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Influence of Season and Sowing Method on the Growth and Yield of Lowland Rice (*Oryza sativa* L.) at Zigau Bauchi State

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Abstract

Field experiment was conducted at Goria farm Zigau, Shira Local Government Area of Bauchi State, Nigeria during the wet and dry seasons of 2015 and 2016 to study the influence of season and sowing method on the growth and yield of lowland rice. A lowland variety FARO 44 was used for the study. The treatments consisted of two seasons (dry and wet) and four different sowing methods (Transplanting, Dibbling, Drilling and Broadcasting). The treatments were laid in Randomized Complete Block Design (RCBD) replicated four times. The result revealed that growing the crop during the wet season produced significantly ($p \leq 0.01$) taller plants than those of the dry season. Dry season sowing on the other hand, had significantly ($p \leq 0.01$) more tillers, number of seeds per spike, spikes number per hill and grain yield (kg/ha) than the wet season rice production. At different sowing methods, transplanting produced a significantly ($p \leq 0.01$) higher number of tillers per plant, number of seeds per spike, seed weight per spike and grain yield (kg/ha) than all the other sowing methods used. The result further revealed that the dibbling method of sowing significantly ($p \leq 0.01$) gave higher number of spikes per hill than all other treatments studied. Rice farmers in the study area can therefore, in addition to their traditional wet season rice production, introduce dry season production which was observed to have high yield potential. Farmers are also advised to transplant their crop instead of their traditional broadcasting method or other methods for higher yield.

Keywords

Performance, Season, Sowing methods, Lowland rice

Introduction

Rice is one of the crops that has attained a staple food status in Nigeria and has also become a major source of calories for millions of people in the country. Today, rice is no longer a luxury food to Nigerians but has become the cereal that constitutes a major source of calorie. There is a high demand for the crop which might have been the reason for the huge gap between the supply and demand. It is an economic crop which may be used for ceremonies, food security, nutritional diversification and employment.

Rice being a tropical crop can be grown during the two distinct seasons (dry and wet) of the year provided that moisture is made available to the crop. Therefore, in addition to traditional wet season rice production, Nigeria has abundant land and water resources to embark on dry season rice production through irrigation to ensure all year-round production. The wet season is the season of the year when annual precipitation (rainfall) occurs and moisture requirement for crop production depends on natural rain. This season is short, usually between May to September especially in the northern parts of the country. In Nigeria, the bulk of rice production is in the wet season which depends strictly on rainfall which is known to be the most limiting production constraint for this system [1].

Dry season (especially in the northern part of the country) is the season of the year with no rainfall and moisture requirement for crop production is primarily dependent on irrigation water. The season is prolonged, spanning from October to May, particular in northern parts of the country.

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Additional yield to annual rice production through dry season production could set Nigeria on a pathway to rice self-sufficiency thereby bridging the demand and supply gap of the crop. However, despite its high yield potential, less emphasis has been directed toward dry season or irrigated rice production which accounts for 10-16% of the total rice area in the country [1,2]) and it is mostly found in the northern parts of the country. Irrigation here is applied from rivers, well, boreholes and wash bores among other sources to supplement the rain for full rice production. This production system accounts for about 18% of the area share of rice production and 27% of domestic production. It is characterized by average yields of 3.5 tonnes/ha but has higher yield potential of 5-7 tonnes [3,4]. Irrigated rice system which has been noted to have best performance in terms of yield should therefore, be given a special consideration to offer opportunity for double cropping in Nigeria, so that the farmer could earn more income with the country being more secure in food.

