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Analysis of Variation for Rain-Fed Rice Production in Dass Local Government Area of Bauchi State, Nigeria

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ABSTRACT

Background and Objective: Rice has become a prominent food crop the world over. Nigeria is the largest rice producer in Africa, but due to the high population, the current domestic production cannot meet the high demand of the populace. The main focus or objective of this study is to determine the disparity in rain-fed rice production in the Dass Local Government Area (LGA) of Bauchi State, Nigeria. **Materials and Methods:** A cross-sectional survey was conducted to collect information on the socio-economic profile, methods of rice planting and inputs used during the production season using a questionnaire. Descriptive statistics presented in tables of frequencies and percentages as well as inferential statistics such as one-way ANOVA and multiple linear regression generated from Just Another Statistical Program (JASP) version 0.16.4.0 were employed to give the most basic characteristics of rain-fed rice farmers surveyed in the study area. **Results:** The majority of the rice farmers fell within the age category of adults and old age and had no extension contact throughout the season with small fragmented landholdings. There was a significant variation in the yield component between broadcasting, direct seeding, or sowing and transplanting ($p<0.001$). Variable inputs used had significant effect on yield ($p<0.05$) except labour. **Conclusion:** Transplanting is the suitable planting method for rice in marshy areas with available and affordable labor. Providing labor-saving technology and encouraging farm mechanization can reduce over-dependency on young household members for manual labor.

KEYWORDS

Planting method, rice production, rain-fed agriculture, farm inputs, farm mechanization, transplanting

INTRODUCTION

In Nigeria, rice is one of the main grains to become a cash crop, especially in the rice-producing regions where it employs more than 80% of the local population[1]. Nigeria has the potential to be at the forefront of rice production in the continent. Nearly all of the country's ecological regions are best suited for rice production[2]. However, it was noted that the average rice yield in Nigeria was 1.2 t ha^{-1} which remains very low when compared to other countries such as India, 2.9 t ha^{-1}, Pakistan, 3.0 t ha^{-1}, China, 6.3 t ha^{-1},

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Egypt, 8.1 t ha^{-1}, Vietnam, 4.2 t ha^{-1} and USA, 7.0 t ha^{-1} [3]. There was an increase in the output of rice over the years as a result of an increase in farmland expansion. However, there has been a falling yield of rice in Nigeria and this situation led to supply deficit circumstances in the country. Nigeria's rice output might be significantly increased by making investments in technological advances, infrastructure and research, establishing the country as a key player in the global rice business. Agriculturals technological breakthroughs are critical to raising productivity, decreasing poverty, cutting production costs, enhancing rural incomes and solving global hunger[4].

The average rice production of rainfed lowland and upland systems in Nigeria is 1.8 t ha^{-1}, falling short of the targeted national norms of 5.0 and 3.0 t ha^{-1}, accordingly. These yields are poor in comparison to highland (3.0 t ha^{-1}) and floodplain (5.0 t ha^{-1}) systems[5]. Local and small-scale producers of rice in Dass LGA have produced very little domestically and cannot fill the growing consumption shortages in the region and the state as a whole. The socioeconomic status of farmers and resource management for rain-fed rice farming indirectly affect the region's overall rice production. Dass is one of the prominent areas in Bauchi State that has a comparative advantage in the production of rice, which is the basis for choosing it for this study. Most of the rice cropping systems in the region are upland and lowland production systems, which are known for being hampered by issues related to poor yield and a resultant drop in overall productivity.

To increase agricultural output with minimal investment in agricultural technologies, such analysis is essential. Understanding the connections between yield and inputs, as well as the manner of planting, may clarify to policymakers and rice farmers the nature of the issues affecting rice production in the study area and helps to create programs that will increase the productivity of rural farmers. The deduction from the study should reinforce the arguments in favour of the use of certain management approaches in rice production.

