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Effect of Nitrogen Fertilizer on the Growth and Yield of Two Different Varieties of Nerica in Mubi, Adamawa State, Nigeria

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Abstract

Field experiments were conducted during 2013 and 2014 cropping seasons at the Teaching and Research Farm of the Department of Agricultural Technology, Federal Polytechnic, Mubi. The studies were to find out which variety will be more suitable for production in Mubi and the higher yielding variety. The design used for the experiments in both seasons (2013 and 2014) was split-plot in a Randomized Complete Block Design (RCBD) in which varieties (NERICA-1 and NERICA-3) constitute the main plot while the four (4) levels of nitrogen (0, 30, 60 and 90 kg N/ha) as subplot in three replication. The following data were collected: plant height, number of tillers per plant, number of spikelets per plant, number of spikelets per spike, number of seeds per plant, weight of seeds per plant, 1000-grain weight and grain yield in kg/ha. Data collected were subjected to analysis of variance (ANOVA) using Dungan's Multiple Range Test (DMRT) at 5% level of significant. The results showed that NERICA-1 was superior over NERICA-3 in almost all the growth parameters and the yield parameters. The results also showed that the treatments are highly significant. The effect of Nitrogen was obvious as can be seen from the treatments. Poor performance was recorded at the control (0 kg N/ha) levels of the two varieties. However, at 60 kg N/ha and 90 kg N/ha the two varieties performed very well respectively according to the amount of Nitrogen applied. The result indicated that NERICA-1 and NERICA-2 can be successfully and commercially produced in Mubi. Both varieties performed fairly good, however, NERICA-1 performed better in the total yield.

Keywords: *NERICA, Nitrogen, Varieties, Growth, Yield*

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Background to the Study
New Rice for Africa (NERICA) is an interspecific culture of rice developed by West Africa Rice Development Association (WARDA) to improve the yield of African varieties (Dingkuhn, Jones, Johnson and Sow, 1998). Nigeria being the most populous country in Africa with over 150 million people (Census, 2006), struggle for food is expected to have increased with the increase in its inhabitants, and the demand for rice has since being rising steadily at about 14% annually (Erenstein, Lancon, Osimane and Kebbeb, 2003). Although 240 million people in West Africa rely on rice as the primary source of food (Sarla and Mallikarjuna, 2005) energy and protein in their diet, the majority of this rice is imported at a cost of $1 billion (Watanabe, Futakuchi and Jones, 2006). Therefore self-sufficiency in domestic rice production would improve food security and aid economic development in the region (Kijima, Serun, Kuuma and Otsuka, 2006).

NERICA rice has high yield potential and short growth cycle, several of them possess early vigour during the vegetative growth phase and this is potentially useful trait for weed competitiveness (Johnson D. E., Dingkuhn M., Jones M. P and Mahamane M. C. 1998).

Likewise a number of them are resistant to Africa pests and diseases such as rice borers, termites and the devastating blast. They also have higher protein content and amino acid balance than most of the imported rice varieties (Erenstein, Lancon, Osimane and Kebbeb, 2003). It has a high yielding potential compared to the conventional ones being developed by International Institute for Tropical Agriculture (IITA).

Many subsistence farmers who grow upland rice do not generally apply fertilizer even though most upland rice areas are defiant in Nitrogen. The response of upland rice to Nitrogen fertilizer has been found to be variable depending on the cultivar grown and the prevailing soil and climatic conditions.

Jashin, Ahmed and Ahmed (2004), found that applying 60 kgN/ha to an upland cultivar BR9 produced the highest Paddy yield in the Philippines farmers have been reported to apply 60 kg N/ha to traditional upland and to get about 3 t/ha of Paddy (Dedatta and Ross, 2005).

Average grown yields of upland rice are generally less than 2000 kg/ha in most of the upland rice producing regions due to many environmental stresses and use of low inputs by farmers (IRRI, 1999). The annual rice production in Nigeria is about 4 million metric tons (FAO, 2008). Despite the fact that there have been a tremendous effort towards rice production by the farmers in Nigeria in general and Mubi in particular, the expected targeted yield is yet to be achieved, because of lack of inputs such as fertilizers, improved varieties etc. There is a need therefore for serious concern on how the farmers will produce higher yield of rice especially the improved varieties such as NERICA.