Similarly, the potential for increase in rice production strongly depends on the ability to integrate a better crop management such as planting methods for different varieties into existing cultivation. Particularly for better crop establishment, sowing method is determined by the crop to be grown. Rice production system with high economic output, seedling establishment which of course is controlled by planting pattern has become more important than ever. Stand arrangement and number of seeds per hill are two cultural practices which exert considerable influence on tillering ability and yield of rice [5]. However, the number of stands established must be sufficient enough to produce the desired number of active tillers per plant and optimum number of spikes at harvest. The method of stand establishment in rice culture can be classified into direct seeding and transplanting. Like other cereal crops, rice can be grown directly into the field instead of first raising the seedlings in the nursery and later transplanting them into the main field. This can be achieved through broadcasting, dibbling and drilling methods. Though transplanting method seems to be more laborious from raising nursery, uprooting and transporting the seedlings. However, it has been shown to be a better practice than the direct method of seeding [6]. According to [7] and [8] direct seeded rice when managed properly can yield as high as the transplanted one. This research therefore intended to study the influence of season and sowing method on the growth and yield of lowland rice.

Material and Methods

Experimental site

Field experiment was conducted at Goria farms in Zigau, Shira Local Government Area of Bauchi State to study the influence of season and sowing method on the growth and yield of rice. The experimental site is located on Latitude 11°25'N and Longitude 9°57'E and at an altitude of 410m above sea level. The warmest month of the year in the study area is April, with an average temperature of 34.5 °C and lowest average temperature of 26.5 °C in the month of January, while the mean annual rainfall of the area is about 600-780 mm. The wet season in and around Shira area commences in around June and ends in October while the dry season lasts for about seven months between November and May.

Soil sampling and analysis

Soil sample was taken randomly at a depth of 0-15 cm and 15-30 cm as recommended by ([9] and one composite soil sample for each sampling depth was prepared and taken to the soil laboratory of the Department of soil science, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University Bauchi for physical and chemical analysis. The sample was analyzed for soil pH, particle size distribution, organic carbon, cation exchange capacity (CEC), total N, available P and exchangeable bases like potassium (K), calcium (Ca), sodium (Na), and magnesium (Mg) (Table 1).

Experimental materials

Lowland rice variety FARO 44 otherwise known as Sippi 692033 was used for the study. The variety was released and registered between 1990 and 1991. It was developed by West Africa Rice Development Association (WARDA), International Institute of Tropical Agriculture (IITA) and National Cereal Research Institute (NCRI). It is an interspecific hybrid between the local African rice and Taiwan rice.The variety has unique characteristics such as medium maturity (110-120 days) especially when compared with the traditional varieties, higher yield, tolerant to some stresses, resistant to blast and has long grain [10]. According to [11] FARO 44 is medicinal for dietary management of diabetes due to its low glycemic indices when compared to other varieties.

Treatments and experimental design

The treatments consisted of four different sowing methods (transplanting from the seed sown first in the nursery, Dibbling, Drilling and Broadcasting) tested in two different seasons (wet and dry). This gave eight treatment combinations which were factorially combined and laid in Randomized Complete Block Design (RCBD) replicated four times.

Table 1: Physico-chemical properties of soil of the experimental site prior to the experiment in 2015.

	Soil depth (cm)	
Soil composition	0-15	15-30
Clay	33.76	43.76
Silt	43.12	37.12
Sand	21.50	19.50
Textural class	Clay loam	Clay loam
Chemical composition		
pH 1:1 (water)	5.59	5.58
Organic carbon (%)	1.61	1.20
Total N (%)	0.07	0.07
Available P (mg/kg)	5.95	11.35
Exchangeable bases (C mol/kg)		
Ca	2.75	2.49
Mg	0.86	0.73
K	0.21	0.18
Na	0.14	0.20
CEC (C mol/kg)	5.67	4.39

Cultural practices

For direct method of sowing (dibbling, drilling and broadcasting) the seeds were sown directly in the field. However, in transplanting method of sowing, seedlings were first raised in the nursery before transplanted. The seeds were sown the same day for both direct seeding and nursery. Uniform inter and intra row spacing of 20 cm was used for dibbling and transplanting methods. In drilling method of seeding the seeds were sown in a groove of 2-3 cm deep spaced at 20 cm. In Broadcasting the seeds were manually spread using hand and covered lightly with soil for effective germination. Seed rates used were; transplanting (40 kg/ha), dibbling (60 kg/ha), drilling (120 kg/ha) and Broadcasting (150 kg/ha). Weeding was done manually at 3, 8 and 12 weeks after sowing. Compound fertilizer NPK 20:10:10 was first applied as basal using broadcast method at the rate of 60 kgN/ha, 30 kgP_2O_5 and 30 kg/haK_2O. The remaining nitrogen dose was then applied in two split doses as top dress at 7th week after sowing and at the booting stage. Under the dry season experiment, surface irrigation method was used to convey water from wash bore through hose pipe to constructed channels between blocks or replicate to each plot. The irrigation water was applied to the treatment plots through a ridge that linked each plot to the constructed channels. Intermittent irrigation was applied with alternate wetting and drying of 3 days interval. However, during the rainfed experiment, the field was left under the natural rainy season for water supply.

