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GROWTH, YIELD AND YIELD COMPONENTS OF *RICE (ORYZA SATIVA L.)* AS INFLUENCED BY NITROGEN FERTILIZER PLACEMENT METHOD AND PLANTING PATTERN AT KADAWA, NIGERIA

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ABSTRACT

Field experiments were conducted at Kadawa irrigation sub-station (110 39' 08^0 *02'E) of* the Institute *for* Agricultural Research, Ahmadu Bello University, Zaria during the 1996-1998 wet seasons, to determine the effect of nitrogen placement method and planting pattern on the performance of rice (0. Sativa L.). Treatment consisted of two N-fertilizer placement methods-surface and deep placement, and four planting patterns-surface, rectangular, triangular and hexagonal laid out in a Randomised Complete Block Design (RCBD), replicated three times. Deep placement of N-fertilizer resulted in significantly higher crop growth rates, days to 50% flowering, grain weight per panicle, 1000 grain weights, grain yield, number of ear bearing tillers, percent filled grains, and plant height. The hexagonal and triangular planting patterns were statistically superior to the rectangular pattern in terms of crop growth rate, grain yield, number of ear-bearing tillers and plant height.

Keywords: Nitrogen placement, planting pattern, rice growth and yield

INTRODUCTION

Rice is widely cultivated in most agro-ecological zones of Nigeria. The country is the largest producer of the crop in West Africa, where it occupies 1.7 million hectares with a production is of 3.2 million tonnes of paddy (FAO, 1996). About 60 percent of the rice area in Nigeria is upland. Irrigated rice occupies only 5 percent of the total paddy land, while the rest is under swamps and 'fadamas' (FACU, 1985). Rice production in Nigeria has not increased appreciably over the years, in spite of the vast area committed. Consequently, thousands of tonnes of the crop is imported annually to bridge the gap between local production and demand by the ever teeming population.

The scenario is solely attributable to the average of 1.5tonne per hectare realised in country. The productivity level is one of the lowest in the world when compared with 6.5 tonnes/ha in Egypt and 7.0 tonnes/h in Japan (FAO 1996). In addition, the soil conditions under which lowland rice is grown, as well as intensity of land use resulted in a variety of fertilizer management problems. It has also been demonstrated that application of recommended rate of nitrogen fertilizer to lowland rice by broadcasting as practised by farmers is inefficient, and expensive in terms of fertilizer cost. Most of the fertilizer is lost by volatilization, leaching and denitrification (DeDatta, *et al.*, 1990). There is therei re a need to seek more appropriate planting pattern for lowland rice in the country to increase production per unit area. Also, to minimize N losses through nitrification and denitrification, Nfertilizer are either mixed with mud and plant residue in form of mud balls or placed at some depth in the soil close to the root zone of the growing rice plants (Chaudhary *et al*. 1986). The concept is to minimize Nmovement to the oxidized layer of the soil. Sufficient research has not been conducted on fertilizer placement methods and use of modified urea fertilizers. As agronomic practices and cropping intensity change, so do planting patterns. Though some investigation work has been carried out on seed rate and planting density in lowland rice, over the years, farmers have adopted various methods of planting rice, either by broadcasting or planting in narrow rows, leading to over crowding. Hence, limiting the growth and yield potential of the crop, especially on the marginal soils of the savannah. This haphazard planting may be responsible for the low productivity of the crop in Nigeria. In view of the above, this research was conducted to:

I . Evaluate the effects of some planting patterns on the performance of rice.
2. Compare the efficacy of the deep placement of N-fertilizer to surface application with respect to growth and yield of rice.

MATERIALS AND METHODS

Experimental Site

Three field trials were conducted at Kadawa Irrigation Research Sub-station (11°39'N, 08°02`E) of the Institute for Agricultural Research, Ahmadu Bello University, Zaria during 1996-1998 wet seasons. The soil was sandy-loam, with DH range of 5.90-6.80 and low in nitrogen, potassium and cation exchange capacity (Table 1). Meteorological situation during the trials was presented in Table 2.

Treatments consisted of two N-fertilizer placement methods: -surface and deep placements and 4 planting patterns namely, square, rectangular, triangular and hexagonal patterns, laid out in a randomized block design replicated three times. Gross and net plot sizes were $20m^2$ and $12m^2$ respectively. Urea as a water soluble fertilizer containing 46%N was used as source of nitrogen.

P 1 = Surface placement with 1/2 dose of N broadcast during transplanting and the rest of 1/2 dose broadcasted 3 weeks after transplanting (WAT).

P2 = Deep placement (mud-balls were made by mixing urea with mud at a ratio of 1:1.). Deep holes (10cm) were made with a stick and the urea mud balls were placed in the hole and covered.

