Ife Journal of Agric. Vol. 6 Nos. 1 & 2 (1984)

Response of two lowland rice varieties to N, P and a combination of other nutrients in a flooded soil

A. OLU OBI and J. A. ADEPETU
Department of Soil Science
University of Ife,
Ile-Ife, Nigeria.

Abstract

A 4x3x2x2 factorial experiment was conducted to evaluate the effects of N, P and a combination of some other nutrients on grain yields of two rice varieties under hydromorphic soil conditions, in the rainforest of southern Nigeria.

The low yielding variety (IR-20) responded better to fertilizer application than the higher yielding variety (OS-6). The best rates of N and P application to both rice varieties in this flooded soil were 60kg N/ha and 25kg N P/ha. Yield response to a combination of 100kg K, 40kg Mg, 5kg Cu, 2kg Zn and 2kg Fe per ha was significant during both years of cropping. Yield response to N.P, and the combined application of the other nutrients were greater during the second than the first year of cropping.

Introduction

Rice is probably the most demanded domestic food crop in Nigeria today; yet most of the rice consumed is imported from other countries. This rice crop has therefore become an important consideration in the Nigerian Government goal of self-sufficiency in food production. There is consequently an urgent need for an increase both in the land area under rice cultivation and in the average yield of rice per hectare of land.

Rice is probably the only important food crop that can be grown successfully in flooded soils because of its ability to oxidise its rhizosphere (Sanchez, 1972). Therefore, the lowland, hydromorphic soils of Nigeria that are generally avoided by farmers can be utilized in increasing rice hectarage. Most of the paddy rice fields in Nigeria occupy periodically flooded river valleys (flood plains) where the wetting period extends beyond the end of the rains into the critical period when rice is heading (Hardcastle, 1959). Previous studies showed widespread response to nitrogen on these soils while phosphorus rêsponse was less widespread, and the response to potassium only occur occasionally (Bredero, 1963, 1964, 1965, 1966; William, 1973a, 1973b; Takahashi, 1963; Honjo, 1968). More recent works have shown that in addition to N and P deficiencies, potassium and magnesium deficiencies may become highly limiting to rice grown in wetland soils under continuous cultivation and high management levels (Ayotade, 1975).

From a summary compiled worldwide on several thousand rice fertilization experiments, Dole (1966) concluded that variability in rice response to fertilization is affected by plant type (cultivar), soil type, solar radiation, water management and cultural practices. The present study was conducted to evaluate the response of two rice cultivars, commonly grown in southern Nigeria, to nitrogen, phosphorus and a combination of K, Mg, Cu, Zn and Fe, when grown in a flooded soil.

Materials and methods:

The study was conducted on a hydromorphic soil at Ashipa about 20km North-West of Ife. The experimental design used was a 4x3x2x2 factorial, as follows: 0, 30,60 and 90kg N/ha as $(NH_4)_2SO_4$; 0,25, and 50kg P/ha as single superphosphate (SSP); with or without other nutrients (100kg K/ha as muriate of potash + 2kg Zn/ha as Zn-chelate+ 2kg Fe/ha as Fe-chelate); and two cultivars of rice viz OS-6 and IR-20. There were three blocks (3 replicates per treatment) each containing 48 plots (treatments). Fertilizer treatment was applied a month after seed emergence, except the 60 and 90kg N/ha treatments which were applied in split doses at one and two months after emergence for the 60kg N treatment, and one, two and three months after emergence for the 90kg/ha treatment. Application was by banding along the crop row about 7.5cm from plant base. The rice was planted first week of April, thinned to two plants/stand at three weeks, and harvested at seed maturity stage in August; the study was conducted in two consecutive years of 1981 and 1982. Before this study was initiated, the land had been used for dry season cultivation of maize without fertilizer for two seasons by a local farmer.

At maturity, rice head was harvested, while the seeds were separated from the seed stalks and weighed. Seed samples were collected randomly from a few plots, ovendried for moisture content determination and this was used to correct for the moisture in the seed yield weight of each plot. Before sowing the second crop, straw residue of the first crop was cut at soil level and removed from the field.

