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Research Article

Effect of Variety, Seedling Transplanting Age and Nitrogen Fertilizer Rates on Growth Performance of Rice in Southern Guinea Savannah, Nigeria

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Abstract

At the National Cereals Research Institute Farms of Edozhigi and Badeggi, situated in the Southern Guinea Savannah of Nigeria, an agronomic field trial was carried out during the 2015 and 2016 planting seasons. The study evaluated how nitrogen fertilizer rates, seedling transplanting age, and variety affected rice growth. The treatments included five inorganic N fertilizer rates (0, 60, 120, 180, and 240 kg N/ha), two rice varieties (FARO 44 and FARO 52) and four seedling transplanting ages (7, 14, 21 and 28 days after planting). Split-split plot arrangement of the treatments was fitted into a Randomized Complete Block Design with three replications. Plant height and number of tillers were the growth parameters measured. When compared to rice planted at Edozhigi, rice grown at Badeggi had significantly ($p<0.05$) taller plants and more tillers. At 30 and 45 DAT throughout both planting seasons, the nitrogen fertilizer rates had a significant effect ($p<0.05$) on the number of tillers. Higher numbers of tillers were produced in 2015 and 2016 with applications of 120 kg N/ha and 180 kg N/ha, respectively. At 30 and 45 DAT during both planting seasons, seedling age had a significant ($p<0.05$) effect on plant height. The tallest plant measuring 61.95 cm was transplanted from seedlings that were 28 days old. During both planting seasons, nitrogen fertilizer rate significantly ($p<0.05$) affected rice plant height at 45 DAT. The tallest plant resulted from the application of 240 kg N/ha. The number of tillers and plant height were significantly influenced by variety. over both planting seasons, at 30 and 45 DAT. While the Faro 44 had more tillers, Faro 52 demonstrated taller plant height. For best rice growth in the Southern Guinea Savannah of Nigeria, 120–240 kg N/ha should be applied to seedlings of Faro 44 and Faro 52 that are 28 days old.

Keywords: *Location, Nitrogen fertilizer rate, planting season, Transplanting age and Variety*

Introduction

More than half of the world's population eats rice (*Oryza sativa* L.), one of the key staple foods (Islam *et al*., 2010). Nigeria's domestic rice output was anticipated to be 2.3 million metric tons in 2016, whereas the country's projected rice demand was 6.3 million metric tons. This led to a consumption deficit of nearly 4 million metric tons, which was covered by imports (F.M.A.R.D. 2016). Tiller productivity in rice is influenced by seedling transplanting age (Aslam *et al*., 2015; Faghani, 2011). It is the primary element that promotes the construction of homogeneous rice stands (Ginigaddara and Ranamukhaarachchi, 2011). The ideal seedling age and timely transplanting influence healthy growth and improve the rice plant's capacity for tillering (Mobasser *et al*., (2007). Since older seedlings have less time available for tiller growth, using early seedlings for transplanting can boost the development potential of tillers (Muyassir, 2012). Although rice growth was increased when 14-day-old seedlings were transplanted, there was no discernible difference when seedlings were 7 days old (Anggraini *et al*.

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2013). Application of nitrogen fertilizer promotes rice development; hence, it is crucial to use nitrogen fertilizers optimally for rice crop growth in order to minimize any adverse effects on the environment (Khakwani *et al*., 2016). According to Kaushal *et al.* (2010), increasing the N fertilizer rate can increase the number of productive tillers. When less N fertilizer is used, rice plant growth is severely hampered (Khatab *et al*., 2013). A higher rate of N fertilizer application, however, promotes rice plant lodging, lengthens the vegetative development cycle, and delays maturity (Uddin, 2003). Lack of nitrogen causes stunted leaf growth in rice, which shortens the growth cycle and causes early flowering as a result of insufficient assimilate formation (Larimi *et al*., 2014). Therefore, controlling N nutrition is a key tactic in regulating rice development and the effectiveness of photosynthesis (Long *et al*., 2013).

One of the most crucial elements to take into account for better rice growth is variety. The differences in underlying genetic features are directly related to the growth characteristics of various cultivars. Due to morphological characteristics including many roots and tillering potentials, some rice cultivars have excellent nutrient utilization efficiency (Shemahonge, 2013). Rice development parameters were considerably influenced by variety, according to studies by Tyeb *et al*. (2013) and Islam *et al*. (2012). Ashrafuzzaman *et al*. (2009) showed variance in morphological components in different varieties of rice. Varieties have varied physiological and morphological qualities that contribute to growth.

