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PRODUCTIVITY OF IRRIGATED AND RAINFED RICE (Oryza sativa L.) AS INFLUENCED BY SEEDLING AGE AND ROW SPACING, IN KURU PLATEAU STATE NIGERIA

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ABSTRACT

A Field experiment was conducted in Kuru Plateau State, Nigeria, during the dry and wet seasons of 2016, 2017 and 2018 to study the effect of seedling age and row spacing on the production of rice. A lowland variety FARO 44 was used for the trial and the treatments used consisted of four seedling ages of 15,17,19 and 35-days after the seeds were sown in the nursery with direct seeded as control, three different inter and intra row spacings of 15cmx15cm, 20cmx20cm and 25cmx25cm and two seasons (wet and dry). Seedling age and the row spacings were factorially combined and laid in a randomized complete block design (RCBD) and replicated 3 times. Six separate trials were carried out, three during the dry season and three during the wet season. The results indicated that seedling age, row spacing and cropping season, had significant ($P \leq 0.05$) effect on the growth and yield characters of the crop. Transplanting 19-day old seedlings produced significantly ($P \leq 0.05$)taller plants with more tillers, panicles/hill, spikelets/panicle, higher seed weight and grain yield than the other seedling ages used. Similarly, growing the crop at row spacing of 25x25cm produced significantly ($P \leq 0.05$) taller plants with higher number of tillers, more panicles/hill, spikelets/panicle, higher seed weight and grain yield than the other spacings used. Growing the crop during the dry season on the other hand, produced significantly ($P \leq 0.05$) higher number of tillers, seed weight and grain yield, while the wet season cropping had taller plants, heavier panicles and more spikelets/panicle. Based on the results obtained, transplanting 19-day old seedlings at a row spacing of 25x25cm during the dry season seemed more promising for higher rice production in the study area.

Keywords: Seedling age, Row Spacing, Transplanting, FARO 44, Kuru, Nigeria.

1. INTRODUCTION

In many parts of Africa including Nigeria, the major challenges facing agriculture is how to increase farm production to meet challenging food needs without degrading the natural resource base. The agricultural sector is the most important in African economy employing as much as 50 to 80 percent of the labor force (Johnson, 1961). The most critical problems in Africa today is how to increase agricultural production to meet increasing food demand arising from an increase in population pressure (Mensah, 1989; Timberlake, 1990; Pretty, 1995). Rice being a staple food crop in most countries in Africa could help solve the plethora of social challenges facing the continent. In Nigeria the demand for rice is continuously growing with per capita consumption increasing at more than 3% annually since the late 1990s with per capita consumption put at

35kg/person/year (USDA, 2010). At the same time Nigeria is experiencing a significant population growth rate estimated at 3.0% per annum (FAO, 2015). This increase in population growth rate also comes with intensification of urbanization, and shifting preferences towards 'premium' rice. Rice is considered an essential crop in Nigeria and is produced in most of the farming ecologies, however production has remained mostly small scale which account for 80% of total production, Nigeria is one of the largest rice producers in Africa and equally one of the largest rice importers in the world (FAO, 2017). Over the past few years rice production has increased due to renewed vigor from the part of the government through favorable policies geared towards increasing production, however productivity remain low. In order to keep this pace of growth and to increase productivity new technologies needs to be encouraged with attendant high adoption rate among the small holder farming population, such technologies include early transplanting of seedlings, sowing of single seedlings per hill as well as increase row spacing among others.

