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Growth Response of Lowland Rice (Oryza Sativa L.) to Seedling Age, Method and Rate of Nitrogen Applinction in Nigeria Savannah

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***Keyword:** seedling age, rate and method of Nitrogen application*

Abstract

Field trials were conducted at the Research farms of the Institute for Agricultural Research Samaru and Kadawa irrigation Research Station during 2017 dry season, to determine the effects of seedling age, rate and method of nitrogen application on lowland rice in Nigerian Savannah. Treatments consisted of four seedlings ages (2, 3, 4, and 5 WAS), two method of nitrogen application (broadcasting and deep placement), and three rate of nitrogen fertilizer (75, 100, and 125 kg ha^{-1}). These were arranged in a split plot design with factorial combination of rate and method of N fertilizer application assigned to main plot and seedling age was placed in sub plot with three replications. The results revealed that, rice transplanted at 3WAS performed better at all sampling periods in both locations, on all the parameters measured during the experiment, such as plant height, leaf area, total dry matter, except at 9WAT on crop growth rate, at Kadawa. Deep placement of N fertilizer resulted in better performance in almost all the sampling periods at both locations, on all the parameters measured, except on crop growth rate 9WAT at Samaru. While at

Kadawa on crop growth rate. The results of the trials further showed that, application of 125 kg N ha^{-1} resulted in the highest performance in almost at all the parameters in both locations, except at Samaru on crop growth rate at 6WAT. While at Kadawa on crop growth rate at 9WAT, and on plant height at 6WAT, in all locations were not significant at 3WAT. Regression analysis showed that linear model was best fit for all the locations. Based on the results it could be conclude that transplants of 3WAS ages with 125 kg ha^{-1} applied as deep placement of N fertilizer gave better growth of rice.

Introduction

Rice *(Oryza sativa* L.*)* is a staple food in many countries of Africa and other parts of the world. It is the most important staple food for half of the human race (Imolehim and Wada, 2000). Saka and Lawal (2009) classified rice as the most important food depended upon by over 50 percent of the World population for about 80 percent of their food need. Due to the growing importance of the crop, Food and Agricultural Organization (2001) estimated that annual rice production should be increased from 586 million metric tons in 2001 to meet the projected global demand of about 756 million metric tonnes by 2030. A recent FAO estimate of cereal supply and demand put the 2017 world rice production at 502.2 million tonnes (FAO, 2018).

Nigeria spent not less than N1 billion daily on rice consumption, while spending had drastically reduced, consumption had increased because of increase of local production of rice (Anonymous, 2017). The consumption rate now is 7.9 million tonnes per annum and the production rate has increased to 5.8 million tonnes per annum. There is projection that in the next two years Nigeria would commence exportation of rice to West African countries as necessary arrangement had been put in place (Anonymous, 2017).

Rice is the world second most consumed cereal grain, it provides more than one fifth of the calories consumed worldwide by humans (Ziegler, 2006). On analysis, the nutritional value per 100g of milled rice is; carbohydrate 79.95g, sugar 0.12g, dietary fibre 1.3g, fat 0.66g and protein 7.13g. It compares favourably with other cereals in amino acids content. Rice contains a low percentage of calcium and its B group vitamins compares favourably to wheat. It also contains 0.07mg thiamin 0.04mg riboflavin, 1.6mg niacin, 1.01mg Pantothemic acid, 0.16mg vitamin B6, 8mg, folate, 28mg calcium, 0.8mg iron, 25mg magnesium, 6mg phosphorus, 1.0mg potassium 1.09mg zinc, and 1.0mg manganese (USDA, 2008).

Raw rice may be ground into flour for many uses including beverages, pudding and bread. The rice bran is high in protein and ideal for use in livestock feed for roughages and protein sources. Rice is used in industries for mainly rice wines, alcoholic beverages, beers, and confectionaries. In Nigeria "Kunu" drink is made from raw rice and the popular "Tuwo" and "Masa" are also delicacies prepared in Nigeria. The parboiled rice is eaten after boiling with stew or prepared into Jollof in homes and during social functions. In fact it is the most popular food at all social functions and meetings irrespective of tribe, religion, or social status. The hulls and husks of grain are used as fuel, bedding, incubation materials for making blocks, tiles, fibre board, ceramics, cement and fillers. It is used as a medium for growing mushroom (Imolehim and Wada 2004).

