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EFFECTS OF SEEDRATE AND FERTILIZER APPLICATION ON THE PERFORMANCE OF UPLAND RICE

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ABSTRACT

The effect of seedrate and fertilizer application on the performance of upland rice were studied at Ekpoma in the forest zone. Rice cultiver ITA 150, was planted at the rates of 1, 2, 3, 4 and 5 seeds per stand and fertilizer was applied at the rates of 0, 50, 100 and 200 kg/ha in the form of NPK (15-15-15) and urea.

Number of tillers increased with increase in seedrate on the three occasions the tillers were counted. Fertilizer increased tillering only at 60 days after planting. Length of leaves was also increased by fertilizer application but seedrate had no effect. The main component of yield recorded was number of panicle which was increased by fertilization and increase in number of seeds planted. Paddy yield was significantly increased by both fertilizer and seedrate. Response to fertilization was very pronounced up to 100kg/ha; the increase from 100 - 200 kg/ha was small. Yield was more than doubled by increasing seedrate from one to five grains per stand.

INTRODUCTION

Rice (*Oryza sativa* L.) is an annual food crop of the tropics. It is the most important cereal grain after wheat. Rice is so widely consumed that there is hardly any country where it is not utilized in one form or the other.

A large proportion of the rice grown in West African Countries, particularly Nigeria, is cultivated by small scale farmers as dryland or upland rice. This accounts for more than sixty percent of the total area devoted to the growth of rice. On a global basis, upland rice production accounts for only 11% of the total area given to rice cultivation (Jacquot and Courtois, 1987). The response of rice to fertilizer application depends on the fertility of the soil as well as the cultivar used.

Nitrogen is the most limiting nutrient in the growth of rice. Sanchez (1976) claimed that Nitrogen is the nutrient element that frequently limits yield in the tropics as well as the temperate regions. According to him, with the exception of some recently cleared land, most cultivated soils are deficient in this element. In general, upland rice responds well to Nitrogen; it is required in large quantities as it is almost in short supply than any other element. Because Nitrogen is required in relatively higher quantities than other nutrients, it is usually used to topdress after a basal application of all other elements. Local rice farmers in Ekpoma area however prefer fertilization once. Some of the reasons for this practice include high cost of fertilizer and labour involved in the application. Many of the farmers consider the second application a waste of time and energy. This method considerably decreases yield as optimum fertilizer levels are not attained.

Nitrogen encourages tillering and plant growth. Deficiency causes stunted growth and reduction in the number of tillers produced. However, when Nitrogen is applied in excessive amount or at wrong stages of growth, increased vegetation, heavy lodging, increased damage from diseases, delayed maturity and reduced grain yield may result (Tanaka, 1959). Phosphorus is also needed for good yield of rice as it encourages the growth of the plant, particularly of the root system. According to Singh and Uriyo (1980) low level of available soil phosphorus can reduce the efficiency of Nitrogen.

Potassium is another important nutrient required by the rice plant. Response of upland rice to potassium is seldom a limiting factor in rice production except in highly defficient soils.

In rice nutrition, trace elements have come to be important since work done by Scientists highlighted their importance in plant nutrition. According to Pathnaik *et al* (1975), dry matter yield, chemical composition and uptake of nutrients of rice varieties can be substantially improved with Fe and Zn fertilization.

Although there are spacing recommendations for upland rice, there is dearth of knowledge on the number of seeds required per stand to maximise yield. There is also no reliable fertilizer recommendation for rice in this ecological zone.

The objective of this study was therefore to investigate the effect of number of grains planted per hole and fertilizer application on tillering and yield of upland rice.

MATERIALS AND METHODS

This study was conducted at the Teaching and Research Farm (Ujemen) of Edo State University, Ekpoma from April to July 1991. The farm is located in the forest zone of Nigeria, latitude 6°05′.

The site had been left fallow for about two years. The vegetation was thus a secondary regrowth dominated mostly by weeds such as *Chromolaena odorata*; *Panicum maximum*, *Ageratum Conizoides*, *Cyperus spp.*, *Euphorbia spp.* and broad leaved weeds such as *Commelina benhalensis*, *Aspilia africana* and *Talinum triangulare*. The land had been used in the past to grow such crops as yams, cassava, groundnut, rice and maize. It was last cropped to cassava. Rainfall was fairly moderate throughout the period of the experiment. Total rainfall during the growing season was 999m. Details of the chemical composition of the soil before cropping are shown in Table 1.

