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YIELD PERFORMANCE OF RICE UNDER LOW INPUT MANAGEMENT

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ABSTRACT

Seven rice lines were studied under low-input and high-input management conditions in Umudike in Abia and Uyo in Akwa-Ibom States of Nigeria using different rates of fertiliser. Results of the experiment showed that low-input management enhanced early maturity by reducing the number of days to 50% flowering while high-input management (100 % NPK 80 kg N/ha, 30 kg P_2O_5/ha and 30 kg K_2O/ha) prolonged the vegetation periods. There was no clear trend in the effect of management level on number of productive tillers, number of panicles per square meter and grain yield in both Umudike and Uyo. The increase recorded as a result of high input management where they exist is not high enough to give the farmer value for his labour and inputs. The performance of the rice lines under 50% fertilizer rate and one weeding at four weeks after germination has shown that rice and can do relatively well under low-input management conditions. Although there were no significant differences among the rice genotypes, the trend was higher yield with TOX 3154-17-1-3-2-2 in Umudike in both years and with TOX 3084-136-1-3-1-2 in Uyo in 2001.

Key: words Rice lines, fertilizer levels, highinput and low-input managements.

INTRODUCTION

Rice breeding has received a very great boost since the middle of the 1960s, as a result of the development of high yielding varieties which were introduced by the International Rice Research Institute (IRRI), Philippines (Rehm and Espig, 1991).

Rice is the most important food crop of about half of the world's human population. It is the leading cereal crop of south and east Asia, which are thickly populated regions of the world (Onwueme and Sinha, 1991). During the 1960s and 1970s, there was a constant increase in global rice production. For instance, from 1961 to 1965, rice was grown on 124 million hectares in the world with an annual production of 253 million tonnes, whereas in 1979, the figures rose to 145 million hectares and 380 million tonnes, which indicates an increase of 16% in hectarage and 50% in grain yield (Onwueme and Sinha, 1991). This increase in production was mainly due to the adoption of modern cultivars and improved cultural and management practices (Onwueme and Sinha, 1991). In 1989, rice was grown on 146 million hectares and the total grain yield was 506 million tonnes, a further increase in production of 33% (Onwueme and Sinha, 1991).

Whereas the Asian, European and Latin American countries have increased rice production during this period known as the green revolution era, the increased prominence of rice as a staple food in the west African sub-region as a result of urbanization has led to increased importation of the commodity. This phenomenon has been even more spectacular in the case of Nigeria. (Lawson and Alluri, 1986. Imports in this case increased from 342,000 t in 1976-78 to more than 600,000 t in 1982 (Zan *et al*, 1984). However, African scientists have not been idle all these years. They worked in collaboration with the International Research Institutes in the zones to develop modern high yielding rice varieties. But these high-yielding varieties can only realize their full yield potentials under high-input and good management conditions and have therefore not contributed meaningfully to increased rice production. This is because the majority of the rice farmers in most developing countries are resource-poor, who can not afford the high costs of inputs coupled with their unavailability in required quantities and at the appropriate times. In Cuba, for example, most farmers cannot afford expensive inputs such as seeds, machinery and agrochemicals, therefore, introduction of new high-yielding varieties that require inputs in order to perform well is not always very useful (Humberto, 2002). This has led to research on low-input management.

Since the onset of this new direction of research in the late 1980s and early 1990s the concept of low-input management condition has not been clearly defined and the protocol for low-input management in the rainforest agroecological zone of south eastern Nigeria has not been developed. It is important to determine the minimum dose of fertilizer required to achieve profitable yield based on soil type and climate without depleting the soils' nutrient status. In 1995, work commenced on the selection of low-input rice breeding lines from 36 high-yielding rice lines composed by the West Africa Rice Development Association (WARDA) and by 1999-2000, seven (7) relatively high yielding low-input lines were selected.

The main objective of this research effort is to develop some strategies for the cultivation of low-input rice varieties for southeastern Nigeria and in particular to find out the optimum fertilizer rate for low-input management of the rice crop.