Transplanting of healthy seedlings of optimum age ensures better rice yield, when seedlings are transplanted at the right time tillering and growth proceed normally (Matsuo and Hoshikawa, 1993). The young seedlings were found to produced better root growth and facilitated increased cell division and cell enlargement due to increased photosynthetic rate subsequently increasing the plant height and number of tillers per hill (Shrirame *et al*. 2000) similar results were reported by Salem *et al*. (2011). When a seedling is transplanted carefully at the initial growth stage, the trauma of root damage caused during uprooting is minimized following a rapid growth with short *phyllochrons* (Pasuquin *et al.*, 2008). 10-day old seedlings had more vigorous stem elongation and higher tillering ability compared with 15- and 40-day old seedlings (Kim *et al*. 1999). It was observed that the tiller production was higher among 30- day old seedlings transplanted (Khatun, 1995). The tallest plant height from younger seedlings might be due to more vigorous, root growth and less transplanting shock because of less leaf area during initial growth stages which stimulate increased cell division causing more stem elongation. Similar types of results were also reported by Rahman (2001).

Pasandaran *et al.* (1999) reported that UDP showed a 25% saving in N fertilizer rates leading to an average increase of 400 kg/ha in rice yield in Indonesia. Similarly, Wani *et al.* (1999) found that among the various slow release or modified sources of urea at different N levels, USG was the best in terms of grain yield enhancement (9.5% to 33.8%) due to higher N use efficiency in rice production in India. Jaiswal and Singh (2001) reported that deep placement of USG effectively increased N use efficiency by 31.7% compared to conventionally applied urea in irrigated rice in India. Bulbule *et al.* (2002) reported that USG briquette applied at the rate of 56 kg N/ha produced 25% higher yield than the recommended dose of 100 kg N/ha using conventional urea in rice crop in India. Tarfa and Kiger (2013) reported that UDP technology increased N use efficiency by 40% and irrigated rice yield in Niger State, Nigeria. In Bangladesh, Bowen *et al.* (2005) reported that rice yield was higher for UDP technology users than farmer's practice and the magnitude of increase was 120 kg/ha with a saving in applied N of 70 kg/ha during Boro season (dry winter) and 890 kg/ha with a saving in applied N of 35 kg/ha during Aman season (monsoon).

Prilled urea (PU) is the most commonly used nitrogenous fertilizer for rice cultivation. The efficiency of nitrogenous fertilizer especially, PU in rice culture is about 25-35 per cent and rest 70-75 percent is lost for many reason after application (BRRI, 2008). PU is a very fast releasing nitrogenous fertilizer that is usually broadcast in splits, can cause a considerable loss as ammonia volatilization, denitrification, surface run off and leaching (De Datta, 1978).

Numerous researchers have reported that recovery of applied N by lowland, rainfed and irrigated rice is invariably low and hardly exceeds 50% (Tilman *et al,* 2002; Dobermann and Cassam, 2004). Yields have substantially increased but remain below the varieties yielding potential; and more fertilizer is used while NUE remains very low (Wopereis *et al,* 1999). This low recovery is attributed to losses of N from soil - water - plant system due to ammonia volatilization, nitrification-denitrification, leaching, and runoff and NH4+ fixation by clays (Singh and Buresh, 1994). This poor efficiency is of great concern for a number of reasons: even if the efficiency of nitrogenous fertilizers remains at the present level, the losses will increase enormously as their consumption is expected to double within the next 25 –30 years; their manufacture involves high - cost technology. The best method widely available to farmers for applying N to rice is to broadcast the fertilizer in split doses; this method is recommended by many extension agencies (Singh and Buresh, 1994).

Slow release nitrogenous fertilizer increases the yield and N uptake by rice due to less loss of nitrogen from the soil (Ramaswamy *et.al.*,1987; Rao and Ghai, 1985). The loss of nitrogen can considerably be reduced by deep placement of USG. Deep placement of USG stops dentrification process and minimizes urea concentration in irrigation water.as a result, it reduces nitrogen loss and improves nitrogen use efficiently by 20-25 percent for better grain production (Craswell and De Datta, 1980).

MATERIALS AND METHODS

The field trials were conducted at the Institute for Agricultural Research (I.A.R) Farms, Samaru, Ahmadu Bello University, Zaria (Latitude 11^0N 39' Longitude 08^0 02' E, 686m above sea level) and Irrigation Reseach Station, Kadawa (Latitude 11^0 11' N Longitude 7^0 38' E 500m above sea level), in Northern Guinea and Sudan Savannah ecological zone of Nigeria respectively, during the 2017 dry season.