TABLE 1: CHARACTERISTICS OF THE SOIL AT THE SITE OF EXPERIMENT, UJEMEN - EKPOMA

p^H (Suspension 1: 2.5 in water)	5.27
Organic carbon (%)	1.35
Total Nitrogen (%)	0.10
C/N ratio	13.5
Cation exchange capacity (CEC)	4.78
Exchangeable K (meg/100g soil)	0.19
Available P (mg/kg)	6.62
Exchangeable Ca (meg/100g soil)	3.79
Exchangeable Mg (meg/100g soil)	0.41
Exchangeable Na (meg/100g soil)	0.09

An upland rice cultivar, ITA 150, was used for the experiment. The cultivar was developed and released by the International Institute for Tropical Agriculture (IITA). Rice was planted on 12 April 1991 at seeding rates of 1, 2, 3, 4 and 5 seeds per stand designated as S_1, S_2, S_3, S_4, and S_5 respectively. Fertilizer was applied at the rate of 0, 50, 100, and 200 kg/ha designated as N_0, N_1, N_2, and N_3 respectively. Fertilizer application was by broadcasting, the first application was at four weeks after planting while the second was applied at booting. Compound fertilizer - NPK (15-15-15) was used for the first application while urea was used for the second application to topdress. The treatment was a 4 x 5 factorial scheme with three replicates. The spacing was 30cm x 30cm on the flat. Each plot measured 1m between plots and 2m between replicates. There were thus a total of sixty plots occupying an area of approximately 0.17ha. Two hand weedings were carried out during the period of growth, the first weeding was done at six weeks after planting, while the second was done at ten weeks.

Plant height, number of tillers, number and length of internodes, length of leaves and number of panicles per stand were determined on ten random samples per plot which were tagged, at ten weeks after sowing. The length of the second basal leaf and the internode between the second and the third basal leaf were measured. Measurement of the leaf was from the leaf base to the tip. The height, number of internodes and length of internodes were all taken from the main tiller on the same stand.

Harvesting was done by hand on 31 July 1992 and this was carried out by harvesting the net plot. After harvesting, the rice was properly dried and threshed manually. It was further dried before taking the weight of the paddy.

The leaf below the flag leaf, Y - leaf (Osiname, 1982) was sampled from different plots at harvest and analysed for N, P, K, Ca, Mg and Na, Nitrogen analysis was carried out using the micro kjeldahl digestion method and ammonia in the digest was estimated using Technicon model II Autoanalyser. For the analysis of the other elements, 1g of finely ground dried sample was weighed into 10m pyrex beaker and placed in a muffle furnace for ashing at 500°C for 3 hours. Phosphorus was estimated using the molybdenum blue technique (Humphrey, 1956) and potassium, calcium, magnesium and sodium were determined by the Gallen Kamp flame digital auto analyser.

RESULTS

Vegetative Characters

Vegetative characters measured were plant height, tillering, length of leaves, number and length of internodes. Seedrate and fertilizer application did not have any significant effect on plant height, though the latter brought about a slight increase (Fig. 1.). The interaction of seedrate x fertilizer was however very significant ($P < 0.05$).

At the highest rate of fertilizer application (200kg/ha), plots with low seedrate produced the tallest plants whereas under the control treatment (no fertilizer) plants at the highest density were tallest.