The broad objective of the study is to determine the variation in rain-fed rice production in Dass LGA of Bauchi state, Nigeria. However, the specific objectives of the study are to:

- Describe the socio-economic characteristics of rice farmers
- Estimate the variability in the yield output across different methods of rice planting
- Determine the effect of variable inputs on rain-fed rice production

Research hypotheses: To guide the study in arriving at meaningful results, the following alternate hypotheses were tested:

HA_1: There is a significant variation between broadcasting, direct-planting and transplanting on the yield performance of rain-fed rice farmers

HA_2: There is a significant difference in the quantity of variable inputs used per hectare of rice produced by rain-fed rice farmers in the area

MATERIALS AND METHODS

Research design: The study employed a cross-sectional survey design that described the variation of rice farmers at a given location over a given situation at a given point in time. In this study, the status of individual rice farmers with respect to the system of rice farming was established at the same point in time.

Area of the study: Dass Local Government Area (LGA) of Bauchi State Nigeria is located in the Bauchi South Senatorial Zone of the State. The area lies in the Northern Guinea Savanna Ecological Zone of Nigeria, at about 8°40 9°30 North and 11°-11°50' East. Due to the geographic advantages, annual rainfall

is fairly higher than in other parts of the state, ranging from 1,000 to 1,300 mm. The pattern consists of 5 months of the wet season and 7 months of the dry season. Major land uses are agriculture, with frequent scattered or dense shifting cyclic cultivation. Like other rural areas in Nigeria, the major livelihood activities include farming, fishing, hunting and carving. The main cereal crops grown are sorghum, rice and maize[5]. The study area was purposefully selected due to its comparative advantage in rice production over other LGAs in the state. The study was conducted between March to end of April, 2019.

Sampling technique: First, the target population (small-scale farmers) was identified and stratified according to their mode of agricultural production that is, rain-fed rice farmers only. The next stratification was based on the method of rice planting, which is broadcasting, direct seeding, sowing and transplanting. The districts where mostly rain-fed rice is grown were the next level of stratification. Eight out of the twelve districts were chosen and 50 farmers also, were randomly selected from each of the selected districts. A total of 400 small-scale rain-fed rice farmers formed the sample size for the study.

Instrument for data collection: A semi-structured questionnaire was used to collect background information on the stated objectives from the rice farmers in the area. The questionnaire consisted of three sections on the socio-economic characteristics of farmers, inputs use for production, method of planting and total rice output.

Method of data collection: A well-structured questionnaire was used to collect data from the respondents. This was administered in order to obtain relevant information on rice production activities in the study area.

Methods of statistical analysis: Data were subjected to a normality test where 43 response outputs were considered abnormal and reduced the data for the analysis to 357 respondents. Descriptive statistics presented in tables of frequencies and percentages were used to describe the socio-economic indices of farmers, while the One-way Analysis of Variance (ANOVA) was applied to diagnose the variability of paddy rice produced using different methods of planting. Multiple linear regression was also used to test the effect of the independent variables on the dependent variable which were all generated from Just Another Statistical Program (JASP) version 0.16.4.0.

Model specification: The Cobb-Douglas production function used in this study was specified in its linear form as:

$$\ln Yij = \ln\beta_0+\ln\beta_1 X_1 ij+\ln\beta_2 X_2 ij+\ln\beta_3 X_3 ij+\ln\beta_4 X_4 ij+\ln\beta_5 X_5 ij+Vij-Uij \quad (1)$$

Where:

Y = Paddy rice output in kg
X_1 = Quantity of seed planted in kg
X_2 = Quantity of herbicide applied in liters
X_3 = Quantity of fertilizer in kg
X_4 = Labour utilized in man-hour
X_5 = Farm size in ha
β_0-β_5 = Regression coefficients

RESULTS AND DISCUSSION

Socioeconomic profiles of rice farmers: Important socio-economic indices of the rice farmers considered in the study include age, levels of formal schooling, farming experience, household size, literacy levels and accessibility to credit facilities, among others. The result of the analysis is presented in Table 1.