MATERIALS AND METHODS

The experiment was carried out in two locations viz: Umudike in Abia State and Uyo in Akwa Ibom State both in the humid forest zone of south eastern Nigeria. In Umudike, the experiment was sited at the Michael Okpara University of Agriculture research farm, (05°29′ N, 07°33′ E, 122 m above sea level). In Uyo, the experiment was located at the National Cereals Research Institute (NCRI) research farm (05°30′ N, 07°05′ E, 100 m above sea level). The soil and climatic data of the experimental sites are presented in Tables 1 and 2, respectively.

Table 1: Agrometeorological data for Umudike and Uyo in 2000 and 2001

Month	Umudike Rainfall Amt (mm)	Umudike Rainfall No. of Days	Umudike Temperature (°C) Max	Umudike Temperature (°C) Min	Umudike RH (%)	Uyo Rainfall Amt (mm)	Uyo Rainfall No. of Days	Uyo Temperature (°C) Max	Uyo Temperature (°C) Min	Uyo RH (%)
2000										
Jan	14.8	2	32.0	23.0		44.3	3	33	23	80
Feb	0.9	1	34.8	26.6		48.9	1	34	22	68
Mar	13.6	5	34.7	23.3		94.4	6	33	23	73
Apr	164.5	13	33.1	23.5		134.5	13	32	23	81
May	153.6	14	31.7	23.5		248.3	13	32	23	79
Jun	265.5	20	30.7	22.8		200.3	13	31	23	86
July	265.2	21	29.7	23.3		158.1	18	29	23	87
Aug	216.9	16	29.7	23.5		134.0	10	26	23	83
Sept	277.5	23	30.3	23.8		310.7	25	28	23	88
Oct	228.4	19	30.7	23.5		172.6	15	29	23	84
Nov	75.9	3	32.6	24.5		97.6	6	31	23	83
Dec	3.8	2	32.4	21.2		19.9	2	33	21	74
Annual	1680.6	139				1663.6	125			
2001										
Jan	0.0	0	33.2	21.0		0.0	0	33	21	75
Feb	7.8	1	35.1	22.9		4.3	2	35	20	69
Mar	175.9	8	34.1	24.0		123.2	8	34	22	77
Apr	224.1	13	32.8	23.8		259.7	14	33	22	81
May	194.3	17	32.4	23.9		262.0	15	32	22	79
Jun	522.7	16	30.9	23.0		606.0	18	30	23	82
July	273.5	17	29.4	22.8		172.4	18	28	23	81
Aug	179.0	24	29.8	22.9		235.4	24	28	23	90
Sept	317.2	23	30.8	23.0		223.5	21	29	24	87
Oct	277.1	16	32.0	23.0		134.1	18	30	23	83
Nov	18.6	2	32.0	22.0		155.6	11	31	23	82
Dec	0.0	0	32.0	23.0		0.0	0	33	22	80
Annual	2190.2	137				2176.7	142			

Sources: Agrometeorological stations at National Root Crops Research Institute, Umudike, Nigeria and National Cereals Research Institute, Sub station , Uyo, Nigeria.

Table 2: Physico-chemical properties of the soils of the study sites at Umudike and Uyo

Soil properties	Umudike	Uyo
Sand (%)	75.2	79.2
Clay (%)	6.4	3.4
Silt (%)	18.4	17.4
Texture	Loamy sand	Loamy sand
pH (H_2O)	4.3	4.6
pH (KCl)	4.0	4.1
Available P ($\mu g\ g^{-1}$)	64.47	91.61
Total N (%)	0.14	0.19
Ogranic C (%)	0.68	0.92
Ca (meq 100^{-1} g soil)	0.67	0.57
Mg (meq 100^{-1} g soil)	0.33	0.38
K (meq 100^{-1} g soil)	0.08	0.08
Na (meq 100^{-1} g soil)	0.14	0.14
Exchageable Acidity (meq 100^{-1} g soil)	0.05	0.05
ECEC (meq 100^{-1} g soil)	1.27	1.22
Fe (ppm)	16.34	26.36
Mn (ppm)	18.89	20.19
Zn (ppm)	1.34	1.28
Cu (ppm)	0.97	0.54

Seven (7) rice lines were used in the study. These were laid out in a factorial arrangement with four NPK fertilizer rates in a randomized complete block design (RCBD) with three replications. The plot size was 4 x 3 m with a spacing of 20 cm x 20 cm. In both years, 4 6 rice seeds were direct seeded per hole.