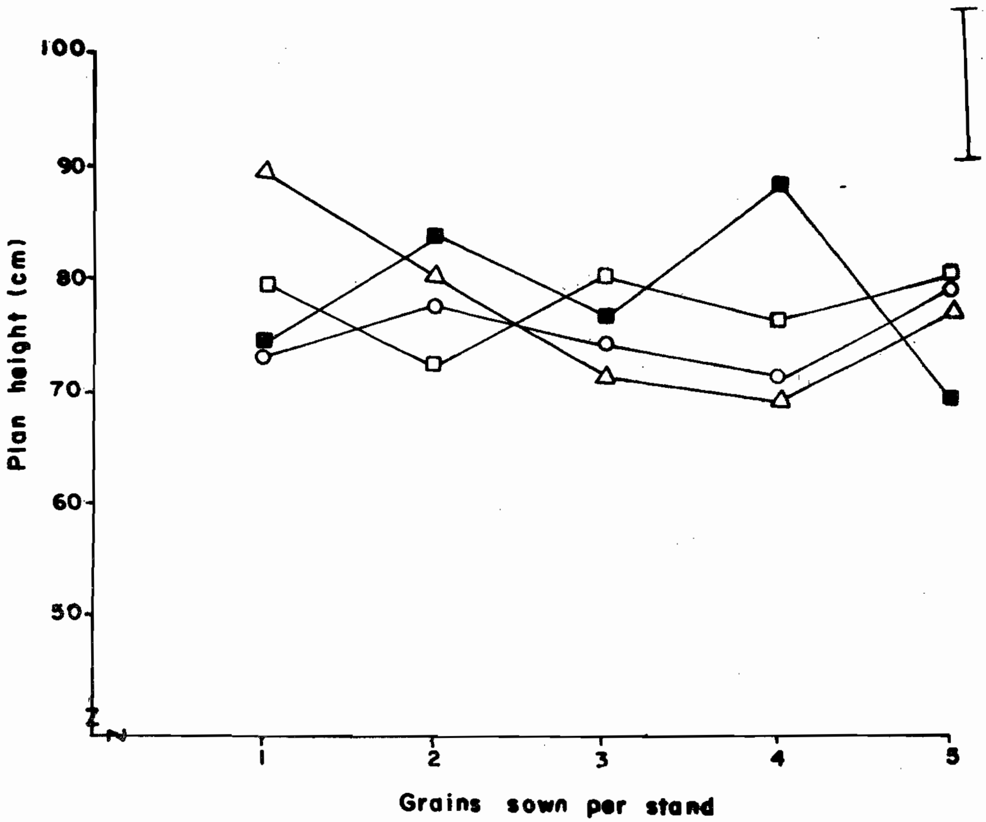

Fig. 1 Effects of seedrate and fertilizer application on plant height. O, control; □ .50kg/ha; ■ 100kg/ha and △, 200kg/ha. Vertical bar represents LSD ($P < 0.05$)

The number of tillers were counted on three different occasions and varied little throughout, the overall mean number being 3.36, 4.47 and 4.93 at 30, 45 and 60 days after seeding respectively. At 30 days after seeding, fertilization had no effect on tillering but number of tillers increased with increase in seedrate (Table 2). Seedrate x fertilizer interaction was also significant ($P < 0.05$). In the unfertilized plots, number of tillers increased linearly with increase in seedrate, but with fertilizer application at different levels, this response was not consistent.

TABLE 2: EFFECTS OF POPULATION DENSITY AND FERTILIZER APPLICATION ON NUMBER OF TILLERS PER STAND AT THIRTY DAYS AFTER PLANTING

Fertilizer Application (Kg/ha)	Seed rate (Grains sown per stand)					
	1	2	3	4	5	Mean
0	2.86	3.00	3.66	3.70	4.23	3.49
50	2.76	2.66	3.26	4.06	3.73	3.29
100	3.13	3.33	2.83	2.90	3.33	3.10
200	2.70	3.70	3.23	3.93	4.30	3.57
Mean	2.86	3.17	3.25	3.65	3.90	

LSD (P = 0.05)

Fertilizer mean	N.S
Seed rate mean	0.531
Interaction	1.063

The second tiller count taken at 45 days after seeding was not affected by fertilization but increase in seedrate had significant effect on tillering (Table 3). There was no significant interaction between treatments.

The third tiller count at 60 days after planting was significantly affected by both fertilization and seedrate (Table 4). Fertilizer increased tiller number by over 20% at the highest level of application. Increased seedrate from one to five per stand increased tillering by about 52%. There was seedrate x fertilizer interaction; the number of tillers increased relatively more with fertilization at low seed rate than at high seedrate.

The length of leaves was significantly increased ($P<0.05$) by fertilization (Table 5). The rate of increase was more pronounced with the application of 50kg/ha than higher levels.

Seedrate had no effect but seedrate x fertilizer interaction was significant ($P < 0.05$); length of leaves increased with fertilization at low seedrate than at high seedrate. For instance, leaf length increased by 56% when 200kg/ha of fertilizer was applied compared with the control at the seedrate of one grain/stand. Conversely, the length of leaf decreased with the application of the same level of fertilizer at the seedrate of five grains per stand.

The treatments had no effect on length and number of internodes. The number of internodes formed were very few and inconsistent with seedrate but internode length was on the average about 30cm.