Additionally, according to Ranjan *et al*. (2015), different rice cultivars require various N fertilizer rates and optimal seedling transplanting ages. However, it has previously been claimed that farmers transplant older rice seedlings (Hossain *et al*., 1983). Transplanted rice needs extra time to recover from transplant shock. When rice seedlings are transplanted at the appropriate age, tillering and growth progress normally, but if transplanting is postponed, fewer tillers are formed during the vegetative stage, which results in poor growth (Mobaser 2007). According to reports, younger seedlings were much less likely to grow after being transplanted due to transplant shock, whereas older seedlings performed better after being transplanted (Kewat *et al*., 2002).

The rice genotype has a significant impact on how well resources are used for growth. Genotypes' growth characteristics are influenced by environmental and genetic variables. According to Alam *et al*. (2008), varietal selection at any location is significant among growth factors. To maximize the benefits of new genetic material, proper agronomic practices depend on the growth traits of distinct kinds. Therefore, the objective of this study was to ascertain how nitrogen fertilizer rates, seedling transplanting age, and variety affected rice development.

Materials and methods

A 2-year agronomic field experiment was planted at two locations Edozhigi (9^o 05^1 N; 5^o 57^1 E) and Badeggi (9^o 45^1 N; 6^o 07^1 E) under lowland ecology at the National Cereals Research Institute (NCRI) Farms during 2015 and 2016 planting seasons. Annual rainfall at the sites ranges between 1,200 – 1,400 mm and mean temperature of between 23^oC – 33^oC. Two Nursery beds (2 x 2 m^2) were prepared by manually raising and levelling the soil with hoe at weekly intervals for four weeks at the two sites near the main field. Healthy seeds of the two FARO rice varieties were obtained from (NCRI) Badeggi. The seeds were soaked in water for 24 hours with excess drained using a muslin cloth prior to planting. The moist seeds were then sown by broadcast method in the prepared seedbeds. The sowing was done at weekly intervals for four weeks to cater for the different seedling transplanting ages. The nursery bed was managed until the seedlings were transplanted.

The experimental design at each site was laid out in a split–split plot arrangement fitted into Randomized Complete Block Design (RCBD) and replicated three times. Treatments consisted of two rice varieties (FARO 44 and FARO 52), four seedling transplanting ages (7, 14, 21 and 28 days after sowing, DAS) and five inorganic N fertilizer rates (0, 60, 120, 180 and 240 kg N/ha.

Prior to field layout, the experimental plot was ploughed and harrowed, followed by the preparation of bounds and sub-sub plots were well levelled using spade before transplanting.

Single super phosphate (SSP) and murate of potash (MOP), respectively, were applied as a base application of inorganic P and K fertilizers at a rate of 40 kg/ha. Half of the various inorganic nitrogen fertilizer (urea) rates were applied along with the P (single super phosphate SSP) and K (murate of potash) prior to transplanting and manually worked into the soil using a hoe, while the other half was broadcast at panicle initiation to the experimental plots based on each treatment. Before planting, the flooded field was drained. Two seedlings were transplanted per hole and the field was flooded after transplanting. Regular weeding was undertaken in the experimental plot using hoe. At 30 and 45 days after transplanting (DAT), growth data were measured. Each plot's two middle rows of five randomly chosen and marked hills were used to count the tillers on each plant. Using a measuring tape, the height of the plants was measured from the ground to the tip of the leaf or panicle on the main stem.

Growth data collected were subjected to analysis of variance (ANOVA) using GenSTAT and the difference between treatments mean tested using least significant difference (LSD) at 5% probability level.

Results and discussion

The effect of treatment factors on plant height: As shown in Table 1, location had a significant impact ($p<0.001$) on rice plant height at 30 and 45 DAT during the 2015 planting season. When compared to rice planted in Edozhigi at 30 and 45 DAT, Badeggi's plants were substantially taller, measuring 41.34 cm and 48.39 cm, respectively. Location had a significant impact ($p<0.001$) on rice plant height at 30 and 45 DAT during the 2016 planting season. Compared to rice planted at Badeggi at 30 DAT, rice planted in Edozhigi had a plant height that was much higher at 34.44 cm. Compared to rice planted in Edozhigi, at 45 DAT rice grown at Badeggi had a plant height that was much higher at 70.78 cm.

