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# Effect of Population Density on the Performance of Upland Rice (*Oryza Sativa*) in a Forest-Savanna Transition Zone

*S.O. Oghalo*

Department of Crop Science, Ambrose Alli University, Ekpoma, Nigeria

**Abstract:** A study to evaluate the appropriate spacing (population density) for upland rice in the forest/Savanna transition zone was carried out during the 2003 cropping season at the Teaching and Research Farm, Ambrose Alli University, Ekpoma. Three spacing (40x x30cm; 30cm x 30cm and 20cm x 30cm) equivalent to three population densities (83, 333, 111, 111 and 166, 666 plants $ha^{-1}$) and three varaities of upland rice (ITA 315; ITA 323 and a local variety) were used. The experimental design was a 3x3 factorial scheme replicated four times. Variety and spacing had significant effects on plant height, tiller numbers, leaves numbers and leaf length. There was no significant interaction between spacing and variety for these traits, except for tiller numbers. Spacing and variety also significantly affected panicle length. Plant population density of 111, 111, plants $ha^{-1}$ and ITA 315 produced the highest yield;

**Key words:** Spacing % Population density % Rice % Transition zone % Rice ecology % Paddy

## INTRODUCTION

Upland rice is the dominant ecology in West Africa [1]. A large proportion of the rice grown in this region and particularly Nigeria is cultivated by small scale, subsistence and resource poor farmers as dryland or upland rice which accounts for more than 60% of the total area given to rice growing. Upland rice refers to rice grown on both level and slopping fields that are not bounded, that is prepared and seeded under dry conditions and depends on rainfall for moisture [2]. Most of the upland rice fields are concentrated in areas with annual rainfall of 1200 mm or more on some of the unproductive soils. Grain yields are generally low and strongly dependent on the amount and distribution of rainfall. Low soil fertility, diseases and pest constrain the production of upland rice [3].

Another major cause of low seed yield in upland rice is the failure to plant at optimum densities. Different genotypes show differential responses to increasing plant population per unit land area. Many reports have indicated that planting of rice at closer spacing increases tillers numbers, panicle and grain yield [4, 5].

The spatial distribution of plants in a crop community is an important factor determining yield [6]. According to Ologunde [7], when the plant population density falls below the optimum level, all inputs of production fail to produce any appreciable effect on yield. Different varieties need specific agronomic and cultural practices to express their best potential in determining the yield responses to plant population. The response of cereals to increasing plant population is unique for each genotype. The establishment of healthy rice in the most suitable arrangement is the foundation of a successful crop production system. Every effort is, therefore, made by the farmer to achieve good yield.

In Nigeria, optimum planting densities are not usually attained because plant population densities are at the discretion of the farmer. In the face of continually declining trend in Nigeria's self sufficiency in rice production coupled with the high cost of importation of rice into the country, farmers' production efficiency must be significantly increased in order to cope with the drastically rising domestic demand. This study was therefore initiated to determine the optimum spacing for the environment and the best cultivar under such population density.

## MATERIALS AND METHODS

A field study was carried out at the Teaching and Research Farm of Ambrose Alli University, Ekpoma

**Corresponding Author:** S.O. Oghalo, Department of Crop Science, Ambrose Alli University, Ekpoma, Nigeria.

located between latitude 6°45[1] N and longitude 6°8[1] E. Ekpoma area falls within the rainforest/savanna transitional zone of South Western Nigeria. It is located within the northern boundary of the rainforest zone with mean annual rainfall of about 1200-1500 mm and mean air temperature of 27°C. The area experience district wet (April to November) and dry (December to March) seasons.

The experiment was conducted during 2003 cropping season on a loamy soil with a $P^H$ of 6.24, total N of 0.09%, organic matter content of 9.66% and ECEC of 6.22 cmo1/kg.

Two improved upland rice cultivars (ITA 315 and ITA 323) were obtained, based on their excellent characteristics from the previous experiments and a local variety commonly found in Ekpoma designated as Ekpoma local were used for the experiment, ITA 315 and ITA 323 were develop and released by the International Institute of Tropical Agriculture (IITA) Ibadan. They are both medium maturing varieties of 115 -125 days.

Ekpoma local is the most common type grown by local farmers in this environment. It grows very tall from 180-200 cm in height with very low tiller formation and late maturing.