TABLE 3: EFFECTS OF POPULATION DENSITY AND FERTILIZER APPLICATION ON NUMBER OF TILLERS PER STAND AT FORTY FIVE DAYS AFTER PLANTING

Fertilizer Application (Kg/ha)	Seed rate (Grains sown per stand)					
	1	2	3	4	5	Mean
0	3.53	3.93	4.86	4.90	5.56	4.56
50	3.50	4.26	4.96	4.66	5.63	4.60
100	3.96	4.50	3.70	4.03	4.50	4.14
200	3.63	5.06	4.50	3.96	5.63	4.56
Mean	3.66	4.44	4.51	4.39	5.33	
LSD (P = 0.05)						
Fertilizer mean	N.S					
Seed rate mean	0.650					
Interaction	N.S					

TABLE 4: EFFECTS OF POPULATION DENSITY AND FERTILIZER APPLICATION ON NUMBER OF TILLERS PER STAND AT SIXTY DAYS AFTER PLANTING

Fertilizer Application (Kg/ha)	Seed rate (Grains sown per stand)					
	1	2	3	4	5	Mean
0	3.53	3.50	4.50	5.20	5.66	4.50
50	4.00	5.06	4.10	4.56	5.63	4.73
100	4.06	4.50	4.90	5.56	6.46	5.09
200	4.50	5.70	5.03	5.13	6.70	5.41
Mean	4.02	4.80	4.71	5.11	6.11	
LSD (P = 0.05)						
Fertilizer mean	0.403					
Seed rate mean	0.450					
Interaction	0.900					

TABLE 5: EFFECTS OF POPULATION DENSITY AND FERTILIZER APPLICATION ON NUMBER OF LENGTH (CM) OF LEAVES

Fertilizer Application (Kg/ha)	Seed rate (Grains sown per stand)					
	1	2	3	4	5	Mean
0	46.53	60.96	54.63	65.40	64.10	58.32
50	64.93	65.46	64.10	66.43	71.46	66.48
100	68.93	57.13	63.70	68.43	48.73	59.43
200	72.76	70.50	65.56	63.33	59.66	66.36
Mean	63.29	63.51	62.00	63.46	61.00	

LSD (P = 0.05)	
Fertilizer mean	5.860
Seed rate mean	N.s
Interaction	13.110

Yield and yield components

The main component of yield produced was number of panicles which was affected by fertilization and seedrate (Table 6). Fertilizer increased panicle number by 19.6% at the highest level of application. The increase with the addition of 50kg/ha of fertilizer was 13.7%. Additional rates of fertilization had very little increase. Increasing seedrate from one to five per stand increased panicle number by 50.4%. There was no seedrate x fertilizer interaction. Paddy yield was significantly increased by both fertilizer and seedrate (Table 7). The increase was linear and was 130% more than the control at the highest level of fertilizer application. Response to fertilization was very pronounced up to 100kg/ha; the increase from 100 - 200kg/ha level of application was small (9.5%). Yield was more than doubled by increasing seedrate from one to five grains per stand (by 129.9%). There was no seedrate x fertilizer interaction.

Of all the elements for which analysis was determined, only magnesium was affected significantly by fertilizer and seedrate. There was however, no particular pattern as shown in Fig. 2. The concentrations of N.K and Ca in that order were the highest in the leaves whilst that of Na was the lowest (Table 8).

TABLE 6: EFFECTS OF POPULATION DENSITY AND FERTILIZER APPLICATION ON NUMBER OF PANICLES PER STAND (SIXTY DAYS AFTER PLANTING)

Fertilizer Application (Kg/ha)	Seed rate (Grains sown per stand)					
	1	2	3	4	5	Mean
0	3.53	3.90	5.06	5.30	5.93	4.74
50	4.16	5.13	5.80	5.76	6.10	5.39
100	4.53	5.60	5.36	5.66	6.13	5.46
200	4.50	5.43	5.60	5.80	7.00	5.67
Mean	4.18	5.02	5.46	5.63	6.29	
LSD (P = 0.05)						
Fertilizer mean	0.470					
Seed rate mean	0.530					
Interaction	N.S					

TABLE 7: EFFECTS OF POPULATION DENSITY AND FERTILIZER APPLICATION ON YIELD (t/ha)

Fertilizer Application (t/ha)	Seed rate (Grains sown per stand)					
	1	2	3	4	5	Mean
0	0.29	0.31	0.58	0.78	1.02	0.60
50	0.43	0.66	0.88	1.08	1.13	0.84
100	0.93	1.30	1.21	1.30	1.55	1.26
200	0.90	1.17	1.33	1.56	1.97	1.38
Mean	0.64	0.86	1.00	1.18	1.42	
LSD (P = 0.05)						
Fertilizer mean	0.142					
Seed rate mean	0.159					
Interaction	N.S					