Materials and Methods
Field experiments were conducted during 2013 and 2014 cropping seasons at the Teaching and Research Farm of the Department of Agricultural Technology, Federal Polytechnic, Mubi to determine the effect of nitrogen on the growth and yield of two varieties of NERICA rice in Mubi, Adamawa State. The land used in each year were cleared of all plant debris, gathered and burnt after which the land was ploughed and harrowed to obtain fine tilt, therefore marked into plots.

The design used for the experiment in both seasons (2013 and 2014) was split-plot in a Randomized Complete Block Design (RCBD) in which varieties (NERICA-1 and NERICA-3) constitute the main plot while the four (4) levels of nitrogen (0, 30, 60 and 90 kg N/ha) as subplot in three replication. Each subplot size was measured 4 m by 3 m ($12m^2$). Each main and subplot as well as replication was separated by 1 m wide pathway. Basal application of cowdung was applied to each main plot two weeks before sowing of seed. The nitrogen treatments were applied in two forms of nitrogenous fertilizer viz: 0, 15, 30 and 45 kg N/ha NPK 15:15:15 top dressing thereafter, 0, 15, 30 and 45 kgN/ha of Urea was applied at anthesis to obtain 0, 30, 60 and 90 kgN/ha nitrogen treatments.

Data collected include the plant height, number of tillers per plant, number of spikelets per plant, number of spikelets per spike, number of seeds per plant, weight of seeds per plant, 1000-grain weight, total grain yield in kg/ha. Data collected were subjected to analysis of variance as described by Gomez and Gomez (1984). Means were separated using Dungan's Multiple Range Test (DMRT) at 5% level of significant (Duncan, 1955).

Result and Discussion

Table 1 shows the effect of variety and nitrogen application on plant height of NERICA rice. At harvest, the two varieties differed significantly (P = 0.01) on plant height. NERICA-3 was observed to be consistently taller than NERICA-1 in the two years to of study as well as combined analysis. Plant height may be an inherent genetic character observed between the two varieties. Similar results on the genetic differences among crops producing characters like plant height were observed as advanced earlier in NERICA (Semagn, Ndjiondjop and Cissoko, 2006).

With the application of nitrogen in 2013, all the parameters taken did not show any significant different on plant height. However, in 2014 the tallest plants were obtained from application of nitrogen at the rate of 90 kg N/ha (135.74 cm). It was followed by application at 60 kg N/ha (80.78 cm) which was not significantly different from application at 30 kg N/ha (75.55 cm) while the shortest plants were recorded from 0 kg N/ha (67.15 cm). This is an indication that these tall plants had the potential for better positioning of leaves for radiation capture by reducing the shading effect of lower leaves by higher leaves, thus allowing radiation capture throughout the canopy.

Table 2 shows the effects of variety and nitrogen application on the number of tillers per plant of rice. There were significant (P = 0.01) difference on the varieties. The highest number of tillers per plant was observed from NERICA-1 rice in both seasons (2013 and 2014) (9.36) while the least (8.95) were recorded from NERICA-3.

Application of nitrogen at the rate of 90 kg N/ha produced the highest number of tillers per plant in both seasons (10.57), it was followed by application at 60 kg N/ha (9.94) while the least were obtained from 0 kg N/ha (6.82). The result is in line with Murata and Matsushima (2008) who reported that both the emergences and development of tillers primordial were greatly influenced by the nitrogen content of the plant and the number of total tillers was found to be strongly correlated (r = 0.96) with the nitrogen content of the plant.

Table 3 shows the effects of variety and nitrogen application on number of spike per plant of NERICA rice in 2013 and 2014 cropping seasons in Mubi.

In 2013, there was no significant different between the two varieties studies. However, in 2014, NERICA-1 was observed to produce significantly higher number of spikes per plant (148.75) while NERICA-3 produced lowest number of spikes per plant (128.29). The difference observed between the two varieties could be due to heredity traits inherent within the two varieties used. Another reason could be the environmental factors which affected the crop prior to the joining stage which is considered as critical stage in rice production (Spencer, Dorward, Abalu, Philip and Ogungbile, 2016).

