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RESPONSE TO DIFFERENT RATES OF NITROGEN BY FIVE VARIETIES OF SWAMP RICE (ORZA SATIVA LINN) UNDER THE TROPICAL WETLAND CONDITIONS OF INI, AKWA IBOM STATE, NIGERIA

N. E. NNEKE

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ABSTRACT

A field experiment was conducted in 2011 and 2012 in Ini Local Government Area of Akwa Ibom State, Nigeria; mainly to determine the optimum nitrogen fertilizer rate for the area as well as select the rice varieties that responded optimally. A split plot design was used with five N rates (0, 50, 100, 150and 200kg/ha) as the sub plot treatments and five rice varieties (Cisadane, Suakoko 8, IR 5, ITA 306 and MAS 2401) as the main plot treatments. Nitrogen was band applied as urea in two equal splits at 2 and 8 weeks after transplanting (WAT). The results showed that the grain yield and growth parameters of the rice varieties were significantly ($P<0.05$) increased by the various N rates. In particular, the rate of 150kg/ha was consistently superior to other rates in increasing yields. It produced the broadest leaf area and the highest number of spikes, per panicle in 2012 and the highest number of tillers per plant and the heaviest grain yield in both years. Among the varieties, Suakoko 8 gave the highest significant ($P< 0.05$) yield response to the applied N fertilizer, followed by IR 5 and MAS 2401 (no significant difference) ITA 306 and Cisadane, in that order. Application of 150kg/ha of N in the form of urea to Suakoko 8 variety is recommended for the area.

KEYWORD: Nitrogen rates, rice varieties, response, growth and yield.

INTRODUCTION

Rice yields are generally low in Ini Local Government Area of Akwa Ibom State. This is attributable to the cultivation of low yielding varieties as well as poor soil fertility. Studies conducted by the Northern Akwa Ibom Swamp Resources Development Project, NAKSRDP (2004), indicated that seven different rice varieties are currently cultivated in Ini, the study area. This calls for a proper evaluation of the yield potentials of the various varieties.

Besides, for the past thirty years, wetland rice paddies in the study area have depended entirely on nutrients supplied from the soil and flood/irrigation water which are now becoming increasingly inadequate to sustain good growth and yield in a continuous cropping system. Opukiri ***et al*** (2001) observed that nitrogen is the most limiting plant nutrient for rice production in the tropics. This is because soil applied N is often lost through various transformation pathways such as volatilization, denitrification and leaching (De Data, 1997) and the fact that soils of southern Nigeria are generally low in total N content, usually 0.02-1.16% (Moorman, 1990). When applied in adequate amount, N encourages vegetative growth. It accounts for the plumpness of the grains and stimulate tillering and panicle formation (Foth, 1998).

Opukiri *et al* (2001) have reported with increase in the rate of applied N fertilizer, parameters such as number of spikelets per panicle, total dry matter and grain yield also increased significantly. However, beyond a certain rate considered as the optimum, no significant increases were observed.

Grist (2006) recommended 30-35kgN/ha for the indica sub-species of rice and 100kgN/ha for the japonica sub-species. Besides, Oyedokun and Sobulo (1999) reported that 30kgN/ha was the optimum N rate for Western Nigeria, while Sobulo (2002) recommended 50kgN/ha for the Savannah region. These blanket recommendations are considered inadequate considering the wide disparity in the soil and climatic conditions of the production areas (Grist, 2006) and the fact that rice varieties differ widely in the response to N fertilizer (Purseglore, 1995).

It is obvious, that the optimum N rate for rice growing areas could well be determined by conducting experiments in specific areas where specific rice varieties are grown. For instance, Opukiri *et al* (2001) have recommended that to obtain satisfactory grain yields, fertilization with urea of 90KgN/ha was adequate for ITA 303 and FARO 11 under the climate and soil of Port Harcourt in Rivers States.

Amidst these conflicting recommendations, this study was therefore, undertaken to determine the optimum N fertilizer rate for Ini soils as well as select the varieties that responded optimally to the rate.

MATERIALS AND METHODS

Field experiments were conducted in 2011 and

N. E. Nneke, Department of Crop Science, University of Uyo, P.M.B. 1017, Uyo, Akwa Ibom State, Nigeria.

2012 in Ini Local Government Area (Latitudes 5^0 03' to 5^0 27' North and Longitudes 7^0 39' to 7^0 56' East) located at the Northern part of Akwa Ibom State in southeastern Nigeria(NAKSRDP, 2004). The average annual rainfall in this area is about 2000mm and falls between March and November with peaks in bimodal pattern. The mean monthly sunshine is 3 hours 31 minutes and mean diurnal temperature is 30^0C (Okoji, 2005).

