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Growth Response of Lowland Rice (Oryza Sativa L.) Variety as Influenced by Sowing Method and Fertilizer Management in Nigeria Savanna

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Abstract

Field trials were conducted at Institute for Agricultural Research, Samaru, and Irrigation Research Station, Kadawa in the northern Guinea and Sudan Savanna ecological zones of Nigeria respectively, during the 2021 wet season. Treatments consisted of three lowland rice varieties (FARO 44, FARO 52, and FARO 57), three sowing methods (dibbling, drilling and broadcasting) and four rates of NPK and Agric-Zyme 3X organic liquid fertilizers (0:0:0 kg NPKha^{-1} + 3.0 Lha^{-1}, 60:30:30 kg NPKha^{-1}+1.5 Lha^{-1}, 60:30:30 kg NPKha^{-1} + 3.0 Lha^{-1} and 120:60:60 kg NPKha^{-1} + 0 Lha^{-1}). The trials were replicated three times, in a factorial arrangement using split plot arrangement. Fertilizer rates and sowing methods were in the main plots and rice variety as subplot. FARO 44 recorded taller plants height and took longer days for effective grain filling periods and FARO 57 took longer day to 50% flowering. Effect of sowing methods was generally not significant on rice, however, broadcasting recorded taller plants heights and higher leaf area index, while dibbling recorded higher paddy yield. Application of 120: 60: 60 NPK kg ha^{-1} out-performed other fertilizer management methods followed by 60: 30: 30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X in all parameters. In conclusion, FARO 57 variety out-performed other varieties used in the study, Drilling method and application of 60: 30: 30 NPK kg ha^{-1} were better for growth, yield and grain quality of lowland rice in the study areas.

Keywords: FARO, Sowing Method, NPK, Agric-Zyme 3X.

Introduction

Rice (*Oryza sativa* L.) belongs to family Poaceae. Production of rice rank second among the food grain and half of the world population receiving the highest (26.2%) calories intake from it in the developing countries of their dietary protein (FAO, 2009). Rice is a staple food in many countries of Africa and other part of the world. It is relatively easy to produce and is grown for sale and for home consumption (Otitujo *et al.*, 2014).

World rice production in 2022 amounted to 776 million tonnes. Asia was the leader in rice production, with the top three producers of the region: China (27 percent of the global total), India (25 percent), and Bangladesh (7 percent) (FAO, 2023). The rice produced in Nigeria amounted to around 8.34 million metric tons in 2021. In previous year, a lower quantity was produced, some 8.17 million metric tons and 8.5 million metric ton in the year

2022. It is increased overall from 2010 to 2016, peaked in 2017, with a value of 10.89 million metric tons (FAO, 2023). The rice produced in Nigeria amounted to around 8.095mm million metric tons in 2023, the consumption rate now is 7.8 million tones (Christopher, 2023)
Kawure *et al.* (2022), reported that rice production in Nigeria was constrained by a number of factors which may include among others, the use of poor agronomic practices (such as planting pattern or seeding method), drought, use of local varieties, and inconsistency of government policy instruments and interventions to boost local production such as import restriction, tariff restriction and inauguration of presidential task force on rice. Kawure *et al.* (2022), further reported that agronomic practices limiting yield, planting pattern and/or planting method are considered to be of great importance, as increase in yield can be ensured by maintaining appropriate plant population through different planting pattern. In rice production, planting methods as if broadcasting, drilling, dibbling, and transplanting have impact on the growth and yield of the crop besides cultivation cost and labour requirement. According to Javaid *et al.* (2012), direct seeded rice when managed properly can yield as high as the transplanted one.
Traditional rice varieties are more than 1metre tall, have a long growth and maturation period (5-6 months) and low yield (1.5-2.0 t ha^{-1}) tonnes per hectare. Improved varieties are shorter (less than 50 cm), are more responsive to fertilization, produce high yields (3.5-5 t ha-1), and are short-duration (Mohammed, 2016). Improper sowing techniques usually affects yield potential of the crop increase in yield may be ensured through different sowing methods such as drilling and dibbling. Sowing improved varieties using appropriate methods of seeding could produce a fast growing and uniform crop with higher yields that could compete with weeds effectively (Kawure *et al.*, 2018). Direct-planted rice offers the advantages of faster and easier planting ensure proper plant population, reduces labour and drudgery, matured 10-12 days earlier, more efficient water use and higher tolerance to water-deficit, and high profit in areas with assured water supply than transplanting (Ashwani *et al.*, 2017). The objectives of the research were to: 1. Determine the varieties for growth development of lowland rice varieties. 2. Determine the appropriate sowing method for lowland rice for growth and development. 3. Determine the effect of combined NPK plus liquid organic fertilizers on growth and deployment of lowland rice.