The higher plant height seen at Badeggi during both planting seasons may be ascribed to the soil's availability and nutritional content as well as the surrounding environment. There has been evidence of a sizable height disparity between places. According to Mohammad *et al.* (2002), plant height is influenced by its surroundings. During the 2015 planting season, the nitrogen fertilizer rates had no significant effect ($p>0.05$) on the height of the rice plants at 30 and 45 DAT. During the 2016 planting season, the nitrogen fertilizer rates had a significant impact ($p<0.05$) on the height of the rice plants at 30 and 45 DAT. The tallest plants during the 2016 planting season were rice with 240 kg N/ha fertilization, measuring 32.97 cm and 58.11 cm at 30 and 45 DAT, respectively. The presence of N, an essential component of cell components such as chlorophyll, nucleic acids, amino acids, ATP, and various plant hormones, may explain why the tallest plants were found at 240 kg N/ha (Mengel and Kirkby, 2001; Sara *et al*., 2013). Nitrogen encourages increased leaf area and enhances photosynthesis, which results in greater accumulation of dry matter. The results of Kandil *et al*. (2010), Ethan *et al*. (2011), and Memory *et al*. (2013), who all reported an increase in plant height with an increase in N rates, are consistent with the result of this study.

During the planting seasons of 2015 and 2016, the age of the seedlings at transplanting had a highly significant impact ($p<0.001$) on the height of the rice plant at 30 and 45 DAT. Rice seedlings transplanted at 28 days after planting in the 2015 growing season developed significantly taller plants at 30 and 45 days after transplanting (DAT), measuring 43.51cm and 51.36 cm, respectively. The tallest plants measured 35.79 cm and 61.95 cm at 30 and 45 DAT, respectively, in the 2016 planting season when rice seedlings were transplanted at 28 after planting. According to Ali *et al*. (2013), in the boro rice cultivar BBRI Dhan 28, transplanted seedlings that were 30 days old had taller plants (98.3 cm) than those that were 15 days old (90.4 cm).

During the planting seasons of 2015 and 2016, variety had a significant impact ($p<0.05$) on plant height at 30 and 45 DAT. Faro 44 had a plant height of 40.14 cm at 30 DAT during the 2015 planting season, whereas Faro 52 had a plant height of 47.53 cm at 45 DAT. Faro 52 had noticeably taller plants during the 2016 planting season, measuring 34.70 cm and 64.61 cm at 30 and 45 DAT, respectively. The genetic make-up of the cultivars and their variations in nutrient uptake could be the cause of the increased plant height seen for FARO 52. Significant height difference has been reported between rice varieties (Garbe *et al*., 2013; Buri *et al*., 2015). Genetic differences between different varieties also caused variation in plant height. Mohammad *et al*. (2002) reported that plant height depends on genetic makeup of a plant and environmental conditions.

The effect of treatment factors on rice number of tillers: As revealed in Table 2, location had a significant effect (p<0.001) on the quantity of rice tillers per stand at 30 and 45 DAT during the 2015 planting season. Rice sown in Edozhigi during the 2015 planting season had significantly more tillers per stand, with 14.97 and 17.64 at 30 and 45 DAT, respectively. Rice grown in Edozhigi during the 2016 planting season had significantly more tillers per stand, with 17.15 and 17.88 at 30 and 45 DAT, respectively. The larger number of tillers seen at Edozhigi at 30 and 45 DAT throughout both planting seasons may be related to environmental and genetic factors as well as the intrinsic fertility of the soil. Tiller formation is a genetically inherited feature that is stable. The interaction of genetic traits and environmental factors, however, controls tiller production. This is in line with the findings of Mc Steen and Leyser (2005), who claimed that the environment had an effect on tiller production and, consequently, tiller quantity.

At 30 and 45 DAT during the planting seasons of 2015 and 2016, nitrogen fertilizer rates had a significant impact (p<0.05) on the number of tillers per stand of rice. However, during the 2015 planting season, rice fertilized with 120 kg N/ha had the most tillers, with 14.55 and 17.95 at 30 and 45 DAT, respectively. The rice that was fertilized with 180 kg N/ha had more tillers per plant during the 2016 planting season, with 12.25 and 16.69 at 30 and 45 DAT, respectively. The increased availability, uptake, and accumulation of N by the rice plants during the planting seasons of 2015 and 2016 may be the cause of the higher number of tillers seen at the rates of 120 kg N/ha and 180 kg N/ha. The results of Yosef (2012), who recorded a maximum tiller number (27.6) at 150 kg/ha N fertilizer, support this. By increasing the N rate to 150 kg/ha, Pramanik and Bera (2013) also reported an increase in the number of tillers per plant in hybrid rice. The quantity of rice tillers at 30 DAT during the 2015 planting season was significantly (p<0.001) influenced by seedling transplanting age. The transplanted rice seedlings with the most tillers, 14.65, were planted 28 days after the seed was first sown. The number of tillers at 45 DAT was not significantly (p> 0.05) impacted by seedling transplanting age. Seedling transplanting age had a significant impact (p<0.05) on the quantity of tillers at 30 and 45 DAT during the 2016 planting season. The number of tillers per stand for rice seedlings transplanted at 28 days after planting was greater, at 12.55 and 19.29 at 30 and 45 days, respectively. The seedling age, which increases photosynthesis due to larger leaf area, could be the reason why the 28-day-old transplanted seedlings generated the most tillers in 2015 and 2016. According to Sarkar *et al.* (2011), transplanting seedlings older than 35 days resulted in more mean tillers per hill (13.36) than transplanting seedlings younger than 25 days (12.41). The age of the seedlings when they are transplanted affects rice tillering, according to Pasuquin *et al.* (2008).