The treatments consisted of five swamp rice varieties (Cisadane, Suakoko 8, IR 5, ITA 306 and MAS 2401) and five levels of N (0, 50, 100, 150 and 200kgN/ha). The experiment was laid out in a split-plot design with the varieties in the main plot treatments and N levels in the sub-plot treatments respectively.

Soil samples were taken at the depth of 0-15cm before each planting and analysed for both physical and chemical properties. Soil pH was determined by electrometric method (Bates, 1954), particle size by the hydrometer method (Bouyoucos, 1951), organic matter by the oxidation method of Bray P-1 (Bray and Kurtz, 1954), K and Na were determined by flame analyzer and Mg and Ca by EDTA titration method (Jackson 1962). Exchange acidity was extracted with IN KCl and the acidity determined by titrating with NaOH (IITA, (1979).

Before planting, the seeds were dressed with Aldrex T in order to check the incidence of brown spot disease which occurred commonly in the area. Transplanting was done in rows at 4 WAP (weeks after planting) at a spacing of 30cm x 30cm. Two seedlings were planted per hill to achieve a plant density of 222, 220 plants per hectare.

Nitrogen fertilizer was band applied as urea in two equal splits at 2 and 8 WAT. To prevent any possible nutrient drift, bunds of 30cm height were built around the various sub-plots. Weeding which combined hoe weeding and hand pulling, were done three times (4,8 and 12 WAT) before harvest. Water level was maintained at a depth of about 15cm throughout the growing season except during weeding and fertilizer application (zero depth). Birds constituted the major pest of the crop and were controlled by employing the services of a “bird boy”.

Twenty randomly chosen and tagged plants per sub-plot were used for the measurement of growth parameters. Measurement began at 4WAT and continued every two weeks until grain harvest.

To obtain plant leaf area, the leaf length and the widest part of selected leaves were measured with a metre rule and the product obtained was multiplied by 0.75 (Hammer, 2000). The number of tillers per plant was obtained by counting the total number of tillers produced by each plant. Similarly, the number of spikes per panicle was obtained by counting the total number of spikes borne by each panicle.

For the young plant, plant height was obtained by measuring each plant from the base of the culm (stem) to the top of the topmost leaf with a tape. For the mature plant, height was measured from the base of the culm to the tip of the panicle. The number of leaves borne by each plant was obtained by counting the total number of leaves borne by the plant.

At 75% browning, the panicles were harvested from a 1.5mx0.9m area using a knife and thereafter threshed and sundried to about 14% moisture content (De Datta *et al*, 1997) to obtain the grain yield.

Statistical Analysis

Data collected were summarized and subjected to analysis of variance (ANOVA); while the least significant difference Test ($P<0.05$) was used to compare treatment means (Gomez and Gomez, 1994).

RESULTS

The physical and chemical characteristics of the soil used for the study are shown in Table 1. The total N contents were 0.06% and 0.14%, respectively, for 2011 and 2012 and were considered too low for the optimum performance of rice. Rice growth were generally higher in 2012, probably due to the residual or cumulative effective of applied N fertilizer in the previous year.

Leaf area was found to increase with increasing rates of N application up to the maximum rate in both years (Table 2). In 2011, the increase was optimum at 150kgN/ha with a mean leaf area of 55.60cm^2. A lower rate of 100kgN/ha was however, found to be optimum in 2012 with an average leaf area of 51.70cm^2, when averaged over the two years, 150kgN/ha was optimum with a mean leaf area of 55.04cm^2. This translated to a percentage leaf area increase of 36.20% over the control.

Except Cisadane which produced the smallest leaf area, all other varieties did not differ significantly with respect to this parameter (Table 2).

Table 1: Some physical and chemical characteristics of the soil used for the study.

	Years	
Soil properties	**2011**	**2012**
Physical characteristics		
Sand (%)	13.60	13.50
Silt (%)	24.10	24.30
Clay (%)	62.30	62.20
Textural class	Clay	Clay
Chemical characteristics		
pH (H_20)	4.23	4.14
Organic matter (%)	3.32	3.35
Total N (%)	0.06	0.14
Available P (mg/kg)	0. 16	6.18
Exchangeable bases		
Ca (cmol/kg)	2.50	2.55
Mg (cmol/kg)	1.30	1.28
K (cmol/kg)	0.09	0.09
Na (cmol/kg)	0.06	0.07
Exchange Acidity	3.32	3.35
ECEC (cmol/kg)	7.27	7.34

Number of Tillers per Plant

Nitrogen application significantly enhanced the tillering ability of the varieties. The highest significant numbers of tillers per plant were 7.86 and 8.29 respectively, for 2011 and 2012. Averaged over the two years, the optimum number of tillers per plant (8.08) was obtained with 150kgN/ha as against 5.24 tillers per plant for the control. This was equivalent to a percentage increase of 54.20% in number of tillers per plant over the zero N treatment (table 3).