2. MATERIALS AND METHODS

A Field experiment was conducted during the dry and wet seasons of 2016, 2017 and 2018 at the research farm of potato program, National Root Crops Research Institute (NRCRI), Kuru Plateau State, Nigeria. The research was carried out to study the productivity of rain fed and irrigated rice as influenced by seedling age and row spacing under both dry and wet cropping seasons. Kuru is located at latitude 08° 44´N and longitude 09º 44´E. The altitude ranges from 1200 meters to a peak of 1,870 meters above sea level around Shere hills. Though situated in the tropical zone, the high altitude means that Kuru has a near temperate climate with an average temperature of between 18ºc and 22ºc. The experimental material, variety FARO 44 was sourced from the National Agricultural Seed Council (NASC). It is a lowland variety otherwise known as Sippi 692033 and the variety was released and registered between 1990 and 1991. It is a medium maturing type, taking 110-120 days to mature, high yielding between 4 to 8t/ha, tolerant to blight and has long grains. The treatments consisted of 4 seedling transplanted ages, 15,17, 19 and 35 days after sowing in the nursery, direct seeded plots considered as control and 3 inter and intra row spacing (15cm x 15cm, 20cm x 20cm and 25cm x 25cm). These treatments were tested in two different cropping seasons (wet and dry) within a year for three years. The 4 transplanted ages and control and the 3-row spacing gave fifteen treatment combinations which where factorially combined and laid out in Randomized Complete Block Design (RCBD) with three replications. According to SRI recommendations, seed rates of 8.5kg/ha and 17kg/ha which gave an equivalent of 163gms and 108.8gms of seeds for the transplanted and direct sown plots, respectively were used.

Before application in the nursery and for the direct sown plots, the seeds were first soaked in water for 24 hours, where floated seeds (immature) were discarded. A nursery bed measuring 1mx10m (10m²) was then prepared close to the research field so as to minimize transportation time between seedling removal from the seed bed and its transportation to the field. The pre-germinated seeds were broadcasted in the nursery and covered lightly with sand and then covered again with a thin layer of mulch (using dry grass). The mulch was however, removed 3 days after. The nurseries beds were irrigated daily for both the dry and wet season experiments. The seedlings emerged 5 days after sowing the seeds in the nursery for both the dry and wet

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season nurseries. For the direct sown seeds however, it took 10 days for the seedlings to emerge on the plots. The plots were marked out in a 'grid' with square pattern at a spacing of 15cm x 15cm, 20cm x 20cm and 25cm x 25cm inter and intra row for both the direct and transplanted plots. All the seeds were sown at the intersection of the lines. For the direct seeded plots, three seeds were sown per hill, which were later thinned to one seedling per stand after seedlings were fully established at 3 weeks after emergence. Under the dry season, sowing was carried out on 28 February 2016, 2017 and 2018, transplanting of seedlings started 15 days after sowing in the nursery corresponding to 10 days after emergence. In the same vein, under the wet season experiment, sowing was carried out on the 5 of June 2016, 2017 and 2018 and the transplanting of seedlings started 15 days after sowing in the nursery which corresponds to 10 days after emergence. During the dry and wet seasons, selective pre-emergence herbicide was applied using knapsack sprayer immediately after the seeds were sown in the nursery as well as the direct seeded plots. Thereafter, manual weeding was carried out at 6, 10 and 14 weeks after sowing (WAS) in order to keep the plots free of weeds at all times.

Data Collection and analysis

In each of the experimental plots of 4m x 4m (16m²), a 0.5m -.05m was removed to eliminate border effect, leaving a net plot of 3.5m x 3.5m (12.25m²). A sample area (m²) was taken using quadrat drill calibrated in 1m x1m. Quadrat drill is one of the many sampling tools commonly used to collect data in the field. It helps restrict the exercise within the quadrat and plants used for sampling were randomly selected from within it. Inside the 1m x 1m quadrat, the planting geometry of 15 cm x 15cm, 20cm x 20cm, and 25cm x 25cm gave 44 plants, 25 plants and 16 plants respectively from which ten (10) plants (hills) were randomly selected for tagging. Tagging was done using red ribbon which can easily be visible. All the data for growth and yield characters however, were taken only at maturity (harvest). All data taken were imputed into MS excel and SPSS version 22 package and subjected to statistical analysis of variance (ANOVA) while significant difference among treatment means were separated using the Duncan Multiple Range Test (DMRT) following the procedure of Duncan (1955).

3. RESULTS AND DISCUSSIONS

3.1 Plant Height (cm)

Table 1 shows that age of seedlings, row spacing and cropping season had significant effects on plant height ($P \leq 0.05$). Seedlings transplanted at 17-day old had taller plants (69.05cm), followed by seedlings transplanted at 19-day old (68.24cm. There was no difference in plant height between 15- and 35-days seedlings (66.67cm) and (66.61cm) respectively; in contrast the direct seeded crops had the least plant height (65.63cm). The significantly taller plants among the different seedling ages, indicates the importance of seedling age in transplanting of rice. The increase in plant height observed with younger seedlings could be due to less root damage during uprooting, as their root length is shorter and less established compared to the 35 days old seedlings and direct seeded crops. Transplanting shock with younger seedlings is minimal compared to older seedlings and direct seeded crops. This result is in agreement with the findings of Durga et al. (2015) who found out that plant height at maturity better reaches its maximum when the crop was transplanted at 14-days after emergence.

