International Journal of Innovative Food, Nutrition & Sustainable Agriculture 14(2):1-9, April-June, 2026

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doi:10.5281/zenodo.19789639

Evaluation of Several Diameters and Depths of Isolated Cell Circular Cavities to Raise Individual Rice Seedlings for Transplanting under System of Rice Intensification (SRI)

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ABSTRACT

Conventional method of raising rice seedlings produces low yield as a result of root interconnection among the broadcasted rice seedling resulting to transplanting of traumatic seedlings. The main purpose of this study was to evaluate various isolated cell circular cavities (ICCC), which is economically and productively paramount for developing individual rice seedling tray. The experiment comprised of ten treatments and three replications including the control treatment. The ICCC comprised of 15.9 mm, 11.8 mm and 8.7 mm diameter. The control treatment was broadcasted rice seeds in a petri dish. Heights of rice seedlings were recorded at 8, 10, 12 and 15 days after sowing (DAS). Correlation analysis were used to determine the relationship between the seedling height and both the depth and diameter of ICCC while Analysis of Variance (ANOVA) were used to determine the significant differences among the various treatments. There is no significant difference between the ICCC with the highest depth (T2, T5 and T8) and the ICCC with the shortest depth (T4, T7 and T10). Finally, the study concluded that it is economically and productively wise to use the cavity with 2 cm depth and 8.7 mm diameter in designing and fabricating of SRI single seedling tray.

Keyword: Transplanting, individual rice seedlings, Seedling tray, Seedling height

1.0 INTRODUCTION

Rice (*Oryza Sativa*) is a staple food in many countries of Africa and other parts of the world. More than 3.5 billion of the world's population use rice as their staple food, which translates to at least half of the people living in the world (Lanessa, 2017). According to the most recent official data, rice is the world's second most important cereal crop following only corn (Rice statistics and facts 2020). They directly provide not less than 42% of the world's required caloric intake.

Nigeria has a potential land area for rice production of between 4.6 million and 4.9 million ha. But it is not counted among the leading world rice producers, as it contributes to 0.8 % of world rice share (Lanessacago, 2017). The statistic of rice production in Nigeria shows a 5% increase every year. For the first half of year, 2016, it has already risen by 2.67%. The import rates have also increased to 5,850 from 4,800 during the same period of time. Now, Nigeria is only capable to supply 49% of domestic demand of rice (Lanessacago, 2017). In 2015, Nigerians spent not less than N̄1bn on rice consumption, adding that while spending had drastically reduced, consumption had increased because of increased local production of the commodity. The consumption rate now is 7.9 million tones and the production rate has increased to 5.8 tons per annum. But the increase in production has not reached the sufficiency level. According to the Nigeria rice production statistics, Nigerian rice importations have made up 50% of the local consumption rates (Lanessacago, 2017).

The practice contributes to both healthier soil and healthier plants, supported by greater root growth and the nurturing of soil microbial abundance and diversity (Mallareddy et,al. 2023). It is based on a number of well-founded agro ecological principles. SRI concepts and practices have also been successfully adapted to upland rice. Some commonly cited benefits are higher grain yield and better rice quality as a result of the proliferation of roots from single seedlings, stronger stalks, more established tillers and climate change readiness. Raising single seedlings for SRI only uses 10% of the seeds, otherwise normally used for other ways of planting rice. The often quoted rice nursery figures for the amount of seeds needed in kg of seeds per ha of paddy area are 50 kg for conventional nursery bed, 25 kg for the conventional tray, and 5 kg for SRI nursery tray (Zubairu et al., 2015).

One of the factors that contribute to higher rice grain production under SRI is transplanting at a very young age. This is based on katayama tillering model, which explained that a large number of tillers can be produced when rice is transplanted at an early age (Laulaine, 2011). The maximum number of tillers produced by rice plants is inversely proportional to the length of phyllochron, which is dependent upon the extent of stresses (Dwipa, et,al. 2020).