Table 1: Frequency distribution for farmers' socio-economic profile

Variables	Frequency	Percentage
Age category		
Youth	95	26.6
Adults	111	31.1
Old age	151	42.3
Maximum level of formal schooling		
Never been to school	21	5.9
Primary school	86	24.1
Secondary school	159	44.5
University undergraduate	77	21.6
University postgraduate	14	3.9
Years of farming experience		
Low	166	46.5
Intermediate	167	46.8
High	24	6.7
Number of persons in the household		
One person only	24	6.7
2-7 person	145	40.6
8-13 person	92	25.8
14-19 person	75	21.0
No response	21	5.9
Extension contact per season		
None	109	30.5
Once only	89	24.9
Twice only	93	26.1
More than two times	66	18.5
Literate household members engaged in rice production		
Never been to school	121	33.9
Primary to secondary	179	50.1
Above secondary school	57	16.0
Membership in cooperative society		
Yes	48	13.5
No	150	42.0
Registered but not attending	159	44.5
Accessibility to credit facilities		
Did not use credit	134	37.5
Used credit	89	25.0
No access to credit	134	37.5

Table 1 indicated that 42.3% of the rice farmers (M = 2.16, SD = 0.816) fell within the old age category, with only 31.1% of the respondents categorized as adults and the remaining 26.6% as youths. Based on the average, rice farmers fell within the adult category (M = 2.94, SD = 0.049).

This is an indication that the majority of the rice farmers were adults/old and fell within the productive age category of 30-49 years. This implied that rice farming is being practised mainly by middle-aged farmers. The majority of the respondents (44.5%) attended secondary schools with only 25.5% who attended post-secondary level of education (undergraduate and postgraduates inclusive). This is an indication that rice farmers had average formal education below the post-secondary school level (M = 2.94, SD = 0.920).

In terms of experience in farming, about 93% of the farmers had low to intermediary farming experience with only about seven percent having a high level of rice farming experience (M = 1.62, SD = 0.612). This is an indication that there were new entrants (youth) into rain-fed rice production in the area. This was attributed to the drift of youth to farming enterprises as a result of the lack of white-collar jobs after finishing schools in the area. A priori expectation is that farmers with more years of farming experience are expected to be more knowledgeable in rice farming operations. The majority of the rice farmers (40.6%) had a household size of two to seven members in the household (M = 2.93, SD = 1.446). Thus, farm households tend to be fairly large, obviously to meet the large labour requirements during the cropping season.

Approximately, 30.5% of the rain-fed rice farmers had no contact with agricultural extension agents during the production season with only 18.5% having more than two contact with extension agents. The majority, 51% had one to two extension contacts per the rice growing season (M = 2.33, SD = 1.096). The number of contacts was not significant enough to bring about any meaningful development during the production season. Where there are no effective extension services, farmers can only fall back on their inherent farming practice as the best teacher. About 50% of the literate household members attended primary to secondary schools. Only 16% had higher educational attainment than secondary education (M = 1.82, SE = 0.684). About 86% of the respondents were not full and active members of different farmers' cooperative organizations (M = 2.32, SD = 0.699). Since cooperative societies afford members the opportunities to enjoy other socio-economic benefits, it became necessary for farmers to register with one form of cooperative organization or another. Approximately, 75% of the farmers had no access to or do not use credit facilities during the farming season (M = 2, SD = 0.866).

According to the findings of this study, youth participation in farming is low. Also, there was a low literacy rate among the farmers in the area. Low literacy could affect the farmers' chances of using improved and sophisticated inputs, thereby affecting the levels of rice production in the area. The result based on years of farming experience shows that there were more new entrants into the farming activities in the study area. Farmers with more years of experience are expected to be more knowledgeable and effective in their farming operations.

The result also, shows that the majority of rice farmers in the study area are over 40 years of age and one would expect the majority of them to have been farming for a long time. The majority of the rice farmers have household sizes between 2 and 7 persons, implying that most farmers' households have large family sizes. This is in line with the researcher's report which found that farm households tend to maintain large family sizes, obviously to meet the large labour requests during the production season[2].