Row spacing of 20x20cm produced taller plants which were at par with that of 25x25cm. Row spacing of 15x15cm on the other hand, had the least plant height. Taller plants with wider spacing compared to closer spacing showed that more nutrients are available to individual crop for establishment and continuous growth while at closer spacing, competition sets in and growth is retarded, Kumal et, al (1998) and Singh et al (2002) obtained similar results and therefore attributed taller plants with optimum seedling density and wider spacing

Growing rice during the wet season produced taller plants (75.75cm), in contrast shorter crops were produced when the crop was grown during the dry season (58.72cm). This shows that rice being a water loving plant, grow faster in the wet season than during the dry season, shorter plants observed during the dry season could be as a result of the regulation of irrigation water applied during the experiment. These findings are in conformity with the reports of Shimono et al. (2007) who observed that adequate water supply leads to taller plants

3.2 Number of tillers/hill

Age of transplanting, row spacing and cropping season had significant effects ($P \leq 0.05$) on the number of tillers/hill. More tillers (70.75) were produced by 19 day old seedlings followed by 17-day old transplanted seedlings (69.46). Seedlings transplanted on day 15 and 35 as well as the direct seeded had fewer tillers at 68.51, 68.81, and 68.77 respectively. Higher number of tillers observed when seedlings were transplanted at a young age with barely 2 leaves shows the importance of seedling age in tillering of rice plant. However, the result further revealed that the seedlings to be transplanted should not be very young as less than 19 day old. Therefore, when younger seedlings are transplanted, it results in more productive tillers. However, when the seedlings are too young, for example 15 days after sowing in the nursery, they result in less number of tillers and this could be because the seedlings are too tender/delicate and when uprooted for transplanting they suffer transplanting shock and root damage. This observation corroborates the result of an earlier study carried out by Uphoff et al. (2003), who concluded that when seedlings are uprooted at 10 days after emergence, they produce fewer tillers compared to 14 days after emergence. Seedlings transplanted at 25x25cm inter and intra row spacing consistently had higher number of tillers (71.96), followed by seedlings transplanted at row spacing of 20x20cm (68.86). Seedlings transplanted/sown at 15x15cm had fewer tillers (67.00). The higher number of tillers observed under 25x25cm spacing could be an indication that all the plants at such spacing, had all the required mineral resources at their disposal to grow and produce more tillers without much competition. The present result agrees with an earlier study by Balasubramanian and Palaniappan (1991) that attributed higher number of tillers to more space for individual plants to put forth more tillers. Dry season rice produced higher number of tillers (73.43) than the wet season cropping (65.08). There was more solar radiation during the dry season which promoted higher photosynthesis. This result is corroborated by an earlier study by Yoshida, (1973), and a more recent report by Sridevi and Chellamuthu (2015), that higher tiller number could be obtained under dry season cropping.

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Table 1: Effect of seedling age, row spacing and cropping season on plant height and number of tillers/hill of rice taken at harvest.

Treatments	Plant height (cm)	Number of tillers/hill
Seedling Age (days)		
15	66.67c	68.51c
17	69.05a	69.46b
19	68.24b	70.75a
35	66.61c	68.81c
DS(Control)	65.63d	68.77c
LS	*	*
SE (±)	0.703	0.491
Row Spacing (cm)		
15x15	66.24b	67.00c
20x20	68.19a	68.86b
25x25	67.29a	71.96a
LS	*	*
SE (±)	0.545	0.380
Season		
Dry	58.72b	73.43a
Wet	75.75a	65.08b
LS	*	*
SE (±)	0.445	0.310

Means followed by same letter (s) in the same column do not differ significantly following Duncan Multiple Range Test (DMRT) LS= Level of Significant. *= Significant at 5% level of probability.

