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Research Article

Response of rice varieties to nitrogen fertilization under irrigation at Talata Mafara, Sudan savanna

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Abstract

A field experiment was conducted during the dry seasons of 2012 and 2013 in Irrigation Research Station, Talata Mafara, Zamfara State, Latitude 12°34′00″ N and Longitude 6°04′00″ E 488m above sea level in the Sudan savanna agro-ecological zone. The objective of the research was to test the effect to various levels of nitrogen (N) fertilization on rice varieties under irrigation and to determine the rice variety suitable for cultivation. The experiment was laid out in a Complete Randomized Block Design (CRBD) using split plot arrangement and was replicated three times. Three rice varieties (Faro 44, 45 and 57) were allocated to the main plot and three nitrogen levels (60, 120 and 180 kg N ha^{-1}) were allocated to the sub plots. The gross and net plot sizes were 5 x 4 and 3 x 3 m respectively. Weeds were controlled using Glyphosate, Butachlor as pre-emergence and Orizo plus as post-emergence herbicides and supplemented with hand pulling at 9 weeks after sowing (WAS). Fertilizer was applied in two split doses. First half was applied at planting using NPK and the remaining half at 6 weeks after transplanting (WAT) using Urea (46 % N). Data collected were analyzed using analysis of variance (ANOVA) and significant means were separated using DMRT at 5 % level of probability. The results of effect of variety on growth parameters showed that Faro 44 recorded higher days to 50 % anthesis but was significantly ($p \leq 0.05$) shorter in height than Faro 57. The effect of the treatment on yield parameters showed that Faro 44 recorded higher thrashing percentage, 1000-grain weight and number of grain panicle^{-1} significantly ($p \leq 0.05$) higher than Faro 45 and 57 in all the seasons. Increasing nitrogen levels from 60 kg N ha^{-1} significantly increased growth and yield parameters. Application of 180 kg N ha^{-1} on Faro 44 is hereby recommended for rice growing in the ecological zone.

Keywords: Response, rice, nitrogen fertilization, irrigation and Sudan savanna

Introduction

Rice (*Oryza sativa* (L.) is an important food crop for more than half of the world population with Asia as the leading producer and Nigeria the largest producer in Africa (Umar *et al.,* 2013). The most important rice producing areas in Nigeria are Kano, Kebbi, Jigawa, Niger, Zamfara, Taraba, Benue, Plateau, Kogi and Nasarawa states (Ajijola *et al.,* 2012). Rice is the sixth major crop in area cultivated in Nigeria after sorghum, millet, cowpea, cassava and yam (Kamara *et al.,* 2011; Olaleye *et al.,* 2008; Vange and Obi, 2006). It came second in the world classification of crops accounting for 27 % of the world cereal production, compared to wheat with 30 % (Birhane, 2013). Rice is one of the oldest cultivated cereal crops (Hussain *et al.,* 2013). A staple food crop in Nigeria that is adapted to both flooded and non-flooded soil conditions in all the agro-ecological zones. Over 90 % of the world production was done under irrigation. Nowadays, increase in food production is the most challenge of the century especially in developing countries due to population explosion and urbanization and hence the demand for the crop is steadily increasing annually (Ajijola *et al.,* 2012). Its production rose from 2.4 million metric tons in 1994 to 3.1 million metric tons in 2002 (Kamara *et al.,* 2011). According to FAOSTAT (2012), Nigeria produced paddy amounting to 4.8 million metric tons valued at $ 1.309 billion, ranked 7th behind millet, vegetables, sorghum, maize, yam and cassava. Goronyo (2017) [The president Rice Farmers Association of Nigeria (RIFAN)] stated in Leadership Newspapers (15th May, 2017) that rice production in Nigeria has increased from 5.5 million tons in 2015 to 5.8 million tons in 2017. According to Umar *et al.* (2013), the potential land area for rice production in Nigeria is estimated to be between 4.6 and 4.9 million hectares that are shared among the upland, rain fed and irrigated lowlands, deep water and mangrove swamp ecologies.