Data collection and statistical analysis

Data were collected on plant height, tiller count and yield characters from 20 randomly selected sampled hills/stands from the net plot size of 4 m^2. The data collected for all the sampled stands and for all the characters observed. The data collected were subjected to Analysis of Variance (ANOVA) using SPSS version 22 package to study the effect of all the treatments. However, where the treatments were observed to be significant, Duncan Multiple Range Test (DMRT) was used to separate the means.

Results

Data obtained in Table 1 shows the physico-chemical properties of the experimental site prior to the trial. The results obtained (Table 1) revealed that average percentage of particle size distribution was sand 20.5 %, silt 40.1%, clay 38.8% and the textural class of the soil was clay loam and the pH was slightly acidic. The result further indicated that the soil was low to moderate in organic carbon (1.20-1.61%), total nitrogen (0.07) and available phosphorus (5.95-11.35). The CEC was generally low (4.39-5.67 C mol/kg). For exchangeable bases, the soil was moderate in Ca^{2+}, low in K^+, Mg^{2+} and Na^+.

Influence of season and sowing method on plant height, tiller counts per plant and number of spikes per hill grown during the dry and wet seasons of 2015 and 2016 is presented in Table 2. There was a significant ($P \leq 0.01$) difference between the two seasons and among the different sowing methods on plant height, tiller counts per plant and number of spikes per hill of rice at harvest. Growing the crop during the wet season produced taller plants than in the dry season for both years. However, dry season rice had more tillers per plant and number of spikes per hill than wet season. At the different sowing methods, transplanting and dibbling methods were observed to produced significantly ($P \leq 0.01$) taller plants than drilling and broadcasting. The result also indicated that transplanted rice had the highest number of tillers in both years when compared with the other sowing methods. Dibbling however, was the second in tiller count with drilling and broadcasting producing the least number of tillers. The dibbling method on the other hand, produces a significantly ($P \leq 0.01$) higher number of spikes than all other methods of sowing studied.

Table 3 shows the influence of season and sowing method on number of seeds per spike, seed weight per spike and grain yield (kg/ha). Except in 2015, no significant difference was observed in 2016 on number of seeds per spike. Dry season sowing significantly ($P \leq 0.01$) produced a higher

Table 2: Influence of season and sowing methods on plant height, number of tillers per plant and number of spikes per hill of lowland rice during dry and rainy seasons of 2015 and 2016 at Zigau, Bauchi State.

	Plant height (cm)		No. of tillers per plant		No. of spikes/hill	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Season (S)						
Dry	54.27^b	55.44^b	7.62^a	8.76^a	11.42^a	11.63
Wet	59.03^a	66.79^a	6.49^b	7.13^b	9.59^b	11.73
LS	**	**	**	**	**	NS
SE (±)	0.757	1.014	0.184	0.227	0.854	1.135
Sowing method (S)						
Transplanting	61.43^a	66.94^a	18.86^a	20.56^a	18.51^b	21.73^b
Dibbling	60.11^a	64.45^a	8.34^b	9.20^b	21.41^a	28.94^a
Drilling	53.00^b	60.59^b	0.90^c	1.00^c	1.00^c	1.00^c
Broadcasting	52.06^b	59.91^b	0.80^c	0.97^c	1.00^c	1.00^c
LS	**	**	**	**	**	**
SE (±)	1.070	1.281	0.260	0.321	0.854	1.605
Interaction						
S × S	NS	NS	**	**	NS	NS

Means followed by different letters within each column of treatments are significantly different following Duncan Multiple Range Test (DMRT)
LS: Level of significance; NS: Not significant; **Significant at 1% level of probability

Table 3: Influence of season and sowing method on number of seeds per spike, seed weight per spike and grain yield (kg/ha) grown during the dry and wet seasons of 2015 and 2016 at Zigau Bauchi State, Nigeria.