The entries were tested under four fertilizer (NPK) levels that included 100% NPK, 50%, 25% of the recommended fertilizer rate and 0% or no fertilizer application. High input management was 100% of the recommended fertilizer rate for the zone which is 80 kg N, 30kg P_2O_5 and 30kg K_2O/ha for the zone (WARDA, 1995) and weedings at two weeks after sowing (WAS) and at 8 WAS, before second fertilizer application. The fertilizer was applied in two split applications (a basal application of 60kg N, 30kg P_2O_5 and 30kg K_2O/ha, two weeks after germination using compound fertilizer NPK: 20:10:10 and top dressing with urea at the rate of 20 kg N/ha at 9 WAS). Low-input management was the use of 0%, 25% or 50% of recommended fertilizer rate for the zone And only one hand weeding at four weeks after germination. No chemical for weed or disease and insect pest controls was used.

A sampling size of five plants per plot was taken at random for analysis of agronomic traits. Data collected included days to 50% flowering, total number of tillers at maturity, number of productive tiller, phenotypic acceptability, and grain yield (t/ha).

Phenotypic acceptability was accessed visually according to the Standard Evaluation System for rice (IRRI, 1988) using a scale of 1-9, where 1 = excellent and 9 = unacceptable. Statistical analysis was carried out using analysis of variance (ANOVA) (Gomez and Gomez, 1984). Mean separation was done by Duncan's New Multiple Range Test (DNMRT) at P = 0.05.

RESULTS AND DISCUSSION

Days to 50% flowering:

There was no significant (P > 0.05) effect of fertilizer application on days to 50% flowering at Umudike in both 2000 and 2001 cropping seasons (Table 3).

Table 3: Effects of fertilizer levels and rice lines on the number of days to 50% flowering in 2000 and 2001 cropping seasons at Umudike

Treatment	2001	2001
Fertilizer levels (%)		
0	103.33	102.70
25	104.00	103.40
50	102.14	101.40
100	104.76	104.30
Se	1.025	0.892
Rice lines		
TOX 3084-136-1-3-1-2	105.75bc	1.6.20b
SUAKOKO 8	116.00a	113.30a
IR 54	97.83ef	98.30c
TOX 3154-17-1-3-2-2	106.25cd	103.60b
BG 90-2	94.67f	96.30c
TOX 3118-47-1-1-2	107.42b	104.80b
ITA 324	100.00de	98.30c
Se	1.356	1.180

Means with different letters (s) are significantly different (P < 0.05) different according to Duncan's new multiple range test. Se = Standard error of a mean.

The days to 50% flowering ranged between102.14 and 104.8 days in 2000 and between 101.4 and 104.3 in 2001 for 50% and 100% fertilizer levels, respectively. Suakoko 8 was late in attaining 50% flowering in 2000 and 2001 while the earliest flowering dates were recorded for BG 90-2 and IR 54 in 2000 and BG 90-2, ITA 324 and IR 54 in 2001 at Umudike. At Uyo, the interaction effect of fertilizer levels and rice lines showed that the earliest flowering lines were TOX 3154-17-1-3-2-2 at 25 and 50% fertilizer levels as well as BG 90-2 at 25% and ITA 324 at 0% fertilizer application while Suakoko 8 flowered late at all the fertilizer application levels (Table 4).

Table 4: Interaction effect of fertilizer levels and rice lines on number of days to 50 % flowering at Uyo in 2000 cropping season

	Fertilizer levels (%)			
Rice lines	0	25	50	100
TOX 3084-136-1-3-1-2	82.67cd	83.00c	83.00c	83.00c
SUAKOKO 8	85.67b	87.00a	85.67b	87.33a
IR 54	82.00c-f	83.00c	82.00c-f	81.67def
TOX 3154-17-1-3-2-2	82.00c-f	81.33ef	81.33ef	82.67cd
BG 90-2	82.67cd	81.00fg	82.67cd	83.00c
TOX 3118-47-1-1-2	83.00c	82.67cd	83.00c	82.33cde
ITA 324	81.33ef	83.00c	80.33g	81.67def

The differences in behaviour of the rice lines in Umudike and Uyo can be explained by the differences in environmental conditions (Table 1). According to Ludler and Muchow (1993), the relative combination of the various components of the environment and the physiological changes of crop coupled with its phenological trend influence ultimate crop performance.