Two weeks after emergence during the first cropping, surface soil samples (0–15cm) were obtained from each plot and analysed for pH (O.01M $CaCl_2$ suspension); organic matter (O,M) by dichromate oxidation method; available-P by molybdate blue method after Bray number one extraction (Bray and Kurtz, 1945), exchangeable cations by amonium acetate extraction, total N by Kjeldahl procedure; particle size distribution by hydrometer method, and CEC by Magnesium acetate saturation technique.

Results and Discussion

Some physical and chemical properties of the surface soil of the experimental site at the beginning of this study are presented in table 1. The pH of the soil varied between 4.1 and 5.4 (in 0.01M $CaCl_2$). The low pH may be explained by low exchangeable Ca level of the soil. Available soil phosphorus (Bray-1) was relatively low, with a mean of about 13.5ppm; while the organic matter content was 1.8% and the total N content averaged 0.05%. Potassium , Mg and Ca levels in the soil seemed adequate for good growth and yield of rice in the soil.

The application of N-fertilizer significantly increased the yield of rice in both years of the study. (Table 2). Grain yield ranged from 2,460 kg/ha with no N applied, to 3,740 kg/ha with 90kg/ha N application on IR-20 variety in the first year of cropping. Application of 30 and 90 kg N/ha to OS-6 rice did not produce any significant increase in yield in the first year whereas application of 60kg N/ha significantly ($P<0.05$) improved the yield. Conversely, grain yield of IR-20 consistently improved with increasing N level. Application of 60kg N resulted in 39% increase in grain yield of IR-20 during the first year of experimentation. The OS-6 variety yielded slightly more than IR-20 at all levels of N during the first year of cultivation and much more during the second year.

ABLE 1: SOME PHYSICAL AND CHEMICAL PROPERTIES OF THE HYDROMORPHIC SOIL USED IN THE STUDY

Soil Property	Mean	Range
pH (0.01M$CaCl_2$)	4.7	4.1 – 5.4
O.M. (%)	1.8	0.7 – 3.0
Clay (%)	33	19 – 48
C.E.C (meq/100g)	19	11 – 37
Total N (%)	0.06	0.02 – 011
Available P (ppm)	13.8	5 – 32
Exchangeable K (ppm)	178	110 – 300
Exchangeable Mg (ppm)	130	67 – 377
Exchangeable Ca (ppm)	527	260 – 1250
Exchangeable Na (ppm)	95	40 – 179

TABLE 2: GRAIN YIELD OF TWO PADDY RICE CULTIVARS AT DIFFERENT LEVELS OF N–FERTILIZER.

Rice Yield (kg/ha)

Treaments	YEAR ONE			YEAR TWO		
	OS–6	IR20	Mean	OS–6	IR20	Mean
N_0	3090	2460	2775	1950	1360	1655
N_{30}	3080	3000	3040	2310	1900	2105
N_{60}	3400	3410	2405	3860	2220	2540
N_{90}	3150	3740	3445	2950	2140	2545
Mean	3180	3153	3191	2518	1905	2211
LSd o.05	129.2	154.1		118.3	92.6	

The yield in the second year was significantly lower than it was in the first year (t <0.01). This could be due to a decline in the soil nutrient status since climatic effect, especially moisture must be minimal in paddy rice. With the expected decline in organic matter during the second year (Adepetu and Corey, 1977) the native soil Nitrogen must have been reduced, resulting in greater need for N fertilizer as shown in yield decline. In the control plot, average grain yield during the second year was 60% of what was obtained during the first year of cropping. It is a widely held view that a higher yielding variety responds better to fertilization than a lower yielding variety (Gross et al., 1953; Twanmley 1960; Dole 1966). Contrary to this concept, this study seems to indicate that the lower yielding rice variety (IR20) responded better to fertilizer application than the higher yielding veriety (OS6). This may be attributed to difference in feeding power of the varieties. On the average, it seem that the best level of N application to both rice varieties was 60kg N/ha (Table 2): The mean yields associated with N_{90} in both years (3445 and 2545 kh/ha) were not substantially different from those associated with N_{60} in the two years (3405 and 2540 kg/ha). There was a better response to added N-fertilizer in the second year than in the first. With IR20, N application at 60kg N/ha resulted in 63% yield increase. Corresponding value during the first year was 39%.

