31	32.6	30.8	19.5	73.5	0.0
Oct.	1-10	3.4	59.8	18.8	54.2	8.41
	11-20	35.2	31.5	19.4	51.1	9.50
	21-31	Nil	35.3	16.7	32.7	10.40

Source: Samaru meteorological station.

Appendix C: Physic-chemical analysis of soil at experiment site, Samaru.

	Seasons	
	1990	1992
Physical properties		
Sand (%)	56.5	39
Silt (%)	36.7	48
Clay (%)	6.8	14
Soil textural class	Sandy loam	Loam
Chemical properties		
Soil pH in water	5.3	4.4
Soil pH in 0.01M $CaCl_2$	4.7	4.2
Organic carbon (%)	0.9	0.5
Total nitrogen (%)	0.021	0.038
Available phosphorus (ppm)	23.18	15.68
Sodium (meq/100g soil)	0.104	0.22
Patassium (meq/100g soil)	0.09	0.28
Calcium (meq/100g soil)	0.749	3.24
Magnesium (meq/100 soil)	0.309	1.07
Cation exchange capacity (CEC) (meq/100g of soil)	1.5	6.80

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Binde Middle School Binde	-	1968	1972	M.S.L.C
Bamongo Secondary Sch. Damongo	-	1972	1977	O'level Cert.
Ghana Secondary Sch. Tamale	-	1977	1979	A'level Cert.
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