During the planting seasons of 2015 and 2016, variety had a significant impact (p<0.05) on the number of rice tillers at 30 and 45 DAT. Faro 52, rice variety, had significantly more tillers during the 2015 planting season, with 14.96 and 17.80 at 30 and 45 DAT, respectively. Faro 44, rice variety, had more tillers in 2016 during the planting season, with 12.02 and 18.32 at 30 and 45 DAT, respectively. According to Ndon & Ndaeyo (2001), variations in the capacity of rice varieties to utilize soil nutrients as well as partition their photosynthates in tiller production may have an impact on the large disparity in the number of tillers per plant found for Faro 44.

Conclusion

With the exception of the number of tillers, Faro 52 outperformed Faro 44 for every parameter evaluated because it produced the highest plant height for optimum growth. The results of this study indicate that there is a growing trend in the parameters measured for seedling transplanting age. It was shown that seedlings transplanted at 28 days of age under excellent management techniques performed better than seedlings transplanted at other ages in the planting seasons of 2015 and 2016. The findings of this study showed that the highest growth factors for rice were 240 kg N/ha. According to the result, transplanting Faro 52 seedlings that are 28 days old with the application of 240 kg N/ha may be more suitable for optimum rice development in Nigeria's Southern Guinea Savannah Ecology.

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Table 1: The impact of location, nitrogen fertilizer rates, seedling transplanting age and variety on rice plant height (cm) during 2015 and 2016 planting seasons.

Treatment factors	2015		2016	
	Plant height 30 DAT	Plant height 45 DAT	Plant height 30 DAT	Plant height 45 DAT

Location				
Badeggi	41.34	48.39	28.55	70.78
Edozhigi	36.98	43.26	34.44	41.65
LSD $_{(0.05)}$	1.52	2.06	0.92	1.15
Nitrogen rate				
0 kg/ha	38.00	44.06	30.90	55.22
60 kg/ha	38.07	44.45	31.03	55.51
120 kg/ha	40.89	48.14	31.04	56.37
180 kg/ha	39.23	45.76	31.54	55.86
240 kg/ha	39.62	46.70	32.96	58.11
LSD $_{(0.05)}$	2.4	3.26	1.46	1.83
Transplanting age				
7 DAT	34.91	42.02	26.65	49.52
14 DAT	36.87	42.76	29.86	54.55
21 DAT	41.35	47.15	33.67	58.84
28 DAT	43.51	51.36	35.79	61.95
LSD $_{(0.05)}$	2.15	2.92	1.30	1.63
Variety				
Faro 52	38.19	47.53	34.70	64.61
Faro 44	40.14	44.11	28.29	47.82
LSD $_{(0.05)}$	1.52	2.06	0.92	1.15

DAT= days after transplanting

Table 2: The impact of location, nitrogen fertilizer rate, seedling transplanting age and variety on rice number of tillers during 2015 and 2016 planting seasons.

Treatment factors	2015		2016	
	Number of tillers 30 DAT	Number of tillers 45 DAT	Number of tillers 30 DAT	Number of tillers 45 DAT
Location				
Badeggi	12.12	14.95	5.62	13.68
Edozhigi	14.97	17.64	17.15	17.88
LSD $_{(0.05)}$	0.77	1.07	1.04	0.74
Nitrogen rates				
0 kg	13.62	14.08	9.83	14.17
60 kg	13.63	15.51	11.31	15.42
120 kg	14.55	17.95	12.16	15.84
180 kg	13.57	17.48	12.25	16.69
240 kg	12.35	16.46	11.37	16.23
LSD $_{(0.05)}$	1.22	1.70	1.64	1.17
Transplanting age				
7 DAT	12.13	15.86	12.00	12.70
14 DAT	13.35	15.94	10.02	14.68
21 DAT	14.05	17.02	10.96	16.43
28 DAT	14.65	16.37	12.55	19.29
LSD $_{(0.05)}$	1.10	1.52	1.47	1.05
Variety				
Faro 52	14.96	17.80	10.75	13.23
Faro 44	12.13	14.79	12.02	18.32
LSD $_{(0.05)}$	0.77	1.07	1.04	0.74

DAT= days after transplanting