The highest number of spike per plant (186.53) was obtained from the application of nitrogen at the rate of 90 kg N/ha in both seasons and combined which was not significantly different from application at the rate of 60 kg N/ha (171.13). It was followed by application at 30 kg N/ha (131.86) which was not significantly different from 0 kg N/ha (102.63 kg N/ha) (Table 3). Branching in crops has been reported (Reddy, 2004) to be enhanced by favorable growth conditions such as warm soil temperature and adequate soil moisture which are obtained in most cases at the early parts of the season when rains are fully established. The production of more spikes from 90 kg N/ha in this study could therefore be attributed to efficient application of nitrogen. Haefele and Wopereis (2005) also reported that efficient utilization of nitrogen fertilizer by rice crop is determined among the other factors by the nature of the soil, variety, season, intensity of cultivation and fertilizer attributes and modifications.

The effects of variety and nitrogen on number of spikelets per spike are presented in Table 4. NERICA-1 produced significantly (P = 0.01) higher number of spikelets (16.76). NERICA-3 (14.92) in both seasons and in the combined. The effect of nitrogen however shows that application at the rate of 30, 60 and 90 kg N/ha consistently had a number of spikelets per spike with each producing 16.76 spikelets, as against the lower number of spikelets recorded at 0 kg N/ha (12.71).

Application of nitrogen had significant (P= 0.01) effect on number of spikelet per spike in both season as well as in combined. There were significant effects where the application of nitrogen at the rate of 90 kg N/ha (17.29) resulted in higher number of spikelets per spike, it was followed by 60 kg N/ha (16.82) while the least number of spike was recorded from 0 kg N/ha (12.71). Production of higher number of spikelets from 90 kg N/ha was not uncommon since 0 kg N/ha had fewer or lower number of tillers per plant. The fewer the tillers in rice, the more spikelets are produced (CIIFAD, 2009). The same trend was observed in WITA-4 and FARO 44 where it was observed that when more tillers are produced the crop tend to make a compensation on the number of spikelets per spike because potentially, a high tillering rice plant tend to "feed" more than the low tillering one (Wantanabe, Futakuchi, Jones and Sobambo, 2006).

Table 5, shows the effects of variety and nitrogen on number of seeds per spike of NERICA rice grown during the rainy seasons of 2013 and 2014 in Mubi. A significant variation (P = 0.01) was observed between the two varieties on the number of seeds per spike. NERICA-1 produced higher number of seeds (187.24) than NERICA-3. The number of seeds per spike may likely depend on the number of tillers produced per stand and decreases with increase of tillers. This result corroborates with the report of WARDA (2008) that most upland varieties were equally bred for improved yield by utilizing the little amount of inputs like moisture and fertility than the land rice varieties.

Application of nitrogen was highly significant (P = 0.01) on number of seeds per plant (Table 5). The highest number of seeds per plant (187.65) was obtained from the application of nitrogen at 90 kg N/ha in both seasons and combined which was not significantly different from 60 kg N/ha (183.71), which was followed by 30 kg N/ha (162.15) while the least was obtained from 0 kg N/ha (127.00). This can be explained that the higher the rate of application of nitrogen, the higher the number of seeds produced. This is in line with report of Katyl, Bijay, Sharma and Craswel (2005) that application nitrogen at 120 kg N/ha and 90 kg N/ha minimized production in yield from the excessive rice cropping.

Table 6 shows the effect of variety and nitrogen on seed weight of NERICA rice grown during the rainy seasons of 2013 and 2014 in Mubi. There was no significant effect between the two varieties and nitrogen in 2014 cropping seasons. However in 2013, NERICA-1 significantly (P = 0.01) produced higher seed weight than NERICA-3 throughout the study period and combined. Seeds from NERICA-1 were significantly heavier than those from NERICA-3. This was not unexpected since the number of seeds per spike and the numbers of spikelets per spike were higher in NERICA-1 than NERICA-3.

Weight of seeds per plant was significantly influenced by application of nitrogen in both seasons as well as in combined. In 2013, the highest weight of seeds 52.46 g was obtained from the application at the rate of 60 kg N/ha which was not significantly different from 90 kg N/ha and 30 kg N/ha (51.96 g and 50.29 g respectively) while the least was obtained from 0 kg N/ha (46.83 g). In 2014, the highest weight of seeds were obtained from application at 60 kg N/ha (53.71 g) which was not significantly different from 90 kg N/ha (51.37 g) while the least weight of seeds were recorded from 0 kg N/ha (46.87 g) (Table 6). Seed weight was found to increase with increasing nitrogen content in the plant during the ripening stage (Matsuo, 2005). Murata and Matsushima (2000) also reported that top dressing nitrogen at the reduction division stage of the rice plant enlarge hull size, thus increasing the weight of potential caryopsis.