Materials and Methods

Field trials were conducted at the Institute for Agricultural Research, Samaru, in the Northern Guinea and Sudan Savanna ecological zones of Nigeria, in 2020 wet season. Treatments consisted of three lowland varieties (FARO 44, FARO 52, and FARO 57), four rates of combined NPK and Agric zyme 3X organic liquid fertilizers (0:0:0 kg ha^{1} plus 3lha^{-1}, 60:30:30 kg NPKha^{-1}plus 1.5lha^{-1}, 60:30:30 kg NPKha^{-1} plus 3lha^{-1} and 120:60:60 kg NPKha^{-1} plus olha^{-1}), and three sowing method (dibbling, drilling and broadcasting). These studies were designed as Randomized Complete Block Designs, laid out in split plots arrangements with fertilizer rates and sowing methods as main plot and lowland rice varieties as sub plots. Gross and net plot sizes were 3.0 m x 4.0 m (12 m^2) and 2 m x3 m (6 m^2) respectively. The treatments were replicated three times. The experimental site was harrowed twice to obtain a fine tilth and marked out into plots (basins) and replicates Each main plot was separated by 1m pathway, the sub-plot by 0.5 m. Seeds were sown according to treatments. Dibbling, at 20cm inter and intra row spacings using 60 kg ha^{-1} seed rate, while seeds were drilled in grooves 2-3cm deep at 20cm spacings using 80 kg ha^{-1} seed rate. Seeds were manually sown at at 100 kg ha^{-1} and covered lightly with soil. The crop was harvested at maturity when the entire plants turned yellowish or golden brown, using sharp locally made handheld sickles. Harvested plants were threshed. Growth data were collected on plant height (cm), leaf area index, net assimilation rate, days to 50 % flowering at 3, 6, 9 and 12 weeks after sowing effective grain-filling period and paddy yield.

Results and Discussion

Details of physical and chemical properties of the soil taken at the experimental sites (Samaru and Kadawa) at a depth of 0-30 cm in 2020 wet season are shown on Table 1. The soils textural classes were loam and sandy loam for Samaru and Kadawa, respectively. Chandrasekaran *et al*. (2007) reported that rice could be grown successfully on a variety of soil, the most important requirement of the soil is its ability to hold moisture. Soil from both locations were found to be slightly acidic with pH of 5.31 and 5.95 with moderate organic carbon content of 11.25 and 14.60 gkg^{-1}, at Samaru and Kadawa, respectively. Daudu *et al.* (2014) reported that rice plant required heavy soil, slightly acidic to neutral (pH 5.5-7.0) high clay content of 40-60% and moderate organic matter. Total nitrogen was low1.35 and 1.60 gkg^{-1} available phosphorus of 10.45 and 11.61 mgkg^{-1} at Samaru and Kadawa. The exchangeable K was 0.12 and 0.15 cmolkg^{-1}, mg was 0.46 and 0.49 cmolkg^{-1}, Ca was 2.65 and 2.95 cmolkg^{-1}, Na was 0.20 and 0.20 cmolkg^{-1}, exchangeable acidity (Al^{+++}+ H^{+}) was 0.30 and 0.20 and low CEC of 3.73 and 3.99 cmolkg^{-1} for both locations. The CEC of the soils of the study area was low to medium according to Esu (1991) rating of <6 = low, 6-2 = medium and <12 = high. The low CEC values of the soils could be attribute to the nature of the silicate clay minerals (Kaolinite) believed to be the dominant clay type in depressed soils (Hassan *et al*., 2011).