With the exception of few countries that have attained self sufficiency, rice demand in Nigeria exceed its production and large quantities are imported to meet the demand at high costs. In 2008, the country expanded $300 million on the importation of the crop equivalent to 36 % of production (Ajijola *et al.,* 2012). The yield of the crop is still low and averages 1.0 t ha^{-1} or less (Singh *et al.,* 1997). Rice production dependent mainly on climatic factors, but the most detrimental is availability of soil moisture. However, production and productivity of the crop is also determined by soil fertility, planting methods and other biotic and abiotic factors which either directly or indirectly affected its growth and development. In order to achieve self-sufficiency in rice production, there is an urgent need to increase yield

Table 1: Effect of variety and Nitrogen levels on plant height and days to 50 % anthesis at Talata Mafara

Treatment	Plant height (cm)		Days to 50 % anthesis	
	2012	2013	2012	2013
Variety (V)				
Faro 57	123.9[a]	130.5[a]	114.4[b]	115.8[b]
Faro 45	112.6[b]	115.2[b]	114.8[b]	116.0[b]
Faro 44	100.3[c]	106.2[c]	119.6[a]	120.0[a]
SE ±	1.98	1.98	0.06	0.04
Nitrogen level (KgNh^{-1})				
60	90.8[c]	95.0[c]	100.0[c]	112.1[c]
120	110.2[b]	115.0[b]	117.9[b]	121.2[b]
180	135.8[a]	140.2[a]	130.7[a]	129.7[a]
SE ±	1.96	1.98	0.06	0.04
Interaction				
V x N	NS	NS	NS	NS

and agronomic practices which can only be achieved under irrigation. The positive response of rice varieties to nitrogen has been attributed to the role of nitrogen in cell division, enlargement, photosynthesis and meristematic synthesis. This study was carried out to determine the effects of nitrogen fertilization on yield and yield components of rice varieties and to determine the rice variety suitable for cultivation in the ecological zone/location.

Materials and methods

The experiment was carried out at Irrigation Research Station in Talata Mafara, Zamfara State on Latitude 12°34′00″N and Longitude 6°04′00″E, 488 m above sea level in the Sudan savanna agro-ecological zone. The experiment consists of three rice varieties, (Faro 44, 45 and 57) and three nitrogen (N) rates (60, 120 and 180 kg N ha^{-1}). The experiment was laid out in a Complete Randomized Block Design using split plot arrangement. Rice varieties were assigned to main plot while nitrogen levels were randomized in the sub-plot and were replicated four times. Rice varieties were broadcasted and irrigated the same day of transplanting. Weeds were controlled using Glyphosate (in order to control emerged weeds prior to land preparation), Butachlor as pre-emergence and Orizo plus as post-emergence herbicides and supplemented with hand pulling at 12 weeks after sowing (WAS). Gross and net plot sizes were 5 x 4 = 20 m^2 and 3 x 3 = 9 m^2, respectively. Fertilizer was applied in 2 split doses; first half at planting comprising half of nitrogen and all of P and K, while the remaining half of N was applied at 6 WAS using urea (46 % N). Data collected on growth (days to 50 % anthesis and plant height) and yield parameters (thrashing percentage, number of grains panicle^{-1}, 1000-grain weight and grain yield) were collected and analyzed using ANOVA. Yields were extrapolated in to kilogram hectare^{-1}. Significant means were separated using Duncan's Multiple Range Test (DMRT) at 5 % level of probability.

Results and Discussion

The results of the effect of variety and nitrogen levels on growth parameters showed that Faro 44 significantly recorded the highest number of days to attain 50 % anthesis (120 days). No significant difference ($p \geq 0.05$) was obtained between Faro 45 and 57 on days to 50 % anthesis. The effect of the variety on plant height showed that Faro 57 was significantly ($p \leq 0.05$) taller reaching up to 130.5 cm than the other two varieties in all the years. The variations in rice height and days to 50 % anthesis could be attributed due to differences in the genetic makeup of the varieties and their response ability to different levels of fertilizer applied. This finding is similar to that reported by Ndaeyo *et al.* (2008) that variations in rice height are attributed to the differences in the genetic makeup of the varieties and their differences in the utilization ability of the different rates of fertilizer applied. The effect of nitrogen levels significantly differed on rice growth parameters. The result showed that increasing N-levels from 60 Kg ha^{-1} significantly ($p \leq 0.05$) increased the days to 50 % anthesis and plant height respectively. This shows that N is an essential nutrient needed for tissue growth and development. These observations are in line with that of Dixit and Patro (1994) who reported increasing rate of NPK fertilizer favoured the vegetative growth in rice plants. It also agreed with the results obtained by Khalid *et al.* (2003) who studied the effect of different levels of NPK fertilizer on the yield and quality of rice CV.IR-6 reported different rates of NPK fertilizer significantly influenced rice plant heights. The results showed that the application of 90 Kg ha^{-1} significantly ($p \leq 0.05$) produced higher agronomic parameters, compared with the control. Furthermore, Ubi *et al.* (2016) reported increasing N rates above 60 kg ha^{-1} significantly increased rice plant height at Iwuru, Cross River State, in Southern Nigeria (Table 1).