Nursery preparation

The seed-beds were sited near the experimental field. The beds were ploughed a=id brought to soft puddle. Calcium ammonium nitrate (CAN) at the rate of 113.5g/m` and Single super phosphate (SSP) at the rate of $4.2g/m^2$ of the nursery were incorporated into the soil. Seeds were treated with benlate-T (Benomyl- 20% thorium 20%) before sowing. The seeds were broadcasted over the surface of the moist soil.

The seedling rate was two plants/hill. The seedlings were transplanted as per the following planting patterns.

S, = Square Pattern (20 x 20 cm)
S2 = Rectangular pattern (40 x 10 cm)

Table l. Physico-chemical properties of the soil of the experimental sites during the 1996, 1997 and 1998 wet seasons at Kadawa. Nigeria

Chemical Properties			
pH in H_2O(1:I)	6.80	6.30	5.90
pH in 0. 1 m CaCl, (1:2:5)	6.40	5.30	5.20
Organic carbon (%)	0.40	0.30	0.59
Total Nitrogen (%)	0.04	0.40	0.05
Available Phosphorus (ppm)	0.27	7.16	5.82
Exchangeable cations (c.mol/kg soil)			
Ca	7.50	5.00	5.00
Mg	0.89	0.83	0.59
	0.15	0.16	0.17
Ca	0.26	0.32	0.34
N	0.10	0.10	0.10
W+Al"	10.10	9.30	9.10
CEC			
Particle size distribution (%)			
Sand	58	56	58
Silt	24	28	26
Clay	18	16	16
Textural class	Sandy-loam	Sandy-loam	Sandy-loam

S_3 = Triangular Pattern (15 x 27 cm) S_4 = Hexagonal pattern (17.3 x 20 cm)

With the help of a marked rope the first line was transplanted the usual way as the square (20 cm apart). However, while planting the second line the rope was shifted 17.3 cm from the first line. This way the distance between adjacent two hills was 20 cm and between rows 17.3 cm.

Cultural Practices

The experimental field area was ploughed and harrowed twice, the land was then leveled before transplanting. Bunds were erected around each plot to conserve moisture and applied nutrients. A preemergent herbicide, Ronster was applied at the rate of 41/ha, while subsequent weed control was by hand picking when necessary. Three weedings were carried out during the entire life of the crop.

Sample of 10 wi.,ile plants were harvested at flowering stage. The samples were washed, dried and ground using Willy mill and the nitrogen, phosphorous and potassium contents of the plant samples were determined.

Table 2. Meteorological situation at Kadawa, Nigeria during the 1996, 1997 and 1998 rainy seasons

1996	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
Maximum Temperature C	23	23	32	32 i	32	35
Minimum Temperature C	54	22 _	21	20	21	22
Relative Humidity %	32.4	6.6	70	76	91	61
Wind Run (km per day)	75.83	88.63	94.53	54.26	45.40	48.43
Total Rain-fall (mm)	84.3	99.9	! 128.1	203.4	123.1	2.15
j 1997						
Maximum Temperature °C	38	33	33	30	32	33
1 Minimum Temperature C	25	22	1	20	21	20
	52.4	676	76	81	75	56
Wind Run (km per day)	102.01	89.41	86.01	52.49	42.46	55.32
Total Rain-fall (mm)	49.6	115.8	237.7	1 175.1 ;	156.6	31.6
1998						
Maximum Temperature °C	_)8	33	31	29	30	33
i Minimum Temperature C	6	25	21	20	21	1
Relative Humidity %	57.4	676	77	81	79	22
Wind Run km (per day)	1 12.25	77.12	68.24	1 42 .64 1	40.21	33.51
Total Rain-fall (mm)	107.0	147.7	303.6 1	418.7	258.9	9.3

Data collected or estimated included, crop growth rate, days to 50% flowering, grain protein, grain: straw ratio, grain weight per panicle, grain yield, number of ear-bearing tillers, percent crude protein, percent field grains, plant height, relative growth rate, and stalk, N.P.K. content.

Percentage of crude protein content was obtained by multiplying with the factors 6.25 (A.O.A.C., 1975). The data collected were subjected to statistical analysis of variance as described by Snedecor and Cochran *(1967)* and the difference among treatment means separated using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

Effect of placement method

The effect of fertilizer placement method and planting pattern in rice growth and yield during 1996-1998 rainy seasons is presented in Table 3.