Land preparation was done manually. Each plot measured 3.6 x 3.6 m with 1 m between plots and 1.5m between replicates. The design was a 3 x 3 factorial scheme with four replicates.

Rice seeds were sown at 4-5 seeds per hole using the dibbling method. Three spacing (40cm x 30cm; 30cm and 20cm x 30cm) representing three population densities (83, 333; 111, 111; 166, 666 plants/ha), respectively, were used. The two factors in the experiment, variety and spacing were thus imposed. Weeding was done manually thrice at 3,7 and 11 weeks after planting (WAP). Fertilizer was applied in two split doses first at 3 WAP (early vegetative stage) and the other half at 7WAP (booting stage). NPK 15 – 15 -15 was used for basal application at the rate of 300kg/ha. Urea was used for the top dressing at the rate of 90kg/ha. Both applications were by side placement.

Plant height, tiller numbers per stand, number of leaves per plant and leaf length were measured at 60 days after planting (DAP). These were determined on ten random samples per plot which were tagged. The length of the second basal leaf was measured. Measurement of the leaf was from the leaf base to the tip. All these parameters were taken on the main tiller on the stand. Data were also collected on panicle number per stand, panicle weight per plant, length of panicle, length of grain and paddy. Harvesting was done by hand at 123 DAP. Paddy yield was determined after drying to a constant weight of 15°C.

Some of the constraints experienced in the course of this study included pest attacks particularly from birds and rodents at tillering, panicle initiation and fruiting.

## RESULT

The results of this experiment showed that spacing significantly (P<0.05) increased plant height (Table 1). The local variety had the tallest plants with a mean of 75.12cm while ITA 315 had the shortest. The spacing of 20cm x 30cm had the tallest plants. However, there was no significant variety x spacing interaction.

Variety and spacing had significant effect of number or tillers. ITA 315 recorded the highest mean number of tillers while the local variety had the lowest (Table 1). The increase in tiller numbers due to spacing was marginal from wider spacing to the lowest. There was a significant interaction between variety and spacing.

As for numbers of leaves, there was a significant difference among varieties (Table 2). The local varieties produced more leaves than the others. Spacing had no significant effect on number of leaves. There was also no significant interaction of variety and spacing. Mean leaf length was statistically the same for the three spacing. The spacing of 20 x 30 cm, however, had the longest leaves (Table 2). However, the three varieties were significantly different from each other for their leaf length. There was also no significant interaction between varieties and spacing.

The main components of yield recorded in this experiment were panicle number per stand, panicle weight per plant and panicle length. Panicle numbers was significantly (P <0.05) different among varieties tested (Table 3). The improve varieties ITA 315 and ITA 323 as expected produced more panicles than the local variety. The increase in number of panicle of ITA 315 over the local variety was above 176%. Spacing did not have any significant effect on panicle number although the spacing of 20 x 30 cm recorded the highest number. There was no significant interaction between variety and spacing. For panicle weight, there were significant differences among treatments for variety and spacing.

Table 1: Effect of spacing of spacing on plant height (cm) and tiller numbers per stand of three rice varieties at sixty days after planning

| | Plant height (cm) | | | | Tiller number | | | |
|---|---|---|---|---|---|---|---|---|
| Spacing (cm) | Variety ITA 315 | ITA 351 | EKP Local | Mean | Variety ITA 315 | ITA 323 | EKP Local | Mean |
| 40 x 30 | 58 77 | 64.02 | 70.44 | 64.41 | 8.15 | 6.65 | 3.74 | 6.15 |
| 30 x 30 | 67.27 | 71.39 | 82.99 | 73.88 | 10.45 | 9.97 | 4.85 | 8.43 |
| 20 x 30 | 65.22 | 79.33 | 80.80 | 75.12 | 10.59 | 8.90 | 4.01 | 7.83 |
| Mean | 63.75 | 71.58 | 78.08 | | 9.73 | 8.48 | 4.20 | |
| LSD (P = 0.05) | | | | | | | | |
| Spacing | | | 4.970 | | | 1.616 | | |
| Variety | | | 4.970 | | | 1.615 | | |
| Interaction | | | NS | | | 3.214 | | |