Table 7 shows the effects of variety and nitrogen on 1000-grain weight during the rainy seasons of 2013 and 2014 in Mubi. The two varieties were observed to vary significantly (P = 0.01) on 1000-grain weight in the two years under the study.

NERICA-1 was observed to produce higher grain weight (4.66 g) than NERICA-3 (4.32 g) throughout the study period. This could be due to the former having more translocation of assimilates to the sink. On the other hand, NERICA-1 may have expanded a lot of its photosynthesis to its large vegetative structure which might have competed highly as sink with the reproductive organ.

Application of nitrogen and significant effect (P = 0.01) on 1000-grain weight (Table 7). The highest 1000-grain weight (5.09 g) was obtained from application at the rate of 60 kg N/ha (5.09 g) which was not significantly different from application at 90 kg N/ha (5.08 g), it was followed by 30 kg N/ha (4.26 g) while the least was recorded from 0 kg N/ha (3.88 g). Application at the rate of 60 kg N/ha was observed to produce higher grain weight than at control (0 kg N/ha) throughout the study period. The low weight with the control (0 kg N/ha) could be as a result of the moisture stress at the end of the season which resulted in the seeds not filling fully (WARDA 2008).

Table 8 shows the effects of variety and nitrogen on grain yield in kg/ha. NERICA-1 was observed to produced higher grain yield (2987.15 kg/ha) in both seasons and combined. The performance of NERICA-1 in gain production may be due to its ability to produce more photosynthesis which were utilized in the production of grains than the other variety during the anthesis and grain filling stages. The present report also lends support from the work of Garba (2006) who reported similar trend during and grain filling in groundnut.

Application of nitrogen were highly significant (P = 0.01) on total grain yield in kg/ha (Table 6). The highest grain yield in kg/ha (3363.62 kg/ha) was obtained from the application of nitrogen at the rate of 60 kg N/ha which was not significantly different from the application at the rate of 90 kg N/ha (3256.75 kg/ha) while the lowest was obtained from 0 kg N/ha (1968.57 kg/ha). Dedatta and Ross (2005) found that applying 60 kg N/ha to an upland cultivar BR9 produced the highest paddy yield.

Conclusion

From the results obtained, it can be concluded that the two varieties of NERICA- used can be suitable and effectively produced in Mubi. However NERICA-1 showed its superiority over NERICA-3 in yield.

Recommendations

The following recommendations could be made, based on the findings of the study:

1. The ideal variety of NERICA in terms of high yielding in NERICA-1.
2. The results should be disseminated to farmers through the Agricultural Authorities to encourage them adopt NERICA production in Mubi to make it available.
3. Further research should be conducted on other varieties of NERICA with the same treatments in other environments.

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Table 1: Effect of Variety and Nitrogen on Plant Height of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	**Plant Height (cm)**		
	2013	**2014**	**Combined**
VARIETY			
NERICA1	89.08[b]	91.57[b]	90.33[b]
NERICA3	91.17[a]	94.46[a]	92.82[a]
Prob of F	0.001	0.001	0.001
Nitrogen (kg N/ha)			
0	64.33[a]	69.96[c]	67.15[c]
30	70.67[a]	80.42[b]	75.55[b]
60	74.72[a]	86.83[b]	80.78[b]
90	148.18[a]	123.29[a]	135.74[a]
Prob of F	0.324	0.05	0.001
Interaction	NS	*	*

Table 2: Effect of Variety and Nitrogen on Number of Tillers of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	Number of Tillers		
	2013	2014	Combined
VARIETY			
NERICA-1	8.88[b]	9.02[b]	8.95[b]
NERICA-3	9.17[a]	9.54[a]	9.36[a]
Prob of F	0.001	0.001	0.001
Nitrogen (kg N/ha)			
0	6.25[c]	7.38[c]	6.82[c]
30	8.92[b]	8.63[b]	8.78[b]
60	10.42[a]	9.46[b]	9.94[b]
90	10.50[a]	10.63[a]	10.57[a]
Prob of F	0.001	0.001	0.001
Interaction	**	**	**