Table 2 presents plant height, LAI, NAR, days to 50% flowering, days to physiological maturity and paddy yield of lowland rice varieties as influenced by sowing method and fertilizer management at Samaru and Kadawa in 2020 wet season. At Samaru, the varieties did not differ significantly on plant height, At Kadawa FARO 44 Variety recorded taller plants than FARO 52 and 57, which were statistically similar. Effect of sowing method was significant on plant height. Similarly, at Samaru, dibbling and drilling were at par and produced shorter plants. At Kadawa, dibbling and drilling were also statistically similar. The taller plants recorded by broadcasting could be as result of etillation for competition of available growth resources. Effect of fertilizer management on plant height was significant. At Samaru, fertilizer management did not differ significantly in plant height, At Kadawa application of 60:30:30 NPK kg ha^{-1} + 1.5 L ha^{-1} Agric-Zyme 3X and 120:60:60 NPK kg ha^{-1} were at par and recorded taller plants and application of 0:0:0 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X recorded shorter plants in the sampling period. This finding was in accordance with Eze *et al.* (2022), observed that NPK, LOF and PM treatment types had significant effect on plant height, stem girth, number of leaves, leaf area. Varieties did not differ significantly on LAI at both locations. At Kadawa broadcasting of rice recorded higher LAI than both dibbling and drilling which were at par. This can be associated with dense canopy produced by plants for reasons that were not planted on a definite space. This finding was contrary to Shrirame *et al*, (2000), the higher leave area index noted for dibbling and drilling was due to the fact that the crops were fixed firmly on the soil and which developed vigorously and resulted in higher leave length and width. At Kadawa application of 120:60:60 NPK kg ha^{-1} recorded higher LAI. Followed by application of 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X then application of 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X and application of 3 L ha^{-1} Agric-Zyme 3X recorded lower LAI. This is also in line with Gala *et al.* (2011), reported that increasing amount of NPK improves considerably the vegetative growth of rice. The larger the leaf area of a plant the more the photosynthetic area and consequently the output is also high. There were no significant differences on NAR among varieties, sowing methods, and fertilizer management at all sampling periods at both locations. Days to 50% flowering (days) of lowland rice varieties as influenced by planting method and fertilizer management at Samaru and Kadawa in 2020 wet season. FARO 57 variety takes longer time before flowering followed by FARO 52 while FARO 44 attain flowering earlier across the locations. This finding agrees with NCRI (2006), reported that 110 – 120 days, 125-130 days, 120-135 days were time for maturity for FARO 44, FARO 52 and FARO 57 respectively. Sowing methods did not significantly affect days to 50% flowering at Samaru and Kadawa. Effect of fertilizer management on days to 50% flowering, this could be as a reason that the three varieties share common agronomic characters. At Samaru application of 120:60:60 NPK kg ha^{-1} takes longer time before flowering and application of 3 L ha^{-1} Agric-Zyme 3X takes shorter time for flowering. Application of 60:30:30 NPK kg ha^{-1} + 1.5 L ha^{-1} Agric-Zyme 3X and 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X were at par. At Kadawa application of 120:60:60 NPK kg ha^{-1} takes longer time before flowering and was statistically similar with application of 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X. Application of 3 L ha^{-1} Agric-Zyme 3X and 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X takes shorter time before flowering and was also statistically similar with application of 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X and 3 L ha^{-1} Agric-Zyme 3X. Effective grain filling period (days) of lowland rice varieties as influenced by sowing method and fertilizer management at Samaru and Kadawa. Varieties significantly differed on effective grain filling periods, where FARO 44 took longer days for grain filling period than FARO 52 and FARO 57 in both Samaru, and Kadawa. This cannot surprise because the varieties shared common agronomic characteristics, this finding was in accordance with Islam *et al.* (2010), who reported that varieties with longer growth duration usually produce more grain, yield than the varieties with shorter growth duration. However, sowing methods had no significant effect on effective days to grain filling period at both locations. At Kadawa application of 120:60:60 NPK kg ha^{-1} took longer days for grain filling period and application of 60:30:30 + 1.5 L ha^{-1} Agric-Zyme 3X, 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X and 120:60:60 NPK kg ha^{-1} were at par. This could be attributed to availability of nutrient present which makes the plants to takes more time on the field, the higher the nutrient the higher value of the parameters recorded. Paddy yield of lowland rice varieties as influenced by sowing method and fertilizer management at Samaru and Kadawa. Generally, there were no significant differences in paddy yield among the three varieties. There was significant effect of sowing methods on paddy yield at Samaru, dibbled rice consistently recorded higher paddy yield that did not differ statistically from drilled rice and broadcast rice recorded lower grain yield and was statistically similar with drilling. The combine application of 60:30:30 NPK kg ha^{-1} + 1.5 L ha^{-1} Agric-Zyme 3X, 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X and 120:60:60 NPK kg ha^{-1} resulted in paddy yield that was statistically at par and application of 3 L ha^{-1} Agric-Zyme 3X only that recorded lower paddy yield at both locations.