NS* = Not significant at 5% level

Table 2: Effect of spacing on leaf number and leaf length of three rice varieties at sixty days after planning

| | Leaves number /plant | | | | Leaf length (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| Spacing (cm) | Variety ITA 315 | ITA 351 | EKP Local | Mean | Variety ITA 315 | ITA 323 | EKP Local | Mean |
| 40 x 30 | 4.73 | 5.60 | 6.03 | 5.46 | 58.08 | 63.20 | 67.71 | 63.93 |
| 30 x 30 | 4.63 | 4.77 | 5.20 | 4.87 | 56.32 | 62.97 | 69.19 | 62.83 |
| 20 x 30 | 5.10 | 4.80 | 5.80 | 5.23 | 63.69 | 63.25 | 67.67 | 64.87 |
| Mean | 4.82 | 5.06 | 5.68 | | 59.36 | 64.14 | 4.20 | |
| LSD (P = 0.05) | | | | | | | | |
| Spacing | | | NS | | | NS* | | |
| Variety | | | 0.619 | | | 4.132 | | |
| Interaction | | | NS* | | | NS* | | |

NS* = Not significant at 5% level

Table 3: Effect of spacing on panicle number, panicle length and grain length of three rice varieties

| Variety | Panicle numbers/plant Variety | | | | Panicle weight/plant Variety | | | | Panicle length (cm)Variety | | | | Grain length (cm)Variety | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spacing (cm) | ITA 315 | ITA 351 | EKP | Mean Local | ITA 315 | ITA 323 | EKP | Mean Local | ITA 315 | ITA 323 | EKP | Mean Local | ITA 315 | ITA 323 | EKP | Mean Local |
| 40 x 30 | 7.89 | 6.04 | 2.93 | 5.62 | 9.49 | 8.45 | 6.73 | 8.22 | 35.47 | 35.24 | 39.15 | 36.62 | 1.01 | 0.99 | 0.82 | 0.94 |
| 30 x 30 | 9.24 | 5.92 | 3.32 | 6.16 | 10.89 | 9.38 | 8.67 | 9.64 | 26.85 | 27.24 | 30.72 | 28.27 | 1.01 | 1.04 | 0.85 | 0.97 |
| 20 x 30 | 8.61 | 7.00 | 3.06 | 6.62 | 10.07 | 10.49 | 8.71 | 9.76 | 30.40 | 26.56 | 4.22 | 30.39 | 1.04 | 1.00 | 0.82 | 0.95 |
| Mean | 8.58 | 6.32 | 3.10 | | 10.15 | 9.44 | 8.04 | | 30.91 | 29.68 | 34.70 | | 1.02 | 1.01 | 0.83 | |
| LSD (P = 0.05) | | | | | | | | | | | | | | | | |
| Spacing | | | NS | | | | 0.802 | | | | 4.455 | | | | NS | |
| Variety | | | 1.392 | | | | 0.804 | | | | NS* | | | | 0.043 | |
| Interaction | | | NS* | | | | NS* | | | | NS* | | | | NS | |

NS* = Not significant at 5% level

ITA 315 had the highest mean weight of 10.5g with the local variety having the lowest, 8.04g (Table 3). The spacing of 30 x 30 cm had more weight than the others. There was also no significant interaction between spacing and variety. When panicle length was measured, only spacing means were significantly different (P<0.05) from each other. There was also no significant interaction of variety x spacing. Paddy yield was significantly increased by both spacing and variety. The spacing of 30 x 30 cm recorded the highest yield (Fig. 1). ITA 315 had the highest yield and the local variety the lowest. ITA 315 had an increase of more than 139% over the local variety. Generally, the yield of the improve varieties more than doubled that of the local variety.