Number of panicles per square meter:

The highest number of panicles/m^2 was recorded for 100% fertilizer level at Uyo in both 2000 and 2001 (Table 5). In 2000, panicles/m^2 increased with increasing level of fertilizer Application whereas in 2001, there was no Significant difference (P>0.05) at 25 and 50% levels. There were no significant differences (P>0.05) between the rice lines in panicles/m^2 in both years. The number of panicles/m^2 ranged from 79.30 in TOX 311847-1-1-2 to 88.0 in ITA 324 in 2000 and from 127 in BG 90-2 to 218 in TOX 311847-1-1-2 in 2001.

Phenotypic acceptability:

Fertilizer application did not influence phenotypic acceptability at Umudike in 2000 and 2001 as well as in Uyo in 2000 (Table 5). At Umudike, phenotypic acceptability varied between 3.4 and 4.3 in 2000 and between 3.0 and 4.0 in 2001.

Table 5: Effects of fertilizer levels and rice lines on yield, yield components and phenotypic acceptability (PA) of rice at Umudike and Uyo in 2000 and 2001 cropping seasons

	2000					2001				
	Total no. of tillers at maturity	No. of prod. tillers per plant	No. of panicles per m^2	PA Phenotypic acceptability	Grain yield (t/ha)	Total no. of tillers at maturity	No. of prod. Tillers per plant	No. of panicles per m^2	PA Phenotypic acceptability	Grain yield (t/ha)
Umudike										
Fertilizer levels (%)										
0	5.71	4.67		4.0	0.810c	10.9b	8.5		4.0	0.595b
25	4.81	4.10		3.9	1.181b	9.2b	9.2		3.0	0.925b
50	6.52	5.24		3.5	1.719a	13.9a	9.8		4.0	1.460a
100	5.24	3.86		4.1	1.148bc	13.5a	10.7		4.0	0.921b
Se	0.514	0.415		0.45	0.149	0.86	0.93		0.20	0.1271
Rice lines										
TOX 3084-136-1-3-1-2	5.50	4.42		3.4b	1.400	12.2	9.2ab		3.0	0.993
SUAKOKO 8	5.08	3.83		4.3a	1.400	14.0	12.8a		3.0	0.653
IR 54	7.08	5.58		4.0ab	1.217	12.7	10.4ab		3.0	1.229
TOX 3154-17-1-3-2-2	4.83	4.42		3.6b	1.492	10.6	8.5b		3.0	1.021
BG 90-2	6.25	4.58		4.3a	0.933	8.9	6.7b		4.0	0.847
TOX 3118-47-1-1-2	4.75	4.00		3.5b	1.075	11.8	9.1ab		4.0	0.937
ITA 324	5.50	4.42		4.0ab	0.983	13.1	10.0ab		4.0	1.146
Se	0.680	0.548		0.60	0.198	1.13	1.23		0.27	0.168
Uyo										
Fertilizer levels (%)										
0	6.38c	5.05c	57.00d	4.99	0.386c	14.1	11.3b	121b	3.86b	1.091c
25	7.91bc	6.43bc	70.60c	4.99	0.560bc	13.5	11.7b	131b	3.57b	1.480bc
50	9.52b	7.10b	88.60b	4.81	0.830b	16.4	13.7a	147b	3.95ab	1.694bc
100	13.43a	10.52a	121.10a	4.33	1.63a	18.4	15.0a	207a	4.33a	1.968a
Se	0.576	0.508	4.187	0.048	0.108	0.67	0.68	16.77	0.16	0.1731
Rice lines										
TOX 3084-136-1-3-1-2	9.25	7.00	86.33	4.99	0.750	14.6	12.6	159	4.66a	1.778
SUAKOKO 8	10.33	7.75	83.33	4.33	0.570	14.2	11.8	147	2.50d	1.472
IR 54	10.83	8.33	80.80	4.49	0.770	14.9	12.5	142	4.00b	1.306
TOX 3154-17-1-3-2-2	8.00	6.08	86.70	4.33	1.070	15.3	11.6	134	4.33ab	1.701
BG 90-2	8.83	6.72	86.10	4.49	0.850	16.4	13.6	127	4.00b	1.493
TOX 3118-47-1-1-2	8.67	7.42	79.30	4.50	0.800	16.3	13.8	218	3.33c	1.674
ITA 324	9.25	7.42	88.00	4.49	1.150	17.6	14.8	136	4.67a	1.486
Se	0.762	0.672	5.539	0.040	0.143	0.89	0.90	22.19	0.209	0.2290

Within each column, for each season and for each location, means with different letter (S) are significantly different ($P < 0.05$) according to Duncan's new multiple range test. Se = Standard error of a mean.