Table 3 presents interaction between sowing methods and varieties on leave area index at 9WAS, Samaru in 2020. FARO 57 when broadcast produced higher LAI and FARO 57 when drilled recorded lower LAI. Table 4 presents the interaction between Varieties and planting methods on NAR at Kadawa FARO 52 when broadcast produced higher NAR and when FARO 57 dibbled produced lower NAR. Table 5 presents interaction between planting methods and varieties on days to 50% flowering at both locations in all years and combined, broadcasting with FARO 57 takes longer time before flowering and broadcasting with FARO 44 takes shorter time for flowering. Table 6 presents interaction between sowing methods and fertilizer management on days to 50% flowering at both locations in all years and combined, application of 120:60:60 NPK kg ha^{-1} to broadcasted rice takes longer time before flowering while application of 3 L ha^{-1} Agric-Zyme 3X to dibbled rice takes shorter time for flowering. Table 7 presents significant interactions between sowing methods and varieties during 2020 wet season at Samaru. Sowing FARO 52 using dibbling or drilling method resulted in higher paddy yield kg ha^{-1}than for other two varieties that have lower paddy yields. Table 8 presents significant interactions between sowing methods and fertilizer management during 2020 wet season at Samaru. Combination dibbling sowing method with 120:60:60 NPK kg ha^{-1} recorded highest paddy yield kg ha^{-1}dibbling sowing method + 60:30:30 NPK kg ha^{-1} + 1.5 L ha^{-1} Agric-Zyme 3X while broadcasting sowing method + 3 L ha^{-1} Agric-Zyme 3X recorded the least paddy yield kg ha^{-1}. The significant interactions between sowing methods and fertilizer management during 2020 wet season at Kadawa revealed that broadcasting + 60:30:30 NPK kg ha^{-1} + 3 L ha^{-1} Agric-Zyme 3X had the highest paddy yield kg ha^{-1}while dibbling planting method + 3 L ha^{-1} Agric-Zyme 3X recorded the least paddy yield kg ha^{-1}.

Conclusion

In conclusion, FARO 57 variety out-performed other varieties, drilling sowing method and application of 60: 30: 30 NPK kg ha^{-1} were better for growth, yield and grain quality of lowland rice in the study area.

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Table 1: Physio-chemical characteristics of the experimental sites during the 2020 wet season at Samaru and Kadawa.