The achievement of reaching total self-reliance in rice production in Nigeria is dependent on farmers' access to high-quality, demand-responsive extension services, as well as other elements including contemporary agricultural practices and better infrastructure[6]. This situation could affect resource-use efficiency since most of the farmers needed to be taught modern and improved methods of farming to increase resource-use efficiency during production periods. Further, cooperative organizations afford the advantage of economic benefits accruing to their members[7]. This was evident in the case of farmers who had to belong to one cooperative society or another before accessing the benefits of project farms, which in turn affected their competence in production positively. Access to agricultural loans has been shown in several studies to be favorably correlated with agricultural productivity. However, Nigeria's small-scale rice producers have not received enough of this essential input.

Variability on yield output across different methods of planting: A one-way independent sample Analysis of Variance (ANOVA) was conducted to assess rice yield variation across three different methods of planting (broadcasting, direct seeding and transplanting). This also enabled us to test the hypothesis that rice yield differs across different methods of planting that is (broadcasting, direct-sowing and transplanting). The ANOVA results from Table 2 suggest that the rice yield mean scores of the different methods of planting differ significantly (F2, 60.33, $p<0.001$). Levene's test showed significance ($p<0.001$), indicating unequal variance assumption. Therefore, Dunnett's T3 Test was used for post hoc comparisons to examine individual differences between groups. The results indicated a significant difference in mean score for the broadcasting method (M = 1175.67, SD = 327.59) compared to the other groups was significantly different from the direct seeding method (M = 1366.69, SD = 459.54) which was also significantly different from the transplanting method (M = 2105.96, SD = 744.33).

Table 2: Summaries of one-way ANOVA

			Test for homogeneity of variance		ANOVA		
Planting Methods	Mean	Std. Dev.	Levene's statistic	Sig.	F-value	Sig.	η^2_p
Broadcasting	1175.65	327.59	21.285	0.000	60.328	0.000	0.254
Direct seeding	1366.69	459.54	-	-	-	-	-
Transplanting	2105.95	744.33	-	-	-	-	-

Group differences

Planting methods	Mean difference	Sig.	95% CI (LL-UL)
Broadcasting-direct sowing	-191.03*	0.003	-325.95↔-56.12
Broadcasting-transplanting	-930.30*	0.000	-1332.25↔-528.34

Source: Computed from survey data, 2015, Note, CI: Confidence Interval, LL: Lower Limit, UL, Upper Limit, η^2_p: Partial Eta-square, Significant level: *p<0.05. In the group differences section, "Mean difference" represents the difference in means between two planting methods, "Sig." represents the significance level of the difference and "95% CI (LL-UL)" represents the confidence interval of the difference, Levene's Statistic is used to test the homogeneity of variance and η^2_p represents the Partial Eta-square value

The mean differences were significant at the 0.001 level. There was a significant effect of the methods of planting on rice yield in the area as reported by p and eta-square values (F_2, 60.328, $p<0.001$, $\eta^2_p = 0.254$). The partial eta-square tells us the effect of the independent methods of planting over the dependent yield outcome.

Comparing the effects of transplanting to broadcasted and direct sowing, paddy yield was much higher with transplanting. The study showed that maintaining the ideal plant population during transplanting increased paddy yields, however direct-sowing on relatively flat ploughed soils in wet conditions may become a substitute option when labour and technological efficiency for transplanting are major issues.

Knowing the difference in rice yield under different planting methods is of great importance for the development of high-quality and yield cultivation. Rice production involves various planting techniques, including manual transplantation, mechanical transplantation, direct seeding and manual broadcasting[8].

The process of transplanting rice seedlings is both laborious and costly. Direct seeding could serve as a substitute, resulting in a reduction of labor needs by more than 20% in terms of working hours[9].

Effect of variable inputs on rain-fed rice production: Variable inputs such as seed, fertilizer, farmland, labour, etc were used in rice production. Thus, this study examined the effect of these inputs on rain-fed rice production in the area. Table 3 presented the multiple regression results of the effect of variable inputs on rice output.