The treatments consisted of four seedling ages (2, 3, 4, 5 Weeks after sowing (WAS)), three rates of fertilizer (75, 100, and 125kgNha^{-1}) and two method of nitrogen fertilizer application (Broadcasting of prilled urea, and deep side placement of urea super granules (USG)). The treatments were factorially combined and laid out in a split plot, with rate and method of fertilizer application as main plot and transplanting age as sub plot. Gross plot size was 3.0m x 4.0m (12m^2) and net plot size of 2m x 4m (8m^2) respectively. The treatments were replicated three times. 50% nitrogen fertilizer was applied according to treatment of 37.5, 50 and 62.5 kgNha^{-1}.N and 50 kg ha^{-1} dose of P_2O_5 and K_2O using, Urea, SSP, MOP and USG were applied at transplanting. The remaining balance of nitrogen was applied at four weeks after transplanting for prilled urea and 10 days for USG, as top dressing. Plant height was measured using a meter rule from ground level of the plant to its fully opened leaves during vegetative growth from each plot at 3, 6, and 9, weeks after transplanting. Leaf area was measured at 3, 6, and 9 WAT using samples of five randomly selected plants. Five leaves from each of the five plants were detached and their area measured using table-top leaf area mater (LI: 3100C) Model. Later area per leaf was determined by dividing with the total number of leaves measured. Thereafter, LA per plant was calculated by multiplying the average area per leaf with the total number of leaves per plant and the values observed recorded for each treatment.

Dry matter per plant was determined at 3, 6, and 9 weeks after transplanting from outside the net plot of each plot. Plants from the different plant/stand population were carefully uprooted outside the net plot and washed to remove soil and other foreign particles. The sample was then oven dried at 70^0C for 48 hours. The oven dried samples were weighed using Metler electronic precision balance and expressed in gram (g) per plant. The data collected was used for growth analysis. Crop growth rate were determined using the values of plant dry weight obtained at 6 and 9 weeks interval from the sampled plants after being oven dried at 70^0C for 48 hours to a constant weight. The following formula by Radford (1967) was used.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \quad (g/m^2/wk)$$

Where = CGR crop growth rate

W_1 = total dry weight at t_1.

W_2 = total dry weight at t_2

T = time in weeks

RESULT AND DISCUSSION

Details of physical and chemical properties of the soil taken for the experimental sites (Samaru and Kadawa) at a depth of 0-30 cm; for analysis during 2017 dry season are shown in table 1. The soils textural classes were found to be loam and sandy loam for Samaru and Kadawa respectively. Table 2 shows effects seedling age, method and rate of N application on plant height (cm), leaf area per plant (m^2), number of leaves per plant, total dry weight, Crop growth rate (CGR) (gm^2 wk^{-1}), Relative growth rate (g g^{-1} wk^{-1}), and Net assimilation rate (g $m^{-2}wk^{-1}$), of lowland rice during the 2017 dry season at Samaru and Kadawa. Transplanting at 3WAS seedlings performed better in all the growth parameters measured (Plant height, leaf area per plant, and tillers per plant), this could be due to the fact that younger seedlings recorded better root growth and facilitated increased cell division and cell enlargement due to increased photosynthetic rate subsequently increasing the plant height and number of tillers per hill. The tallest plant from younger seedlings might be due to more vigor, root growth and less transplant shock because of reduced leaf area during initial growth stages which stimulated increased cell division causing more stem elongation (Peng, 1998). Similar results were also reported by Rahman (2001).

The results showed that the two methods of nitrogen application (broadcasting and deep placement) differed in all parameters, sampling periods at both the locations, in which deep placement resulted in better performance. Nitrogen use efficiency under irrigated rice increases by 40%, reduces weed competition as fertilizer is placed near rice plants roots, irrigated rice crop yields increase up to 20-30% UDP increase efficiency of N use in rice by placing it in the soil reducing N loss through gaseous emissions and /or floodwater run-off. In broadcast application of urea, 40% of N fertilizer volatizes into the atmosphere (Tarfa and Kiger, 2013). Urea Deep Placement (UDP) technology is highly effective in improving crop uptake of applied nitrogen fertilizers in irrigated rice system (Bowen *et al*. 2004).