Soil depth 0-30cm

	Samaru	Kadawa
Soil Composition	**2020**	**2020**
Particle size (g/kg)		
Clay	120	80
Silt	430	380
Sand	450	540
Textural class	Loam	Sandy loam
Chemical Properties		
pH in water	5.31	5.95
pH in 0.01m$CaCl_2$	4.45	4.25
Organic carbon gkg^{-1}	11.25	14.60
Available P (gkg^{-1})	10.45	11.61
Total nitrogen (gkg^{-1})	1.35	1.60
Exchangeable Cation ($cmolkg^{-1}$)		
K ($cmolkg^{-1}$)	0.12	0.15
Mg ($cmolkg^{-1}$)	0.46	0.49
Ca ($cmolkg^{-1}$)	2.65	2.95
Na ($cmolkg^{-1}$)	0.20	0.20
Al^{+++}+ H^{+} ($cmolkg^{-1}$)	0.30	0.20
CEC ($cmolkg^{-1}$)	3.73	3.99

Source: Soil analytical laboratory, Agronomy Department, Faculty of Agriculture, ABU, Zaria

Table 2: Growth response of lowland rice varieties as influenced by sowing method and fertilizer management in Nigerian savannah during 2021 wet season

Treatment	**Plant height (cm)**		**Leaf area index (cm^2)**		**Net assimilation rate**		**days to 50% flowering (days)**		**Effective grain filling period (days)**		**Paddy yield (Kg ha^{-1})**	
Variety	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**
FARO 44	64.428	67.517a	3.385	1.338	0.456	0.695	87.167c	83.028c	18.472a	18.389a	2471.8	1655.6
FARO 52	61.444	65.150ab	3.415	1.338	0.298	1.005	90.472b	88.972b	17.417b	16.833ab	2616.2	1790.3
FARO 57	64.156	61.750b	3.340	1.378	0.326	0.642	103.611a	104.500a	17.583ab	15.417b	2497.7	1776.4
SE±	1.068	1.747	0.085	0.098	0.069	0.139	0.762	0.921	0.346	0.923	106.314	103.525
Planting method												
Dibbling	61.244b	61.322b	3.344	1.131b	0.365	0.630	93.417	90.833	17.833	16.667	2755.1a	1689.8
Drilling	62.833b	65.878ab	3.357	1.219b	0.367	0.756	93.111	92.139	17.861	16.750	2512.0ab	1621.8
Broadcasting	65.950a	67.217a	3.439	1.701a	0.348	0.956	94.722	93.528	17.778	17.222	2318.5b	1910.6
SE±	1.068	1.747	0.085	0.098	0.069	0.139	0.762	0.921	0.346	0.923	106.314	103.525
Fertilizer management (NPK kg ha^{-1} + L ha^{-1} Agrizyme)												
0: 0: 0 + 3	62.467	60.193b	3.256	1.040b	0.315	0.996	90.333c	91.333ab	17.963	20.000a	2119.8b	1252.5b
60:30:30 + 1.5	63.807	66.726a	3.433	1.557a	0.377	0.988	93.259b	90.963b	17.370	15.037b	2504.9a	1709.3a
60:30:30 + 3	62.459	65.874ab	3.298	1.270ab	0.406	0.599	93.444b	91.778ab	18.000	15.926b	2636.4a	2002.5a
120: 60:60 + 0	64.637	66.430a	3.533	1.536a	0.342	0.539	97.963a	94.593a	17.963	16.556b	2853.1a	1998.8a
SE±	1.233	2.018	0.099	0.113	0.079	0.160	0.879	1.063	0.399	1.066	122.765	119.544
Interaction												
P x V	NS	NS	**	NS	NS	*	*	*	NS	NS	*	NS
F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x F	NS	NS	NS	NS	NS	NS	**	*	NS	NS	*	*
P x F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within treatment group are not significant at 5% level of probability. NS= not significant, **= significant at 1%, *= significant at 5% level of probability, WAS week after Sowing, NPK= Nitrogen phosphorus potassium, Agrizyme= Organic Liquid Fertilizer.