The yield of rice as a function of added phosphorus fertilizer (Table 3) showed a significant response to P application (L. S.D.<0.05) in both years of cropping. Phosphorus application at 25kg P/ha gave the highest yield with both varieties. OS6 and IR20 had grain yields of 3350 and 3280 kg/ha respectively for the first year and 2760 and 2240 kg/ha respectively in the second year. The difference in grainyield between the second and third levels of P application was not significant in the first year of cropping. However, in the second year, 25kg P/ha was superior to 50 kg P/ha for both rice varieties. Also the yield in the second year was lower in all cases when compared with that of the first. Conceivably, there was considerable depletion in the soil nutrients in the second year. This probably resulted in a reduced yield which was apparent in the control plot. Such a situation allowed for a significant response to P application by both varieties in the second year of cropping. As was observed for N application, IR20 responded better to P application than OS6 in both years of cropping.

TABLE 3: GRAIN YIELD OF TWO PADDY RICE CULTIVARS AT DIFFERENT LEVELS OF P–APPLICATIONS.

Treaments	Rice Yield (kg/ha) YEAR ONE			YEAR TWO		
	OS–6	IR20	Mean	OS–6	IR20	Mean
P_o	3070	2900	2985	2520	1840	2180
P_{25}	3350	3280	3315	2760	2240	2500
P_{50}	3280	3270	3275	2520	1760	2140
Mean	3233	3150	3192	2600	1947	2273
LSD 0.05	113.1	170.7		105.3	120.2	

The level of Bray-1 extractable P in this soil averaged 13.8ppm; this is less than the value of 15-20ppm regarded as the cirtical minimum requirement for good yield in upland soils of South Western Nigeria (Adepetu *et al,* 1979). Earlier studies of paddy soil elsewhere have shown increased Bray-P in soil resulting from flooding of different soils (Mahapatra and Patrick, 1969); and this has been attributed to increased pH of acid soils with flooding (Tanaka *et al,* 1969). The detectable Bray-P level in the soil of the present study seemed very low for a flooded soil, and therefore indicates P inadequacy in the soil. Also, De Datta (1978) observed that, inspite of the high mobility of P in wetland soils, fertilizer P applied to such soil is still largely fixed, mainly as Fe-P in acid soils.

Application of P beyond 25kg/ha was apparently not very useful to the rice crops (Table 3). Since P was applied during each of the first and second successive crops, the second crop must have taken advantage of the residual P from the first application, in addition to the amount applied during that second crop. Therefore, the true amount of applied P needed for optimum production during the second crop was probably a little less than the 25kg P/ha that was applied. This value was not determined in this study.

There was a significant reponse to the combined addition of other nutrients (K, Mg, Cu, Zn, Fe) in the two years of cropping (Tables 4 and 5). Even though OS-6, had a higher yield than IR-20, the latter responded better to the addition of these nutrients. As was observed for N and P, the yield in the second year was considerably lower than what it was in the first year. On the average, the addition of these other nutrients led to yield increases of 16 and 13% in the first and second years of cropping respectively.

There was no statistically significant difference in varietal response to the treatments ($P>0.05$) duirng the first year of cropping however, OS-6 showed superior response during the second year (Table 5). The interaction between the varieties and added nitrogen was highly significant ($P<0.01$) in the first but not in the second year. Also, a significant interaction was observed among N, P and crop varieties during the first but not during the second year of cropping. No interaction was evident between P and N or between P and variety in either years of cropping.

TABLE 4: EFFECT OF K, Mg, Cu, Zn, Fe MIXTURE (M*) ON YIELD OF TWO PADDY RICE CULTIVARS.

Rice Yield (kg/ha)

Treatments M Levels	YEAR ONE			YEAR TWO		
	OS–6	IR20	Mean	OS–6	IR20	Mean
With	3369a	3505a	3437	2620a	2080a	2350
Without	3138b	2788b	2963	2430a	1720b	2075
Mean	3253	3147	3200	2525	1900	2213
LSD 0.05	119.6	133.1	78.4	106.7		

* kg/ha: 50K, 40Mg, 5 Cu, 2Zn, 2Fe.