This means that the plants were phenotypically more acceptable in 2001 than in 2000. The same trend was also observed in Uyo in 2000 and 2001, in which it ranged from 4.33 to 4.99 and from 2.50 to 4.67 respectively. However, phenotypic acceptability was significantly higher in Suakoko 8, BG 90-2, IR 54 and ITA 324 and least with TOX 3084-136-1-3-1-2, TOX 3154-17-1-3-2-2 and TOX 3118-47-1-1-2 in Umudike in 2000 whereas there was no effect in 2001. In Uyo in 2000, there was no difference in phenotypic acceptability between the rice lines but in 2001, it was highest for TOX 3084-136-1-3-1-2 and ITA 324 and least for Suakoko 8 and TOX 3118-47-1-1-2 (Table 5). The lower the phenotypic acceptability, the better the plant's visual expression.

Productive tillers and grain yield:

There was no significant difference in productive tillers and grain yield among the rice lines in 2000 and 2001in Umudike (Table 5). The productive tillers ranged from 3.83 (Suakoko 8) to 5.58 (IR 54) in 2000 and from 6.70 (BG 90-2) to 12.8 (Suakoko 8) in 2001 while the grain yield ranged from 0.93 t/ha (BG 90-2) to 1.49 t/ha (TOX 3154-17-1-3-2-2) in 2000 and from 0.85 t/ha (BG 90-2) to 1.23 t/ha (TOX 3154-17-1-3-2-2) in 2001. The highest grain yield was with 50% fertilizer level in 2000 and 2001 in Umudike, while the lowest yields were with 0 and 100% fertilizer application levels which were however not significantly different. It was observed that the top dressing with urea at the booting stage made the crops in the field very greenish but this did not translate into higher crop yield. This suggests that topdressing with urea should be carried out before the booting stage under Umudike conditions. Therefore, more precise timing of top dressing will be required

In Uyo, the number of productive tillers and grain yield were each not significantly ($P>0.05$) influenced by rice lines in 2000 and 2001, but 100% fertilizer level produced significantly ($P<0.05$) the highest grain yield, followed by 50% while the least grain yield was with 0 and 25% fertilizer levels (Table 5). The number of productive tillers ranged from 6.08 (TOX 3154-17-1-3-2-2) to 8.33 (IR 54) in 2000 while it varied from 11.60 (TOX 3154-17-1-3-2-2) to 14.80 (ITA 324) in 2001. The grain yield also varied from 0.57 t/ha (Suakoko 8) to 1.15 t/ha (ITA 324) in 2000 and from 1.31 t/ha (IR 54) to 1.78 t/ha (TOX 3154-17-1-3-2-2) in 2001.

The performance of the low-input rice genotypes in both locations can be explained by the soil characteristics and rainfall distribution patterns in the two locations.

The soil in Uyo had higher clay content which meant higher water retention capacity while the rainfall was more frequent but less torrential. On the other hand, the Umudike soil was more sandy with more torrential rainfalls which could easily wash off applied fertilizer. Therefore, for Umudike conditions, where top dressing can only increase the cost of production thereby adversely affecting the farmer's economic well being as well as the environment through pollution, low-input rice varieties would be very appropriate and the farmer would be sure of some yield with minimal inputs. According to Evans (1993), subsistence farmers are more particular about yield reliability and not so much of high yield that is unstable which would not guarantee his harvest security.

Although 0% fertilizer level was able to produce some yield in the same field for two consecutive cropping seasons, continuos cropping without fertilizer should not be recommended as this is capable of depleting and degrading the soil.

CONCLUSION

In Umudike in both years, the highest yield was obtained with 50% fertilizer level (low input), especially with TOX 3154-17-3-2-2 than with the recommended rate while at Uyo, the yield was highest with TOX 3084-136-1-3-1-2 at the recommended rate. This means that low input management was achievable for rice production, especially in Umudike.

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