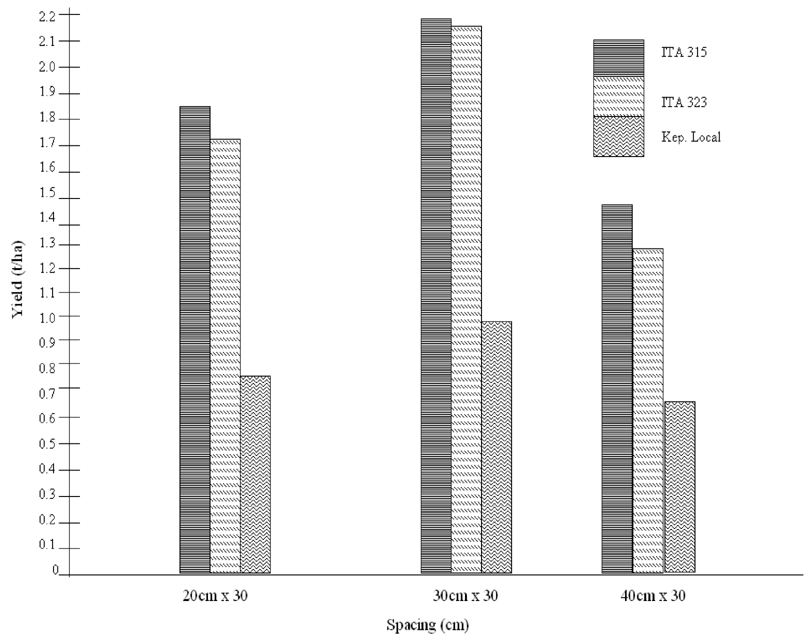


Fig. 1: Effect of spacing on paddy yield (t/ha) of three varieties. Vertical bar represents LSD at 5%

## DISCUSSION

From the results on plant height, the local varieties had the tallest plants compared to the improved varieties. Local varieties of rice tended to grow vegetatively at the expense of yield due to inherent genetic make up of the cultivar. This is one attribute of the local variety that renders it susceptible to lodging thereby reducing its yield quality [8]. Increase population density also increased vegetative characters such as plant height, tiller numbers leaves number and leaf length. Tillering was significantly affected by both variety and spacing although very few tillers were found particularly in the local variety. The reason for low tiller formation in the local variety could be due to poor tillering abilities of local varieties. According to a report of the International Rice Research Institute (IRRI) [9], the major constraint to rice production particularly in developing countries is the inability to get improved varieties by farmers as local varieties are still being used. Tillering is a major factor that determines yield in rice [10]. According to Lu [11], the major constrain to upland rice production among others is the low tillering ability of varieties. It was also observe in this study that there was a significant interaction between variety and spacing on tillering (Table 1). A significant interaction between population density and variety is an indication that optimum plant population would vary with variety. This is an indication that the distance between plants could be an important factor in determining yield. This work is in agreement with the findings of IITA scientists [12], found that greater tiller number were produced at higher population densities.

Spacing did not show any significant difference on panicle number formed. Variety however affected it. Panicle number was generally low although increased population density enhanced it. Breseghello and Perpertuo [13], found that panicle number increased with increased population density. Similar results were obtained by Ologunde [7], who found similar relationship between plant densities and nitrogen fertilization in maize. The panicle weight of the three varieties varied significantly with different planting densities. ITA 315 had higher panicle weight over the other varieties. Panicle weight is a significant factor in the final yield of rice as reported by Olofintoye and Ajayi [14]. Ighalo and Remison [5] found that a positive correlations between panicle numbers and yield and panicle weight and yield.

The results showed that spacing significantly increased yield of rice at medium to close spacing. Yield was infact more than doubled by decreasing spacing from 40 x 30 cm to 20 x 30 cm. This may have been as a result of maximum utilization of nutrients and other resources in the soil which may not have been utilized with wider spacing. The very low yield obtained in this study was probably due to the extensive pest attack suffered at panicle and heading stages. First, from sap sucking Heteroptera when grains are young and milky and finally from a flock of rice eating birds. The sporadic nature of birds' damages to rice is due firstly to the highly mobile nature. Secondly, to the great variation in the pest population caused by climatic changes and thirdly, birds seriously damage cultivated rice mainly when they are unable to obtain a sufficient supply of their natural food of wild grass seeds. Stanishaw [15] had earlier rated grain eating birds as the most damaging pests of rice in West Africa. There were also sporadic attacks from rodents *Twyrramus Swinderramus* (grass cutter), which reduced rice grain yield and maximum damage occurred at tillering and heading stage. Islam and Mofazzel [16] had rated rats as the most important among the vertebrate pests of rice.

In this experiment, close spacing (high population density) increased tillering, panicle numbers, panicle weight and paddy yield. Similar results were reported by Fagade and De Datta [17] and Ighalo and Remison [5] have highlighted the direct relationship between these agronomic traits of rice and rice yield.

## CONCLUSION

Different varieties get to their optimum yield at different spacing (population densities). In the study under focus, a spacing of 30 x 30 cm (medium to high population density) was found to have enhanced both vegetative and yield traits of rice and consequently produced the highest yield.

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