Among the varieties, Suakoko 8 produced the highest significant mean number of tillers per plant and Cisadane, the least ITA 306, IR 5 and MAS 241 were not significantly different from one another (table 3).

Plant Height

The height of plant increased significantly as the rates of nitrogen increased (Table 4). This is in agreement with the work of Lal *et al*, 2001) who observed that increased nitrogen rates produced significant increase in plant height of rice. A separation of the mean height levels however, showed no significant increase in height above 100kgN/ha.

Table 2: Response of leaf area (cm^2) of five varieties of swamp rice to N rates

N-rate	2011	2012	Mean	Variety	2011	2012	Mean
0	38.61	42.21	40.41	C	38.83	47.40	43.12
50	44.00	47.43	45.51	S	51.23	48.94	50.09
100	49.73	51.70	50.22	R	50.31	53-61	51.96
150	55.60	55.47	55.04	T	51.13	52.88	52.01
200	56.45	56.49	56.47	M	48.48	50.47	49.70
LSD (0.05)	**5.29**	**4.06**	**3.68**	**LSD (0.05)**	**2.78**	**4.61**	**3.70**

Table 3: Response of number of tillers per plant of five varieties of swamp rice to N-rates.

N-rate	2011	2012	Mean	Variety	2011	2012	Mean
0	5.05	5.43	5.24	C	5.52	5.68	5.60
50	5.72	6.25	5.99	S	8.28	8.65	8.47
100	6.79	7.30	7.05	R	6.78	6.91	6.85
150	7.86	8.29	8.08	T	6.82	7.51	6.99
200	8.14	8.58	8.36	M	6.15	7.47	6.81
LSD (0.05)	**0.57**	**0.61**	**0.59**	**LSD (0.05)**	**0.64**	**0.67**	**0.66**

Table 4: Response of Plant Height of five swamp variety of rice to N-rates.

N-rate	2011	2012	Mean	Variety	2011	2012	Mean
0	75.10	84.30	79.70	C	90.00	94.08	92.04
50	81.58	84.00	85.29	S	116.03	124.03	120.06
100	86.50	92.30	89.65	R	105.06	115.06	110.12
150	90.00	98.00	94.00	T	104.24	112.24	108.48
200	94.50	96.36	95.43	M	147.12	153.13	150.24
LSD (0.05)	**4.92**	**4.95**	**4.32**	**LSD (0.05)**	**5.15**	**5.30**	**5.44**

Table 5: Response of number of spikes per panicle of five swamp rice varieties to N-rates.

N-rate	2011	2012	Mean	Variety	2011	2012	Mean
0	8.70	9.20	8.95	C	7.33	8.23	7.75
50	9.25	10.41	9.85	S	11.37	12.34	11.86
100	10.69	11.01	10.63	R	9.87	11.28	10.58
150	11.27	11.20	11.47	T	10.77	10.25	10.51
200	11.71	12.10	11.91	M	11.69	12.38	12.04
LSD (0.05)	**0.54**	**0.78**	**0.66**	**LSD (0.05)**	**0.55**	**0.61**	**0.58**

Table 6: Response of number of leaves per plant of five swamp rice varieties to N-rates.

N-rate	2011	2012	Mean	Variety	2011	2012	Mean
0	6.02	6.00	6.01	C	6.10	6.80	6.65
50	6.06	6.02	6.31	S	6.60	6.62	6.61
100	6.60	6.65	6.50	R	6.40	6.42	6.42
150	6.80	7.00	6.75	T	6.10	6.12	6.06
200	6.90	7.28	6.89	M	7.00	7.64	7.32
LSD (0.05)	**0.40**	**0.42**	**0.40**	**LSD (0.05)**	**0.35**	**0.40**	**0.38**

Table 7: Response of the grain yield (t/ha) of five rice varieties to N-rates.

N-rate	2011	2012	Mean	Variety	2011	2012	Mean
0	2.35	2.31	2.33	C	2.10	1.63	1.87
50	2.70	2.68	2.69	S	4.53	4.66	4.60
100	3.17	3.25	3.21	R	2.88	3.01	2.95
150	3.81	3.75	3.80	T	3.15	2.23	3.19
200	3.82	3.83	3.82	M	3.21	3.33	3.27
LSD (0.05)	**0.14**	**0.35**	**0.25**	**LSD (0.05)**	**0.17**	**0.33**	**0.25**

In rice, tallness is not much of an advantage infact, as reported by Calabio and De Datta (2005) nitrogen application promotes plant height resulting in the susceptibility of the rice crop to lodging particularly in rices with lower lodging resistance. This translates to reduced grain yields. MAS 2401 suffered considerable lodging due to its enormous height (>150cm at maturity).