3.3 Panicle length

Table 2 shows that age of seedlings, row spacing and cropping season had significant effects ($P \leq 0.05$) on panicle length. The 35 day old transplants and direct seeded crops produced longer panicles while 19-day old transplanted seedlings recorded shorter panicles. This could be due to less number of tillers that were produced by the direct seeded and the 35 day old seedlings. The direct seeded took about 10 days to emerge to the surface, while the 35 day old transplanted seedlings may have suffered root damage during uprooting, both reasons could result in delay of establishment of the seedlings in the field and thus affect panicle length. When fewer tillers are produced there is less competition among the individual tillers hence the resulting panicles grow longer but they may produce fewer grains compared to 19 day old seedlings with more tillers and spikelets per panicle. This finding is in conformity with the results obtained by Mondal et al. (2013), who concluded in an earlier study that when tillers are few, they experience less competition and therefore produce longer panicles, but that the final grain yield will be influenced more by the number of tillers than by the length of the panicle. At the different row, 25x25cm produced longer panicles, followed by row spacing of 20x20cm while row spacing of 15x15cm had shorter panicles. This could be due to lack of competition for sunlight and nutrients between the widely spaced plants, while the densely spaced plants tend to undergo intense competition which then resulted in shorter panicles. Similar trends were reported by Mahmood et al. (2002) who noted that rice transplanted at wider spacing of 20x15cm or 30x15cm recorded significantly longer panicles than at closer spacing of 15x15cm. Longer panicles produced when older seedlings (35 day old) were transplanted during the dry season, could be due to few number of tillers produced by the older seedlings which gave rise to minimal competition for nutrients and sunlight. Similar results were reported by Sarker et al. (2002) who observed that transplanting older seedlings could result in longer panicles due to less number of tillers.

3.4 Number of panicles/hill

Age of transplanting, row spacing and cropping season had significant effects ($P \leq 0.05$) on number of panicles/hill. The 19 day old transplanted seedlings produced higher number of panicles followed by 17-day old seedlings. There was no difference in number of panicles between the 15, 35 day old seedlings and the direct seeded crops. This result indicates that transplanting younger seedlings might have increased the number of panicles produced per hill. This could be that when seedlings are transplanted early, they experience minimal transplanting shock. On the other hand, 35 day old seedling had less number of panicles per hill this could be that when seedlings remained longer in the nursery, the transplanting shock is more severe. Direct sown plants had the least number of panicles per hill, which could be due to the fact that nutrients in the endosperm were utilized to promote growth through the top soil. The findings of this study is supported by the earlier results of Sarker et al. (2002) and Akbar (2004) who noted that when rice seedlings are transplanted early the crop experienced minimal transplanting shock which then help the crop to put out more tillers and eventually more panicles. It was also pointed out that when 30-day old seedlings are transplanted they developed less number of panicles which could be as a result of transplanting shock. Row spacing of 25x25cm produced more panicles, followed by row spacing of 20x20cm, while row spacing of 15x15cm had the least number of panicles. This could be because of enough space provided which led to less competition for nutrients in the soil between seedlings. Similarly, wider spacing affords the plant leaves more area for solar radiation interception, thereby resulting in higher rate of photosynthesis, which ultimately increases panicle formation. The result of the study is in conformity with the findings of Biradir (2009) who stated that planting in square method at wider spacing of 25x25cm resulted in profuse tillering under SRI cultivation which might have facilitated plants for better utilization of resources, therefore leading to the production of more panicles/hill.

3.5 Panicle weight (g)

The significant effect ($P \leq 0.05$) of seedling age, row spacing and cropping season on panicle weight shows that 19 day old transplanted seedlings produced heavier panicles, followed by seedlings transplanted on day 17. The direct seeded crops and 35 days old produced the least panicle weight. This result shows that when seedlings are transplanted early, they tend to absorb enough moisture from the soil to carry out their photosynthetic activities, therefore the accumulation of carbohydrate in the panicles tend to increase the weight of the panicles. Lighter panicle as a result of transplanting older seedlings (35 days old), which was at par with direct seeded crops, could be due to poor grain filling leading to lower panicle weight. This result corroborates the work of Alam (2006) who recorded heavier panicles under 18-day old seedlings and lighter panicles when 12 days old seedlings were transplanted. The different row spacing showed that the 25x25cm seedlings produced heavier panicles, followed by seedlings transplanted at row spacing of 20x20cm; 15x15cm had the least panicle weight. This could be because wider spacing enables the seedlings to develop more roots due to lack of competition between the plants. Also with enough nutrients and available sunlight, more carbohydrate is produced leading to more grain filling and thus heavy panicles. Similar views were also expressed by Alam (2006) who noted that panicle weight varied with various planting geometry with maximum weight obtained under 25x25cm spacing.