The effect of variety and varying N-levels on yield parameters significantly differed. Ndon and Ndaeyo (2001) stated that the natural endowments of crop cultivars to optimally utilize available nutrients and subsequently partition its photosynthates for dry matter accumulation and/or conversion for economic yield vary Thrashing percentage, number of grains panicle^{-1}, 1000-grain weight and grain yield significantly ($p \leq 0.05$) differed among the rice varieties assessed. Except grain yield ha^{-1}, Faro 44 significantly recorded the highest Thrashing percentage and number of grains panicle^{-1} in all the years (Table 2 and 3). This difference in grain production may be due to its ability to produce more photosynthates which were utilized in the production of grains during anthesis and grain filling stages. The highest grain yield (156.2 and 140.0 Kg ha^{-1}) was obtained by Faro 45 which was significantly ($p \leq 0.05$) different with the other varieties in all the growing seasons. The result of the effect of varying N-levels on yield showed that increasing level of N from 60 Kg ha^{-1} increased yield and further increase to180 Kg ha^{-1} linearly and significantly ($p \leq 0.05$) increased the parameter assessed.

This finding is in agreement with Hag et al. (2002) and Manzoor et al. (2006) who reported increase in grain yield of rice as the rates of NPK were increased in Lahore, Pakistan.

Table 2: Effect of variety and nitrogen levels on thrashing percentage and number of grain panicle^{-1} at Talata Mafara

Treatment	Thrashing (%)		Number of grains panicle^{-1}	
	2012	2013	2012	2013
Variety (V)				
Faro 57	80.0^{c}	80.2^{c}	136.0^{c}	146.0^{c}
Faro 45	87.0^{b}	85.8^{b}	148.0^{b}	165.0^{b}
Faro 44	96.0^{a}	95.7^{a}	173.0^{a}	185.0^{a}
SE ±	0.09	0.09	1.06	1.16
Nitrogen level (KgNh^{-1})				
60	80.0^{c}	77.0^{c}	138.4^{c}	138.0^{c}
120	85.0^{b}	87.9^{b}	142.9^{b}	158.0^{b}
180	97.0^{a}	96.7^{a}	147.0^{a}	160.0^{a}
SE ±	0.09	0.09	1.06	1.16
Interaction				
V x N	NS	NS	NS	NS

Means followed by unlike letter(s) within the same column are significantly different at 5 % level of probability. NS = not significant

Table 3: Effect of variety and nitrogen levels on 1000-grain weight and grain yield at Talata Mafara

Treatment	1000-grain weight (g)		Grain yield (Kg ha^{-1})	
	2012	2013	2012	2013
Variety (V)				
Faro 57	23.2^{c}	22.2^{c}	150.8^{b}	126.6^{b}
Faro 45	23.7^{b}	22.7^{b}	156.2^{a}	140.0^{a}
Faro 44	24.0^{a}	23.6^{a}	143.0^{c}	117.7^{c}
SE ±	0.04	0.04	0.82	0.83
Nitrogen level (KgNh^{-1})				
60	22.1^{a}	21.2^{a}	131.0^{c}	122.8^{c}
120	23.0^{b}	22.3^{b}	154.0^{b}	126.0^{b}
180	24.2^{c}	23.3^{c}	166.2^{a}	134.6^{a}
SE ±	0.04	0.04	0.82	0.83
Interaction				
V x N	NS	NS	NS	NS

Means followed by unlike letter(s) within the same column are significantly different at 5 % level of probability. NS = not significant

The result of the 1000 -weight is in agreement with the result obtained by Fageria and Baligar (2001) who reported weight of 1000-grains increased significantly with increasing nitrogen rates in Brazil.

Conclusion

The results obtained from this study showed that Faro 45 significantly recorded the highest yield during 2012 and 2013 growing seasons respectively. Varying nitrogen levels from 60 Kg N ha^{-1} correspondingly increased growth and yield parameters with the highest at 180 kg N ha^{-1}. Faro 45 at N rate of 180 Kg N ha^{-1} is hereby recommended for rice cultivation in the ecological zone.

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