Deep placement of N-fertilizer significantly increased plant height, crop growth rates, number of ear-bearing tiller, percent filled grains, grain yield per panicle, days to 50% and grain yield per hectare over surface application in 1996. The trend was similar in subsequent years of study, except that i

Effect of planting pattern

The triangular and hexagonal patterns of planting resulted in higher crop growth rate, number of ear bearing tillers and grain yield in the three years of experimentation than other patterns evaluated (Table 4). Rectangular pattern of planting resulted in shorter plants in 1996 and 1997, and lower grain weight per panicle in 1996 and 1998. The square and rectangular patterns of planting, significantly delayed flowering in 1996 compared to the triangular and hexagonal patterns.

DISCUSSION

The general crop performance on growth and yield parameter such as plant height, crop growth rate, flag leaf area, 1000-grain weight, and grain weight per panicle were better in 1997, followed by 1998 and 1996 in that order. These observations could be attributed to differences in agro-climatic conditions during the growth and development of the crop as manifested by the amount and distribution of rainfall and temperature ranges. Atmospheric temperature has considerable effect on growth and development of rice. Rice requires relatively high temperatures (2535°C) for optimum growth and development (ICAR, 1976). In 1997, the maximum temperatures during the growth period were higher (18.78-37.37°C) than those of 1998 season (20.33-36°C). Another reason could be the effect of wind velocity which averaged 59.86 and 42.52 km/day in 1997 and 1998 respectively. Generally, gentle wind during the crop growing period would increase turbulence within the canopy. Therefore the air blown around the plants could have replenished the carbon-dioxide supply to the plants (Matsubayashi *et al.*, 1967), and hence improved photosynthesis and ultimately assimilate formation. The yield contributing factors were also higher in 1997 compared to other years (1996 and 1998) of study, due to vigorous plant growth, prolific formation and development of photosynthetic apparatus. The higher yield components observed in 1997 may be as a result of better development of vegetative and photosynthetic apparatus and balanced development between vegetative and reproductive growth. DeDatta (1981) reported high day temperature and solar radiation coupled with low night temperatures beneficial to the information of heavier and numerous panicles, which ultimately resulted in I gher grain yield.

Effect of Nitrogen Placement Method

Deep placement of nitrogen in form of urea mud-balls, because of its slow release of nitrogen to the crop, significantly increased plant height, crop growth rate and improved tillering capacity of the rice plant over the surface placement of nitrogen. The superiority of deep placement of Nfertilizer in ,.omparison to surface placement in promoting rice growth and development and grain crude protein content could be directly related to the efficacy of the deeply placed nitrogen in providing steady released of nitrogen to rice plant for a longer period relatively to

. Table 3: Effect of nitrogen placement method on growth and yield of rice during the 1996, 1997 and 1998 rainy seasons at Kadawa, Nigeria

Treatments	(Plant height ht	Crp growth rate	Relative i growth ; I rate / plant/ day)	No. of Ear bearing tillers per m^2	G/S ratio (g)	Percent ~ filled grain	? Grain weight/ panicle	1000 grain weight	150% flowering	Grain yield~)	Grain protein	N		
1996														
Placement method (m)														
Surface	75.07b	74.16b	0.46	393.65b	0.43	73.97b	2.59b	24.81	91.22b	; 3.24b	7.96	1.33	0.26	1.73
Deep	77.77a	81.06a	0.49	440.73a	0.43	77.86a	2.83a	24.93	92.14a	4.01 a	8.27	1.37	0.26	1.81
SE±	0.62	1.06	0.01	5.94	0.01	0.98	0.07	0.12	0.40	0.07	0.20	0.04	0.00	0.07 '
1997														
Placement method (m)														
Surface	93.17b	. 80.94b	0.33	491.54b	0.43	73.20b	4.30b	27.74b	3.67b	7.83b	92.50b	1.26b	0.24b	1.57
Deep	99.16a	_ 105.37a	0.36	603.69a	0.45	79.84a	5.36a	28.09a	4.86a	8.86a	93.00a	1.40	0.26a	1.73
SE±	0.57	2.83	0.01	8.29	0.01	0.60	0.11	0.12	0.09	0.17	0.26	0.03	0.003	0.06
1998														
Placement method (m)														
Surface	81.95b	79.16b	0.49b	427.02b	0.40	69.365	3.66b	25.57b	90.79	3.49b	. 7.08b	1.17	0.26	1.71
Deep	87.78a	107.90a	0.55a	501.01a	0.42	95.87a	4.19a	26.98a	91.28	4.61 a	7.68a	1.23	0.27	1.83
L SE±	1.14	3.85	0.01	10.31	0.01	1.03	0.08	0.21	0.28	0.12	0.12	0.02	0.004	0.03

Means followed by different letters within the same column of any treatment group are significantly different ($p<0.05$)