TABLE 5: ANALYSIS OF VARIANCE SHOWING THE MAIN EFFECTS AS WELL AS INTERACTIONS AMONG YIELD INFLUENCING FACTORS.

		Year One		Year Two	
Source	**d.f.**	**M.S.**	**F**	**M.S.**	**F**
Treatments	47	9227	2.06**	11170	2 39**
Error	94	4485	–	4676	–
N	3	2780	6.20**	60937	13 03**
P	2	16008	3.57*	4765	N.S
M	1	16656	3.71*	42470	9.08**
V	1	2309	N.S	182116	38.94**
NV	3	30911	6.89**	2364	N.S
PV	2	288	N.S	116	N.S.
NPV	6	11216	2.50*	2108	N.S.

* Significant effect at 95% confidence level

** Significant effect at 99% confidence level.

N.S. No significant effect at 9% level.

References:

Adepetu, J. A; Adebayo, A Aduayi, E. and Alofe, C. 1979. **A preliminary survey of the fertility status of soils of Ondo State under traditional cultivation.** *Ife J. A. Agric. 1(2): 134 149.*
and Corey, R.B. 1977. Changes in N and P availability and P fractions in Iwo soil from Nigeria under intensive cultivation. *Pl Soils, 46: 309 316.*

Ayotade, K. A. 1975. Nitrogen Fertilization of lowland rice. I. Some soil fertility factors limiting rice response to higher Nitrogen rates. *Nigcr. Agric. J. 12(1): 74 – 87.*

Bray, R. H. and Kurtz, L. T. 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Sci., 59: 39 45.*

Bredero, T. J. 1963. The efficiency of phosphorus and nitrogen fertilization in swamp rice on some Nigerian alluvial soils. *Federal Dept. Agric. Res. Ibadan, Nigeria. Memo 48, 13pp.*

1964. Rice fertilization in Niger Province. *Samaru Agric. Newsletter 6: 118 – 120.*

1965. Nigrogen, phosphorus, and potassium uptake by lowland rice and its relation to yields on some alluvial soil. *Agron. J., 57: 421 – 425.*

1966. Fertilizer response in swamp rice in Northern Nigeria. *Expl. Agric., 2:33–43.*

De Datta, S. K. 1978. Fertilizer management for efficient use in Wetland soils. PP 671 to 701. In *Soils and Rice.* International Rice Research Institute. Los Banos, Philippines.

Doyle, J. J. 1966. The response of rice to fertilizer. *FAO Agric. Series. No. 70. FAO. Rome.*

Gross, H.D; Puovis E.R. and Ahlgren G.H. 1953. The response of alfalfa varieties to different soil fertility levels. *Agron. J., 45: 118–120.*

Mahapatra, I. C. and Patrick, W.H. 1969. Inorganic P. transformation in water-logged soils. *Soil Sci., 1-7:281–288.*

Hardcastle, J.E.Y. 1959. The development of rice production and research in the Federation of Nigeria. *Trop. Agric. Trin., 36:79–95.*

Honjo, Y. 1968. Experimental Reports on lowland rice in Nigeria. *End of tour report, Fed. Dept. Agric. Res. Ibadan, Nigeria, 152pp.*

Sanchez, P. A. 1972. Nitorgen fertilization and management in tropical rice. *North Carolina Agric. Expt. Sta. Tech. Bull. No. 213, 31pp.*

Takahashi, J. 1963. Fertilizer reseach on rice in Nigeria. *FAO Rept. No. 1786. FAO, Rome 1963.*

Tanaka, A; Watanabe, N. and Isizuka, Y. 1969 A crtical study of the P concentration in the soil solution of submerged soils. *J. Sci. Soil Man. Jpn. 40 (10): 406–416.*

Twamleys, B.E. 1960. Variety, fertilizer management interaction in alfalfa. *Con. J. Plant Sci., 40: 130- 138.*

William, A. 1973a. The trend of rice fertilization in Binin-kebbi. *Fed. Dept. Agric. Res. Ibadan Nigeria Memo 108, 5pp.*

1973b. Recommendation for rice fertilization in the Niger and Kaduna river basins. *Fed. Dept. Agric. Res. Ibadan Nigeria. Memo* No 109, 3pp.