Table 3: Effect of Variety and Nitrogen on Number of Spikes Per Plant of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	Number of Spike Per Plant		
	2013	2014	Combined
VARIETY			
NERICA-1	149.88[a]	148.75[a]	149.32[a]
NERICA-3	139.79[a]	128.29[b]	133.54[b]
Prob of F	0.421	0.001	0.05
Nitrogen (kg N/ha)			
0	99.83[b]	105.42[c]	102.63[b]
30	137.29[b]	126.75[b]	131.86[b]
60	185.83[a]	156.42[b]	171.13[a]
90	184.30[a]	188.75[a]	186.53[a]
Prob of F	0.001	0.05	0.001
Interaction	NS	*	*

Table 4: Effect of Variety and Nitrogen on Number of Spikelets Per Spike of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	Number of Tillers		
	2013	2014	Combined
VARIETY			
NERICA-1	16.58[a]	16.94[a]	16.76[a]
NERICA-3	14.00[b]	15.84[b]	14.92[b]
Prob of F	0.001	0.001	0.001
Nitrogen (kg N/ha)			
0	11.67[b]	13.75[c]	12.71[c]
30	15.21[b]	14.17[b]	14.69[c]
60	17.67[a]	15.96[b]	16.82[a]
90	17.29[a]	17.29[a]	17.29[a]
Prob of F	0.001	0.001	0.001
Interaction	**	**	**

Table 5: Effect of Variety and Nitrogen on Number of Seeds Per Spike of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	Number of Seeds Per Spike		
	2013	2014	Combined
VARIETY			
NERICA1	187.92[a]	186.56[a]	187.24[a]
NERICA3	142.33[b]	172.27[b]	157.30[b]
Prob of F	0.001	0.001	0.001
Nitrogen (kg N/ha)			
0	112.33[c]	141.67[b]	127.00[c]
30	160.37[b]	163.92[b]	162.15[b]
60	194.71[a]	172.71[a]	183.71[a]
90	193.08[a]	182.21[a]	187.65[a]
Prob of F	0.001	0.001	0.001
Interaction	**	**	**

Table 6: Effect of Variety and Nitrogen on Weight of Seeds Per Plant of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	Weight of Seeds Per Plant (g)		
	2013	2014	Combined
VARIETY			
NERICA1	52.21[a]	50.94[a]	51.58[a]
NERICA3	48.56[b]	50.57[a]	49.57[b]
Prob of F	0.001	0.137	0.001
Nitrogen (kg N/ha)			
0	46.83[b]	46.87[b]	46.85[b]
30	50.29[a]	49.58[b]	49.94[b]
60	52.46[a]	53.71[a]	53.08[a]
90	51.96[a]	51.37[a]	51.67[a]
Prob of F	0.001	0.001	0.001
Interaction	*	NS	*

Table 7: Effect of Variety and Nitrogen on 1000-Grain Weight of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	1000-Grain Weight		
	2013	2014	Combined
VARIETY			
NERICA1	4.82[a]	4.49[a]	4.66[a]
NERICA3	4.33[b]	4.31[b]	4.32[b]
Prob of F	0.001	0.001	0.001
Nitrogen (kg N/ha)			
0	3.67[c]	4.08[b]	3.88[c]
30	4.17[b]	4.35[b]	4.26[b]
60	5.31[a]	4.85[b]	5.08[a]
90	5.16[a]	5.02[a]	5.09[a]
Prob of F	0.001	0.001	0.001
Interaction	**	**	**

Table 8: Effect of Variety and Nitrogen on Yield of NERICA Rice in 2013 and 2014 Cropping Seasons in Mubi

Treatment	Grain Yield in kg/ha		
	2013	2014	Combined
VARIETY			
NERICA1	3344.35^{a}	2629.95^{a}	2987.15^{a}
NERICA3	2164.92^{b}	2380.57^{b}	2272.75^{b}
Prob of F	0.001	0.051	0.001
Nitrogen (kg N/ha)			
0	1485.76^{c}	2451.38^{b}	1968.57^{b}
30	2248.12^{b}	2611.10^{b}	2429.61^{b}
60	3788.18^{a}	2939.05^{b}	3363.62^{a}
90	3496.49^{b}	3017.00^{a}	3256.75^{a}
Prob of F	0.001	0.001	0.001
Interaction	**	*	**