Table 2: Effect of seedling age, row spacing and cropping season on panicle length, number of panicles/hill and panicle weight of rice taken at harvest

Treatments	Panicle length(cm)	Number of panicles/hill	panicle weight (g)
Seedling Age (days)			
15	21.59d	33.94c	28.58b

17	21.72b	34.93b	28.46b
19	21.69c	35.33a	28.79a
35	22.21a	33.93c	27.46c
DS(Control)	22.16a	33.66c	27.68c
LS	*	*	*
SE (±)	0.103	0.372	0.273
Row Spacing (cm)			
15x15	21.70c	32.40c	26.13c
20x20	21.90b	35.06b	27.77b
25x25	22.02a	36.52a	30.71a
LS	*	*	*
SE (±)	0.079	0.288	0.212
Season			
Dry	21.81	34.89	25.89b
Wet	21.94	34.42	30.51a
LS	NS	NS	*
SE (±)	0.065	0.235	0.173

Means followed by same letter (s) in the same column do not differ significantly following Duncan Multiple Range Test (DMRT).LS= Level of Significant. *= Significant at 5% level of probability. NS = Not Significant

3.6 Number of spikelet/panicle

Table 3 shows a significant effect ($P \leq 0.05$) of seedling age, row spacing and cropping season on number of spikelets/panicle. More spikelets were observed with the 19 day old transplanted seedlings, followed by 17-day old transplanted seedlings. On the other hand, fewer spikelets were produced by seedlings transplanted on day 15 and 35 as well as the direct seeded crop. This result indicates that transplanting young seedlings under good cultural practices and weather conditions could lead to the production of higher yield characters like spikelets. Transplanting

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younger seedlings before the fourth phyllochron tend to experience minimal transplanting shock, which might have given rise to more tillers, which subsequently led to the production of more spikelets per panicles. Similar results were reported by Durga et al. (2015), who observed that when seedlings are transplanted early before the fourth phyllochron, they tend to suffer minimal transplanting shock and as a result they quickly establish in the field. Row spacing of 25x25cm had higher number of spikelets/panicle, while 15x15cm had the least number of spikelets/panicle. This could be due to minimal competition for nutrients as well as efficient use of available resources for photosynthesis. This result agrees with the earlier results of Hay and Walker (1989) who observed that increase in plant population as a result of closer row spacing may lead to increase inter plant competition which may subsequently affect yield and yield components. The wet season crop had more spikelets/panicle than dry season crop. This could be due to the fact that rice is a water loving plant, however high soil moisture content especially during the reproductive stage could lead to spikelet sterility. Similar results were obtained by Hay and Walker (1989), and therefore concluded that spikelet sterility usually occurs when there is too much soil moisture content during the reproductive stage.

3.7 One thousand seed weight (g)

Age of seedlings, row spacing and cropping season showed significant ($P \leq 0.05$) variation on one thousand seed weight. The 17 and 19-day old seedlings produced heavier seeds, compared to the other treatment combinations. This result showed that there was better grain filling of younger transplants than the older ones. When seedlings are transplanted early with minimal transplanting shock, they tend to establish better with healthy and heavier grains, this present report lend support for the results of Paul et al. (2016), who reported that when seedlings are transplanted early, they experience better performance both in growth and yield characters leading to better grain filling and thus heavier seeds. Inter and intra row spacing of 25x25cm produced higher seed weight than the other row spacing used, while transplanting at 15x15cm consistently had the least seed weight. This result indicates that there is better utilization of mineral resources and sunlight for photosynthesis when seedlings are transplanted at such distance. These findings agree with that of Banison (2002), who noted that seedlings spaced 25x25cm had higher 1000 seed weight due to minimal competition among them with better grain filling. Considering the two seasons under investigation, there was a significantly ($P \leq 0.05$) higher seed weight observed with the crop grown during the dry season compared to when the crop was cultivated during the wet season. This could be attributed to favorable conditions like high intensity of light and efficient water management which probably led to higher availability and translocation of nutrients during growth and development stage of the crop. The decrease in one thousand seed weight recorded during the wet season may also relate to low sunshine hours like the cloudy days as earlier reported by Benitos (1992).