Table 3: Interaction between sowing methods and varieties on LAI in 2020 wet season at Samaru

Treatment	Variety		
Planting Method	**FARO 44**	**FARO 52**	**FARO 57**
Dibbling	3.371cd	3.422bc	3.239d
Drilling	3.501b	3.535b	3.034e
Broadcasting	3.284cd	3.288cd	3.748a
SE±	0.148		

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

Table 4: Interaction between varieties and sowing methods on net assimilation rate in 2020 wet season at Kadawa

Treatment	Variety		
Planting Method	**FARO 44**	**FARO 52**	**FARO 57**
Dibbling	0.644cd	0.812bc	0.434d
Drilling	0.959b	0.800bc	0.509d
Broadcasting	0.479d	1.404a	0.984b
SE±	0.240		

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

Table 5: Interaction between sowing methods, varieties on days to 50% flowering in 2020 wet season at Samaru and Kadawa

Treatment	Variety		
Planting Method	**FARO 44**	**FARO 52**	**FARO 57**
Samaru 2020			
Dibbling	88.583e	88.917e	102.750b
Drilling	87.750e	90.000d	101.583b
Broadcasting	85.167f	92.500c	106.500a
SE±	1.319		
Kadawa 2020			
Dibbling	82.500f	87.417d	102.583b
Drilling	85.500e	87.833d	103.083b
Broadcasting	81.083f	91.667c	107.833a
SE±	1.595		

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

Table 6: Interaction between sowing methods, varieties, and fertilizer management on days to 50% flowering in 2020 wet season at Samaru and Kadawa

Treatment	Fertilizer management (NPK kg ha^{-1} + L ha^{-1} Agric-Zyme 3X)			
Planting method	**0: 0: 0 + 3**	**60:30:30 + 1.5**	**60:30:30 + 3**	**120: 60:60 + 0**
Samaru 2020				
Dibbling	86.222f	96.778b	94.111c	96.556b
Drilling	90.333e	92.222d	92.111de	97.778b
Broadcasting	94.444c	90.778de	94.111c	99.556a
SE±	1.523			
Kadawa 2020				
Dibbling	86.111f	89.889e	94.111b	93.222bc
Drilling	94.333b	90.556e	91.000de	92.667bcd
Broadcasting	93.556bc	92.444cd	90.222e	97.889a
SE±	1.841			

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

Table 7: Interaction between sowing methods and varieties on paddy yield during 2020 wet season at Samaru

Treatment	Variety		
Planting Method	**FARO 44**	**FARO 52**	**FARO 57**
Dibbling	2604.167cd	3004.167a	2656.944bc
Drilling	2461.111de	2804.167b	2270.833f
Broadcasting	2350.000ef	2040.278g	2565.278cd
SE±	184.147		

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

Table 8: Interaction between sowing methods, varieties and fertilizer management on paddy yield during 2020 and 2021wet seasons at Samaru and Kadawa

Treatment	Fertilizer management (NPK kg ha^{-1} + L ha^{-1} Agric-Zyme 3X)			
Planting method	**0: 0: 0 + 3**	**60:30:30 + 1.5**	**60:30:30 + 3**	**120: 60:60 + 0**
Samaru 2020				
Dibbling	2224.074e	3081.481a	2607.407cd	3107.407a
Drilling	2492.593d	2227.778e	2492.593d	2835.185b
Broadcasting	1642.593f	2205.556e	2809.259bc	2616.667cd
SE±	212.629			
Kadawa 2020				
Dibbling	859.259e	1725.926bc	1877.778b	2296.296a
Drilling	1224.074d	1766.667bc	1670.370c	1825.926bc
Broadcasting	1674.074bc	1635.185c	2459.259a	1874.074b
SE±	207.050			

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