Table 3: Effect of planting patterns on growth and yield of rice during the 1996, 1997 and 1998 rainy seasons at xaaawa, iv tgc' la

Table 3: Effect of planting patterns on growth and yield of rice during the 1996, 1997 ghd Iqy n seasons at Kadawa, Nigeria

Treatments	Plant height (cm)	Crop growth rate	Relative growth rate (g/plant day)	Ear bearing tillers per m2	G/S ratio (g)	Percent filled grain	Grain weight/ Panicle	1000 grain weight	50% flowering	Grain yield (tha-1)	Grain protein content	N	P	
11996														
Planting pattern (P)														
Square	73.81 a	; 63.80b	0.46	372.35b	0.43	77.50	Q.67a	24.30	92.83a	3.11b	8.46	1.37	0.26 a	1.72
Rectangular	70.89b	62.81b	v.4	~328.31 c	0.42	74.17	2.34b	24.00	91.50ab	3.02b		1.32	0.26	1.841
Triangular	72.88ab	i 80.29a	0.45	1485.40a	0.44	75.40	2.52a	24.39	90.83b	4.02a	8.15	1.39	0.26	1.75
Hexagonal	73.80a	80.00a	=0.45	485.51 a	0.44	76.59	2.68a	24.41	90.56b	4.06a		1.33	0.26	1.77
j SE±	0.76	€1.97	0.01		0.01	1.39	0.08	10.15 0.15	0.57	8.08	~ 7.87	0.05	0.01	0.10
11997														
Planting pattern (P)														
Square	97.57a	85.28b	0.33	487.38b	0.43	76.47	4.89	28.11	3.98b	8.42	91.62	1.35	0.25	1.60
Rectangular	93.68b	81.69b	0.32	420.44c	0.43	75.04	4.46	127.52	3.40c	8.76	91.81	1.32	0.25	1.70
Triangular	96.49a	100.76a	0.34	632.39a	0.44	76.15	4.78	27.71	4.53a	) 8.02	90.67	1.33	0.25	1.64
i Hexagonal	95.20ab	97.92a	10.34	618.20a	0.46	76.53	14.97		4.65a	7.72	89.19	1.28	0.25	1.62
SE±	0.81	4.00	0.02	1111.72	0.01	0.85	.27.57	0.20	0.12	0.24	0.37	0.04	0.01	0.08
:1998														
Planting pattern (P)														
Square	87.35	75.74b	0.51	426.23b	0.44	74.65	4.04a	26.58	90.91	3.75b	**7.34**	1.17	0.27	1.70'
Rectangular	82.51	73.77b	0.50	353.39c	0.34	70.39	3.64b	26.01	90.90	3.39b	7.50	1.17	0.25	1.81
Triangular	83.38	109.06a	0.52	532,63a	0.42	71.66	3.93ab	26.28	18938		**7.24**	1.18	0.27	1.79
Hexagonal	84.85	107.34a	0.53	522.67a	0.42	73.41	3.95ab	26.42	89.45	4.37a	7.16	1.17	0.26	1.80
SE±	1.62	5.45	0.01	14.58	0.01	1.46	0.11	0.31	0.51	0.71	10.17	0.03	0.01	10.07

Means followed by different letters within the same column of any treatment group are significantly different ($p<0.05$)

the surface placement. Most of the surface applied N-fertilizer might have volatilized. washed off or leached beyond the root zone of the growing rice plant. These nutrients therefore, become unavailable for the growth and development of the crop. This is in agreement with reports of Abinchandani and Patnik (1957) and Soliman and Mohammed (1995).

Effect of planting pattern

The superior performance of the hexagonal and triangular planting patterns, with respect to plant height, crop growth rate. number of ear-bearing tillers, and grain yield, could be due to the fact that in the hexagonal arrangement, the plants were equi-distant in all directions. This arrangement could have resulted in better utilization of space and even availability of nutrients, thereby increasing the plant population by about 16% per unit area (Lawal, 2001). The hexagonal arrangement resulted in 19.73 and 15.98% increase in yield when compared with the square and triangular patterns, respectively. This is attributable to the increase in number of

ear-bearing tillers per metre square. Similar explanation sufficed for the triangular arrangement, because the hexagonal is made up of six triangles. In both the triangular and hexagonal arrangement, light interception and exploitation of essential elements in the soils are more efficient. Kursheed and Bhaskram (1988) reported that planting rice in hexagonal or triangular pattern increased grain yield by 8-12% than the square pattern.

CONCLUSION

From the foregoing, the adoption of the hexagonal pattern of planting rice and deep placement of N-fertilizer has been shown to increase rice growth yield and yield attributes appreciably over other methods tested. The adoption of these practices will go a long way in increasing rice production tremendously.

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