This was not the case with the shorter varieties. However, it has been reported by Komolafe *et al* (1999) that taller rice varieties have the advantage of not being easily submerged in flood water.

Number of Spikes Per Panicle

Number of spikes per panicle was significantly affected by N application. In 2011, spike number per panicle increased by 28.39% by increasing N level from O to 150 kgN/ha. Similarly in 2012, it increased significantly by 19.67% with the application of 100kgN/ha compared to the control (Table.5). Averaged over the two year the number of spikes per panicle appreciated significantly by 28.15% when the level was increased from O to 150 kgN/ha.

The pair of MAS 2401 and Suakolo 8 produced the highest mean number of spikes per panicle, followed by the pair of IR 5 and ITA 360; while Cisadane recorded the least number (Table5).

Number of leaves per Plant

Nitrogen application at the rate of 100kgN/ha and above significantly increased the number of leaves per plant over the control (Table 6). The increase in the number of leaves might have been due to the increase in the number of nodes. The result was in agreement with Yamaguchi (2002) who observed that application of nitrogen produced significant increase in number of leaves per plant of the rice crop. It was however, not in agreement with Komolafe *et al* (1999) who reported that nitrogen application promotes internode extension without a corresponding increase in leaf number.

MAS 2401 produced the highest number of leaves per plant followed by Suakoko 8. The lowest number of leaves was recorded by ITA 306, Cisadane and IR 5.

Grain Yield

There were significant responses of the varieties to applied N in both years, despite the critically low soil N content in the first year (Table 7). Averaged over the two years, the response was optimum at 150kgN/ha with a grain yield of 3.80t/ha, as against the yield of 2.33t/ha obtained from the control. This translated to a percentage grain yield increase of 63.09%.

Suakoko 8 produced a significantly highest mean grain yield of 4.60t/ha, followed by the pair of MAS 2401 and ITA 306 (not significantly different). IR 5 and Cisadane produced the lowest grain yields (Table 7).

DISCUSSION

The total N contents of 0.06% (2011) and 0.14% (2012) obtained from the experimental plot were considered low. However they were in agreement with Moormann (1990) who reported that soils of Southern Nigeria have low N content of between 0.02 and 1.16%. The low N content underscored the need for N fertilization to enhance good growth and yield.

The increase in the total N content of the soil in 2012 and the generally better performance of the five rice varieties in the same year, could be attributed to the residual or cumulative effect of applied N in the previous year. The result is similar to that of Adepoju (2001), who reported of higher yields of maize in the late season than in the early season due to the cumulative effects of applied P in the early season.

The grain yield and the growth parameters of the rice varieties were significantly increased by N application. This observation was similar to those reported by Agboola and Oko (1996) and Opukiri *et al* (2001); that N application at various rates significantly increased the grain yield and growth parameters of rice varieties. The rates of 100 and 150kgN/ha produced the highest effects. The rate of 100kgN/ha gave the highest number of leaves/plant and the tallest plants in 2011 only. Similarly, the rate of 150/kgN/ha produced the broadest leaf area and the highest number of spikes per panicle in 2012 and the highest number of tillers per plant and the heaviest grain yield in both years. It is obvious that the rate of 150kgN/ha was superior to other rates in influencing growth and yield. Among the varieties, Suakoko 8 gave the highest significant response to the applied N. Notably, it produced the highest significant grain yields in both 2011 and 2012.

Curiously, the yield of ITA 306 was relatively poor; this is inconsistent with the report by the National Cereals Research Institute (NCRI) as cited by IITA (2006), that the variety possesses superior yielding ability over varieties currently being cultivated in Nigeria. Its mean grain yield of 6.5-7.5 t/ha reported by the source cited above. Be as it may, the variety had some desirable qualities it was short statured, high tillering and short maturity. Other varieties namely, IR 5 and MAS 2401 responded fairly well to the applied N but the later variety was long maturing and exceptionally tall, hence highly susceptible to lodging. In all, Cisadane variety responded poorly and was easily the least adaptable variety to the wetland ecology of the study area.

CONCLUSION

Rice growth and yield were found to have increased as the level of N increased, up to the maximum level. However, the highest significant increases were obtained with the rate of 150kgN/ha. This suggests that 150kgN/ha was the most suitable N rate for the topical wetland soil of the study area for rice production.

Among the varieties, Suakoko 8 performed relatively better, especially in grain yield, than the other varieties. it is obvious that this variety was the most responsive to the applied N fertilizer.

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