The table shows the results of fitting a multiple linear regression model to determine the effect between Y (rice yield) and 5 independent variables. The equation of the fitted model is:

$$Y = 3.46659-0.303657*X_1-0.128649*X_2+0.316244*X_3-0.0273142*X_4+0.966237*X_5 \quad (2)$$

Where:

Y = Paddy rice yield in kg
X_1 = Quantity of seed planted in kg
X_2 = Quantity of herbicide applied in liters
X_3 = Quantity of fertilizer in kg
X_4 = Labour utilized in man-hour
X_5 = Farm size in hectare

Table 3: Multiple linear regression results

Hypothesis	Regression weights	Beta-coefficients	T-value	p-values	Results
H_1 (Intercept)		0.139	24.874	0.001	Supported
H_1	$X_1 \rightarrow Y$	-0.304	-3.870	0.001	Supported
H_2	$X_2 \rightarrow Y$	-0.129	-2.207	0.028	Supported
H_3	$X_3 \rightarrow Y$	0.316	4.503	0.001	Supported
H_4	$X_4 \rightarrow Y$	-0.027	-1.204	0.230	Not supported
H_5	$X_5 \rightarrow Y$	0.966	9.068	0.001	Supported
R	0.843				
R^2	0.711				
R^2 (adj.)	0.707				
Cohen's (f^2)	2.64				
Std. Error Est.	0.094				
F-value	5,351	172.41		0.001	Supported

Source: Computed from survey data

The dependent variable (paddy rice yield) was regressed on predicting or independent variables of seed, fertilizer, agrochemicals, labour and farm size. The Analysis of Variance (ANOVA) table reveals that the independent variables significantly predict paddy rice yield in the area, $F(5,351) = 172.41$, $p<0.001$, which indicates that the five factors under study have a significant effect on paddy rice production. Moreover, R in the table confirmed that there was an 84% relationship between the dependent variable (Y) and the independent variables. Furthermore, the $R^2 = 71.06$ depicts that the model explains 71.06% of the variation in paddy rice yield. Cohen's (f^2) measures the effect size of the dependent variable on independent variables. The value 2.46 represents a very high effect size. Additionally, coefficients were further assessed to ascertain the influence of each of the factors on the criterion variable (rice yield). The results revealed that the quantity of seed planted has a significant but negative influence on rice yield ($\beta = -0.3037$, $T = -3.87$, $p = 0.001$). Hence, herbicide use ($\beta = -0.1286$, $T = -2.2071$, $p = 0.028$) also had a significant negative influence on rice yield. The fertilizer applied ($\beta = 0.3162$, $T = 4.5027$, $p = 0.001$) had a positive as well as significant effect on rice yield. Farmland ($\beta = 0.9662$, $T = 9.0684$, $p = 0.001$) also had a significant influence on rice output with the exception of labour.

From the analysis, it could be inferred that the variable inputs used for the rain-fed rice production had a significant effect with only the exception of labour used. It was found that paddy producers in the Kwande area were deemed to be technically inefficient in their use of agricultural resources[10]. The study on rice productivity contribution to Nigeria's growth in GDP supports the assumption that expensive fertilizer, seed, labor, herbicides and land rent costs are the major reason of poor rice yield. Furthermore, the scarcity of rice to supplement local supply may be ascribed to problems such as rising input costs, poor income from agriculture, inefficient resource management and inadequate funding[11]. It was revealed that the primary factors of productive efficiency in the region were farmland size and the amounts of fertilizer used by the farmers.

The study reveals that a majority of rice farmers in the area fall within the adult/old age category, which suggests that there is a need to attract younger farmers into the sector to ensure continuity and sustainability. The low level of literacy among rice farmers in the study area could negatively impact their ability to access and effectively utilize modern farming inputs, which could hamper agricultural productivity in the region. The low level of participation in cooperative organizations could limit the economic benefits that farmers can access, which may further reduce their productivity and profitability. The limited access to credit facilities among rice farmers may also limit their ability to invest in their farms and increase production.