3.8 Grain yield (t/ha)

Grain yield of rice as influenced by seedling age, row spacing and cropping season showed that there was a significant ($P \leq 0.05$) variation among all the treatments, the 19-day old transplanted seedlings consistently had higher grain yield than the rest of the treatments applied. This was followed by 17-day old seedlings, while 15-day old transplanted seedlings produced the least grain yield, which was at par with the 35-day old transplanted seedlings and the direct seeded plots. Increase in grain yield with younger seedlings compared to 35 day old and direct seeded crops, shows the importance of transplanting young seedlings rather than aged ones and transplanting rice rather than direct seeding in the field. The reason could be that at younger age the transplanting shock is minimal because the root is shallow, unlike older seedlings that are deeply rooted and could therefore suffer root damage and more intense transplanting shock. These findings are in conformity with the findings of Uphoff (2003) and Zhang et al. (2004) and the recent report of Durga et al (2015) that higher grain yield was obtained when 12 and 14 days old seedlings were transplanted. At the different row spacing, it was observed that row spacing of 25x25cm produced significantly ($P \leq 0.05$) higher grain yield followed by seedlings transplanted at row spacing of 20x20cm. Seedlings transplanted at the row spacing of 15x15cm however, had the least grain yield per hectare. This shows that with minimal competition between the plants for mineral resources, and probably better ability of the plant leaves to utilize the energy from the sun for photosynthesis and translocation of assimilates, yields are bound to increase significantly. These findings corroborates reports of several other researchers e.g. Uphoff et al. (2003), Luikham (2008) and Thawait et al. (2014), who concluded that higher grain yields were obtained at wider rice spacing e.g 25x25cm compared to narrow spacing of 15x15cm. Between the two seasons, significant difference was also observed. The dry season crop production, resulted in higher grain yield than the wet season production, this could be due to better water management, optimum conditions for light interception, aerating the soil using cono weeder, soil being kept moist rather than flooded and planting one seedling per hill as recommended by SRI. During the dry season, there was higher intensity of solar radiation, and therefore, with good water management, photosynthetic activities will equally be high and more translocation of carbohydrates for grain formation and filling as well as other yield components of rice will be increased. Similar observations were made by De-Datta (1981) while studying the effect of solar radiation between flowering and ripening on grain yield of rice

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Table 3: Effect of seedling age, row spacing and cropping season on spikelet/panicle, 1000 seed weight and grain yield of rice taken at harvest

Treatments	Spikelet/panicle	1000 seed weight(g)	(Grain yield t/ha)
Seedling Age (days)			
15	154.96c	22.68b	3.57c
17	170.32b	24.08a	4.38b
19	180.25a	24.00a	5.28a
35	154.87c	22.62b	3.33c
DS(Control)	156.57c	22.76b	3.14c
LS	*	*	*
SE (±)	4.668	0.400	0.070
Row Spacing (cm)			
15x15	139.44c	21.63c	4.27b
20x20	158.79b	22.63b	4.50b
25x25	191.95a	24.42a	5.29a
LS	*	*	*
SE (±)	3.615	0.310	0.054
Season			
Dry	128.75b	24.11a	6.04a
Wet	198.04a	23.37b	4.12b
LS	*	*	*
SE (±)	2.952	0.253	0.044

Means followed by same letter (s) in the same column do not differ significantly following Duncan Multiple Range Test (DMRT) LS= Level of Significant. *= Significant at 5% level of probability

4. CONCLUSION AND RECOMMENDATIONS

Based on the results obtained from the study it can be concluded that transplanting of rice at 19 days after sowing in the nursery and at a spacing of 25x25cm during the dry season, increased the grain yield.

Therefore based on the findings the farmers in the study area are advised to i) raise seedlings in the nursery and later transplant at the age of 19 days after sowing in the nursery, ii) during transplanting farmers should space the seedlings as wide as 25x25cm for optimum rice production, iii) dry season should be practiced for all year round rice production and higher yield of the crop.

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