TABLE 8: EFFECTS OF FERTILIZER APPLICATION ON NUTRIENT CONCENTRATION (%) IN RICE LEAVES AT HARVEST

Nutrient Concentration (%)	Fertilizer application (kg)					
	0	50	100	200	Mean	S.E
N	2.60	2.81	2.91	2.92	2.81	0.656
P	0.13	0.12	0.14	0.14	0.13	0.026
K	0.94	0.91	0.85	0.90	0.90	0.173
Ca	0.90	0.80	0.84	0.90	0.86	0.147
Mg	0.41	0.36	0.48	0.44	0.42	0.082
Na	0.02	0.02	0.02	0.02	0.02	0.001

DISCUSSION

The results in this study show that rice responds a great deal to fertilizer application. Unfortunately, most rice farmers in Nigeria invest little on fertilizers. Though the area planted to rice in Nigeria is still relatively small, the demand for the crop has been growing steadily. The increased demand reflects the shift in diet that has resulted from urbanization and so production practices must be improved upon to boost yield. Plant height measured at sixty days after planting was not affected by fertilizer application. It was however observed that fertilized plants of the lower seedrate had taller plants. Earlier work by Lee (1960) and Arraudeau and Vergara (1988) have similarly shown that plant height was increased with fertilization, especially nitrogen.

From the result of the experiment, tillering did not vary much with fertilization, though there was a progressive increase in tiller formation, the overall mean number of tillers was low on the three occasions they were counted. The reason for the low tiller formation observed for the different occasions could be due to poor tillering ability of the variety. Fertilizer application however increased tiller number significantly ($P < 0.05$) at 60 days. This is in conformity with the results obtained by Hussien *et al* (1978) who showed that tillering and yield of rice are affected by nitrogen application. Similar results by Muruppu (1979) has also shown that nitrogen N application increases vegetative characters and consequently yield.

Results have consistently indicated that N is the nutrient limiting rice yield. In a fertilizer trial involving a substraction series of upland rice at Mbo plains in the Cameroons, it was found that absence of N, P and S reduced yields significantly but other nutrients had little effect (ANON, 1984). Scientists at the IITA also found in a separate experiment that grain yield, tiller and panicle number increased with N fertilizer but there was no clear response to P and K fertilizers (ANON, 1984). The results obtained in the present study agree with that of Dastur (1940) who found out that the application of N - fertilizer significantly increased yield of rice. Although, panicle number was generally low in this study (Table 6), higher rates of N application enhanced it as reported by Abichandani and Patnaik (1959). Similar result was obtained by Onochie (1974) when he found out that panicle number increased with nitrogen fertilization made at booting stage (79th and 106th day) in OS_6 and IR 20 respectively.

As expected, increased seeding rate increased tillering, panicle number and yield in this study. Plant height measured at 60 days after planting was not affected; though seedrate x fertilizer interaction was significant. Plants sown with one