	No of seeds/spike		Seed weight/spike (g)		Grain yield (kg/ha)	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Season (S)						
Dry	143.13[a]	150.50	3.58	4.09[a]	5.0[a]	6.0[a]
Wet	124.81[b]	145.50	3.44	3.52[b]	4.4[b]	5.2[b]
LS	**	NS	NS	*	**	**
SE (±)	2.761	2.489	0.110	0.147	0.07	0.17
Sowing method (S)						
Transplanting	147.13[a]	152.88	4.46[a]	5.01[a]	6.22[a]	7.14[a]
Dibbling	137.00[ab]	150.88	3.92[b]	4.31[b]	5.50[b]	6.29[b]
Drilling	126.88[bc]	142.63	3.01[c]	3.25[c]	3.77[c]	4.56[c]
Broadcasting	124.88[c]	145.63	2.59[d]	2.65[c]	3.29[d]	4.46[c]
LS	**	NS	**	**	**	**
SE (±)	3.905	3.520	0.156	0.207	0.010	0.246
Interaction						
S × S	NS	NS	NS		**	NS

Means followed by unlike letter (s) within each column of treatments are significantly different using Duncan Multiple Range Test (DMRT)
LS: Level of significance; NS: Not significant; **Significant at 1% level of probability

number of seeds per spike and grain yield (kg/ha) than the wet season. Similarly, the two seasons differed significantly ($P \leq 0.05$) in seed weight however, only in 2016. Dry season had higher seed weight than when the crop was grown in the wet season. At the different sowing methods, except in 2015 no significant difference was observed on number of seeds per spike in 2016. Transplanting had higher number of seeds per spike followed by dibbling method. Drilling and broadcast methods on the other hand had the least number of seeds per spike. Transplanting method recorded higher seed weight and grain yield (kg/ha) compared to dibbling, drilling and broadcasting methods.

Discussion

Plant height

Differences on plant height observed between the two seasons indicated that during the wet season, rice plants grow faster than during the dry season. The shorter plants observed during the dry season production could be attributed to low temperatures observed at an early stage of growth, which might have probably slowed the growth rate. This work is in line with the report of [12] who reported that low temperatures results in slow growth in rice. The performance of transplanting and dibbling methods in producing taller plants than drilling and broadcast methods could be an indication that spacing and competition is of paramount importance in rice production. Rice under transplanting and dibbling in this study were spaced apart at 20 × 20 cm intra and inter row and therefore, had enough room to be nourished during photosynthesis and assimilates absorption from the soil. This indicated that growth dynamics and partitioning pattern in rice depends on sowing methods. This research corroborates with the findings of [13] and [14] and who reported higher plant height under transplanting than other methods of seeding.

Tiller counts per plant

The significant performance of rice grown during the dry season over the rainfed on tiller count may not be uncounted with high temperature during the months of March and April months when rice is known to tiller profusely [15,16]. Even though varietal characteristics has been known to be the major determining factor in tillering ability in rice [17], environmental factors aside temperature may also affect the process within a single variety.

At different sowing methods where, transplanted rice was observed to perform better than the other sowing methods on tiller production may be attributed to proper spacing and reduced plant density when compared with dibbling, drilling and broadcasting. Transplanting method may allow for more radiation to be intercepted by the canopy due to reduced mutual shading for effective photosynthesis. Therefore, lower tiller population observed in sowing methods other than transplanting may be connected to the higher plant density which could exert more pressure on available nutrients, space and sunlight there by reducing individual plant performance. The present study is in agreement with the early reports of [18] that transplanting enables optimal spacing which may probably increase tillers and paddy yield over poor spacing particularly broadcasting and drilling.