The highest nitrogen rate of 125 kg ha^{-1} positively influenced almost all the growth, yield and yield characters of rice crop measured in this experiment. This may be attributed to the low nitrogen level in the experimental sites (0.60 and 0.41) at Samaru and Kadawa respectively, which was responsible for its poor performance of the crops in the area where lower nitrogen level were used. This could be attributed to the ability of nitrogen in promoting growth and development. It was also attributed to the fact that N is an important constituent of chloropyl, amino acid and nucleic acid, it also plays an important role in carbohydrate and protein metabolism, hence is essential in plant growth and development. Nitrogen is also essential in all processes associated with protoplasm, enzymatic reactions and photosynthesis (Das, 2009). Nitrogen fertilization promotes cell division and enlargement that ultimately enhanced vegetative growth through increased number and size of leaves that resulted in increased leaf area. Large leaf area enhanced the capacity of the rice plants to intercept adequate sunlight, which resulted in the production of more assimilate thereby, enhancing growth and development of the crop as was earlier observed by (loomis *et al.* 1971).

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Table 1: Physio-chemical characteristics of the experimental sites during the 2017 dry season at Samaru and Kadawa

SOIL COMPOSITION	SAMARU	KADAWA
PARTICLE SIZE (G/KG)		
CLAY	120	100
SILT	430	210
SAND	450	690
TEXTURAL CLASS	Loam	Sandy loam
CHEMICAL PROPERTIES		
PH IN WATER	5.96	6.05
PH IN 0.01MCACL$_2$	5.33	5.78
ORGANIC CARBON GKG^{-1}	13.56	12.18
AVAILABLE P (GKG^{-1})	12.21	9.71
TOTAL NITROGEN (GKG^{-1})	0.60	0.41
EXCHANGEABLE CATION (CMOLKG^{-1})		
K (CMOLKG^{-1})	0.025	0.012
MG (CMOLKG^{-1})	0.615	0.401
CA (CMOLKG^{-1})	3.12	2.93
NA (CMOLKG^{-1})	0.183	0.103
CEC (CMOLKG^{-1})	3.943	3.450

Table 1: Growth response of lowland rice to transplanting age, methods and rates of nitrogen application in Nigeria savannah

TREATMENT	PLANT HEIGHT (CM)		LEAF AREA (CM^2)		TOTAL DRY MATTER (G)		CROP GROWTH RATE (GM^2WK^{-1})		NUMBER OF TILLERS PER PLANT		GRAIN YIELD	
	Samaru	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**
SEEDLING AGE (WAS)												
2	35.65d	37.73c	183.89c	359.24c	12.74c	17.28c	2.02b	2.84	8.01c	18.28c	979.17c	1486.11b
3	37.16a	39.83a	218.28a	397.12a	14.36a	18.71a	2.28a	2.76	10.17a	21.40a	1506.94a	2055.56a
4	36.38b	38.52b	203.04b	380.16b	13.35b	18.09b	2.07ab	2.79	9.61b	18.92b	1180.56b	1631.94b
5	35.99c	36.87d	187.66c	354.39c	11.94d	16.92c	1.79c	2.83	7.32d	17.63c	611.11d	1215.28c
SE±	0.107	0.173	3.338	5.901	0.208	0.203	0.080	0.097	0.193	0.275	0.040	0.055
NITROGEN APPLICATION METHOD												
BROADCASTING (UREA)	35.76b	37.47b	179.02b	355.04b	12.41b	16.96b	1.91b	2.81	8.12b	17.54b	850.70b	1399.30b
DEEP PLACEMENT (USG)	36.83a	39.01a	217.41a	390.41a	13.79a	18.54a	2.16a	2.83	9.43a	20.58a	1288.20a	1795.10a
SE±	0.112	0.155	3.767	5.030	0.191	0.121	0.045	0.065	0.048	0.210	90.963	103.114
NITROGEN RATE (KG HA^{-1})												
75	34.45c	35.28c	132.76c	296.15c	10.43c	15.49c	1.73c	2.93	6.37c	15.99c	765.60b	932.30c
100	36.70b	37.99b	191.38b	375.14b	12.89b	17.08b	1.96b	2.68	8.69b	17.94b	838.50b	1541.70b
125	37.72a	41.44a	270.51a	446.89a	15.98a	20.68a	2.43a	2.83	11.28a	23.24a	1604.20a	2317.70a
SE±	0.137	0.190	4.613	6.161	0.223	0.148	0.056	0.079	0.059	0.258	111.406	126.288
INTERACTION												
D X M	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
D X R	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
R X M	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
D X R X M	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter (s) are not significant at 5% level of significant of probability using Duncan multiple rage test (DMRT).