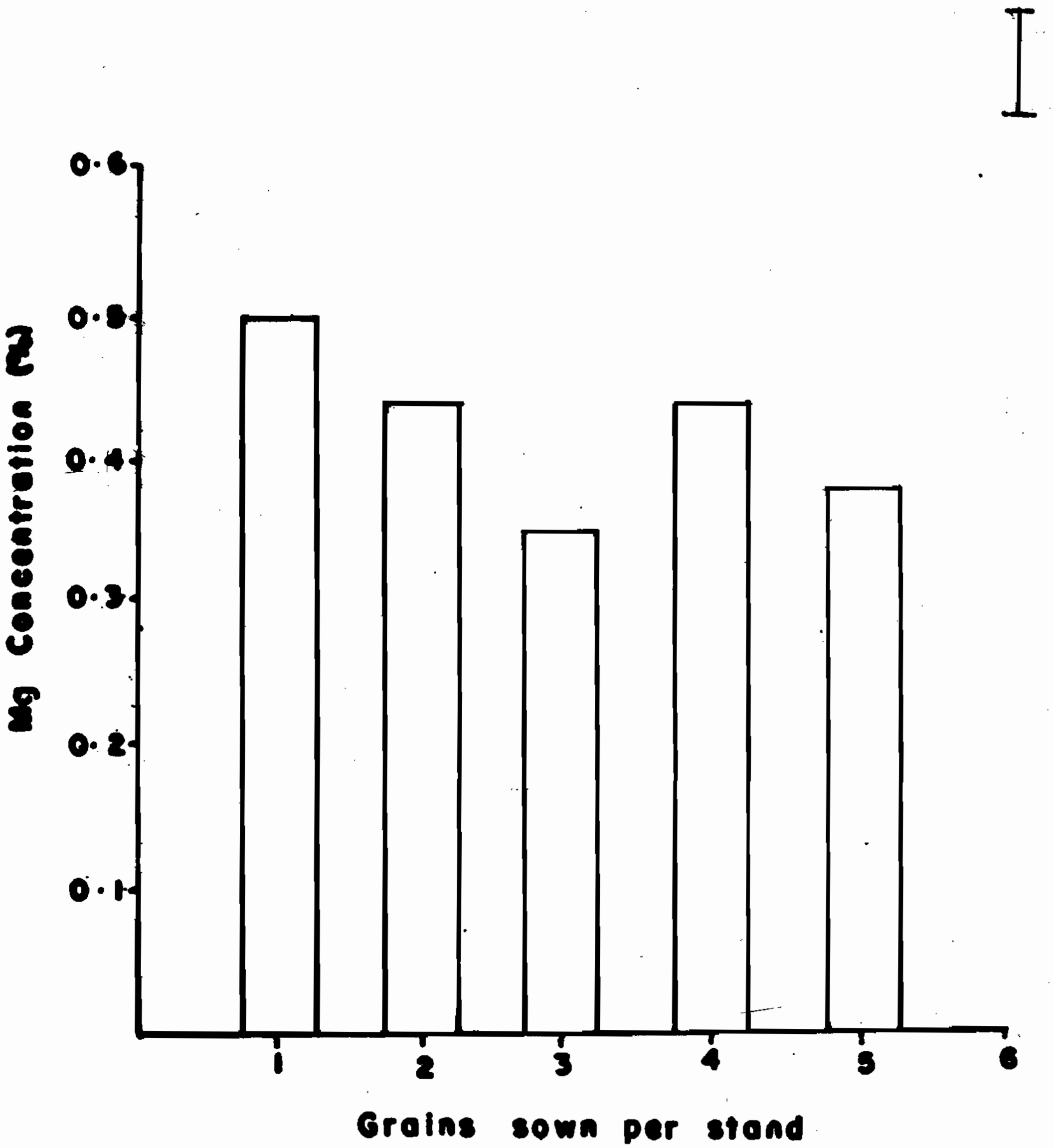

Fig. 2 Effect of grain sown per stand on percentage magnesium concentration in leaves of rice. Vertical bar represents SE ($P < 0.05$)

grain per stand had the tallest plants while plants sown with five grains per stand had the shortest. The reason for this could probably be due to less intra plant competition in plants with fewer seeds. Seedrate also had a significant effect on tillering. Tiller number increased by about 52% when seedrate was increased from one to five. Konokhova (1985) similarly reported increased tiller number for higher seed density in rice. Yield was in fact more than doubled by increasing seedrate from one to five seeds per hole.

Most reports in the literature on spacing trials on rice highlights results of dibbling at different spacings but none is available on the effects of seed number per hole on yield. The yield record in this present study were obviously low. Several reasons can be adduced for this. . These include poor tillering ability resulting in the formation of few panicles and vertebrate pest attack. Weaver birds were a menace at fruiting despite efforts at scaring them. There were also sporadic attacks from rodents and grass cutters. Reduction in yield due to pests could be very pronounced as reported by Funmilayo and Akande (1985) who gave an estimate of 40% loss. In a survey by IITA rice scientists, grain eating birds were rated as the most damaging pest of rice in Central and West Africa. (ANON, 1986).

Only magnesium was significantly affected by fertilizer application and seedrate probably due to higher Mg recovery in the tissues of rice. The concentrations of other elements, N,P,K, Ca and Na did not show any statistical significance. The apparent lack of significance in N content is difficult to explain as the result obtained is contrary to the one of Tanaka (1959). The lack of significance by the other elements was probably due to the fact that they were applied in smaller quantities as basal applications since according to Humes *et al* (1979), response of rice to fertilizer at low rates is very poor which invariably affects their recovery in leaves. From this study, it is clear that the yield of rice was influenced by tillering and the number of panicles formed and these were dependent on seedrate. The yield was also influenced by fertilizer application though there was no response to NPK above 100/ha. It is therefore recommended that farmers who wish to embark on the cultivation of this variety or any low tillering variety should increase the number of seeds sown per hole substantially as this will increase the tillering ability and consequently enhance the formation of more panicles.

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