Number of spikes per hill

Number of spikes per hill, as it was observed to be higher during dry season than wet season, might be attributed to higher number spikes per hill at harvest when compared with the wet season sowing. Similarly, the number of panicles per hill is affected mostly by climatic conditions. The higher number of spikes per hill observed during the dry season might not be unconnected with the high temperature and solar radiation between flowering and ripening. According to [19] high day temperature and solar radiation with low night temperatures are apparently conducive for more panicle production without much reduction in spikelet number.

Higher number of spikes per hill observed in dibbling than transplanting, drilling and broadcasting for both years, could be that even though transplanting had higher tiller count but was not effective in optimizing the performance

of rice in terms of spike count per hill when compared with dibbling method. When broadcasting and drilling methods of sowing were used on the other hand no productive tillers were produced which may probably be due to population dependent stresses. High density of broadcasting and drilling might have induced mutual shading and higher competition for sunlight. This work agrees with findings of [20] who reported that at higher seeding rates, more nonproductive tillers were produced as compared to low seeding rates.

Number of seeds and seeds weight per spike

Proper water management and optimum condition for light interception could have been the reason for higher number of seeds and seed weight per spike of rice grown under dry season than during the wet season. In the dry season, when light intensity is high, photosynthetic reaction may also be high and more transition of carbohydrates for grain filling with increase in number of seeds per spike of rice. This work lends support from the earlier work of [21] who reported that number of grains per panicle, grain filling and yield are affected by light intensity particularly during reproductive and ripening phases.

In transplanting where the use of light and nutrients are most suitable, they tend to a better environment for photosynthesis and movement of assimilates therefore, performed better than all other methods of sowing. It is possible that less competition and more efficient photosynthesis in transplanting led to the increase in number of seeds per spike when compared with the high-density sowing methods of broadcasting and drilling. The lower number of seeds per spike of observed in drilling and broadcasting could therefore be attributed to the intense competition for light, nutrients and space between the adjacent plants. This report corroborates with that of [22] that transplanting in rice enables optimal plant population and proper spacing which may probably be the reason for increase in number of seeds per panicle than direct seeded rice.

Grain yield (kg/ha)

Differences in the prevailing conditions of the two seasons may have direct influence on the physiological processes that affect the plants growth, development, and grain formation. The significantly ($P \leq 0.01$) higher grain yield observed under the dry season could be due to proper water management and optimum condition for light interception. In the dry season, when light intensity is high, photosynthetic reaction may be high and more transition of carbohydrates for grain formation with increased in most yield components of rice. The result therefore, indicated that where irrigation water is available, rice can be grown in the dry season and the grain yield will be higher than in the wet season because of the higher intensity of solar radiation. During the reproductive stage solar radiation affects spikelet number per spike and during ripening it affects number of filled grains [21], which may probably affect the grain yield. Similarly, the same observations were made by De-Datta [19] while studying effect of solar radiation between flowering and ripening on grain yield of rice.

The significant performance of transplanting over the other sowing methods could be attributed to optimum plant population by planting the seedlings at specific distance which may allow for more radiation to be intercepted by the canopy due to reduced mutual leaf shading for more efficient photosynthesis, therefore the highest yield. Increase in plant population of different sowing methods, may increase competition between adjacent plants [23] which subsequently affect yield. The result of this study is in line with the earlier work of Well and Faw (1978) who reported that rice yield was limited under dense population due to reduced light interception. According to [22]) seedling transplanting and direct seed dibbling methods gave the highest dry matter and paddy yields than seed drilling and broadcasting. The report of [13] also indicated that transplanting enables optimal plant density and proper spacing which can increase tiller production and total grain yield.

Conclusion and Recommendation

Based on the results of the present study, it is worthy to mention that dry season rice production produced higher grain yield. Similarly, higher grain yield was observed when the crop was first raised in the nursery and then later transplanted. The present study therefore, recommends that beside farmer's traditional wet season rice production, they should introduce dry season rice farming which has higher potential in terms of yield. Farmers are also advised to transplant their rice instead of their traditional broadcasting method or other direct methods for higher yield.

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