The findings of this study could be used to inform policies aimed at attracting younger farmers into the sector and improving the literacy levels of existing farmers. The study's findings could also be used to develop strategies for increasing participation in cooperative organizations and improving access to credit

facilities for rice farmers. Future studies should explore the reasons behind the low levels of youth participation in rice farming in the study area and develop strategies to attract more young people into the sector. Future research should also focus on identifying ways to improve the literacy levels of rice farmers, which could improve their access to and utilization of modern farming inputs. Further research is needed to explore the reasons behind the low level of participation in cooperative organizations and develop strategies to increase participation and explore ways to improve access to credit facilities for rice farmers in the study area.

CONCLUSION

The study revealed that there was a significant difference in the rice yield across different methods of planting being practised in the study area i.e., direct sowing, broadcasting and transplanting. However, transplanting was found to be the most suitable rice planting method that gives more yields to the farmers in the area. It was, therefore, recommended that substituting manual labour by encouraging farm mechanization should be promoted in the area. Farmers should also be encouraged to embark on increased rice transplanting where necessary, rather than direct sowing or broadcasting, to enhance yield.

SIGNIFICANCE STATEMENT

The analysis of variation in rain-fed rice production in Dass Local Government Area of Bauchi State, Nigeria is essential for assessing the resilience of smallholder farmers in the face of changing weather patterns and other environmental factors. This research could help identify best practices for sustainable rain-fed rice farming in the region and inform policies aimed at promoting agricultural development and reducing rural poverty.

REFERENCES

1. Abdullahi, A., 2012. Comparative economic analysis of rice production by adopters and non-adopters of improved varieties among farmer in Paikoro local government area of Niger State. Niger. J. Basic Appl. Sci., 20: 146-151.
2. Ataboh, O.E., J.C. Umeh and P.T. Tsue, 2014. Determinants of technical efficiency among rice farmers in Kogi State, Nigeria. J. Agric. Sustainability, 6: 39-49.
3. Akinwale, J.A., A.A. Ladele and B.R. Olajide, 2016. Yield differentials among participating and non-participating rice farmers in public/private partnership in Benue and Ogun States, Nigeria. Agrosearch, 16: 25-39.
4. Awotide, B.A., A.A. Karimov and A. Diagne, 2016. Agricultural technology adoption, commercialization and smallholder rice farmers' welfare in rural Nigeria. Agric. Econ., Vol. 4. 10.1186/s40100-016-0047-8.
5. Akintayo, O.I., M.A.Y. Rahji, T.T. Awoyemi and A.I. Adeoti, 2011. Determinants of yield gap in lowland rice production in North-Central Nigeria. Agrosearch, 11: 1-10.
6. Usman, S., I.Y. Ilu and B.A. Sa'adatu, 2013. Improving farmers' efficiency in rice production in Nigeria: The relevance of agricultural extension. J. Agric. Ext., 17: 159-166.
7. Kolawole, A.A. and A. Michael, 2021. Economic analysis of rice production by small-holder women farmers in Adamawa State, Nigeria. Croatian Rev. Econ. Bus. Social Stat., 7: 1-12.
8. Bian, J.I., F.F. Xu, C. Han, S. Qiu and J.L. Ge *et al*., 2018. Effects of planting methods on yield and quality of different types of *Japonica* rice in Northern Jiangsu plain, China. J. Integr. Agric., 17: 2624-2635.
9. Tomar, R., N.B. Singh, V. Singh and D. Kumar, 2018. Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. J. Pharmacogn. Phytochem., 7: 520-527.
10. Akighir, D.T. and T. Shabu, 2011. Efficiency of resource use in rice farming enterprise in Kwande local government area of Benue State, Nigeria. Int. J. Hum. Soc. Sci., 1: 215-220.
11. Ayinde, O.E., D.A. Bessler and F.E Oni, 2017. Analysis of supply response and price risk on rice production in Nigeria. J. Agribus. Rural Dev., 43: 17-24.