Rice is immensely consumed in Nigeria by almost everybody. In addition, there is high potentiality of its production in the country. But the farmers are cultivating it below the desired/expected quantity due to various obstacles. The obstacles are many but among the leading ones are transplanting shock or using of traumatic seedlings for transplanting as a results of broadcasting of the rice seeds in nursery and removing or separating single seedling from the cluster of seedlings. This leads to poor growth and development of the rice seedlings as well as low rice yield after cultivation. Generally, uprooting rice seedlings for transplanting in conventional practice causes root deterioration (Ota 1975; Sakai & Yoshida, 1957). It has been reported that around a range of 40 to 60% of the rice roots during transplanting significantly reduces subsequent rice roots and shoot dry matter build up (Ros, et al. 1998). Therefore, there is a need to adopt the SRI standard of raising single rice seedlings in order to increase shoot and root dry matter accumulation during transplanting as well as avoiding transplanting traumatic seedlings in paddy field and to acquire bumper harvest.

The main purpose of this study is to evaluate various isolated cell circular cavities (ICCC), which is economically and productively paramount for developing individual rice seedling tray using ICCC for raising individual rice seedlings in SRI farming. The specific objectives of this study are: To determine the possibility of raising single rice seedlings in an ICCC individually, to determine the relationship between the seedling`s height and height of ICCC, to determine the relationship between the seedling`s height and diameters of the ICCC and to determine the best depth and diameter that is suitable for ICCC for fabricating single rice seedling tray.

2.0 MATERIALS AND METHODS

Preparation of Growing Cavities

Three different plastic pipes with diameter 8.7 mm, 11.8 mm and 15.9 mm was used to improvise the various ICCC. The pipes were cut into three different depths (2 cm, 3 cm and 4 cm) for each of the three plastic pipes. Nine plastic pipes was used as isolated growing cavities in each replication which was kept on a wooden tray to serve as the base. The ICCC comprised of different diameters and depths. The depths and diameters of the ICCC was measured using venier caliper.

Soil and Compost Mixture

The rice seeds for the study was organically fertilized using compost manure with a composition of four different ingredients at different proportions. It consists of cow dung (30 %), goat dung (30 %), cowpea husk (35 %) and ash (5 %) as illustrated in Figure 1 (Haden et al. 2007). Soil was taken from a paddy field of Mashangwari forest in Gashua town of Bade local government area of Yobe state. The soil was then being grounded and sieved using 2 mm sieve. The compost was mixed with soil using soil to compost ratio of 1:1 (Wayayok et al. 2017).

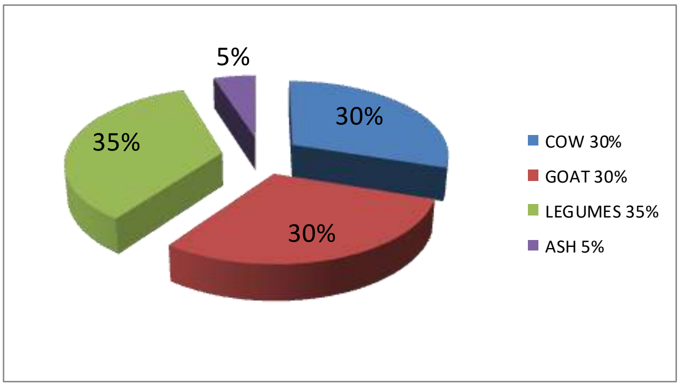

Figure 1. Compositions of compost ingredients

Sorting and Priming of Rice Seeds

Seed sorting was done through putting a fresh egg in water, followed by applying salt in to the water until the egg floated. The rice seeds were then be soaked in the salty water in order to remove the floated seeds as immature with less endosperm, and the sunken seeds was considered as the best seeds for the experiment (Ramanadane & Ponnuswamy 2019). The rice seeds were immediately rinsed for several times to wash away the salt from the seeds. The seeds were soaked in water for 48 hours and later drained and enclosed in piece of cotton sheet. The enclosed seeds in the cotton sheet was kept in high temperature location in order to allow the seeds to be sprouted for easy germination process. This brilliant technique was already being validated by many scientific and research institutions on different crops. It also plays a vital and wonderful role in hastening the rate of germination and early seedling establishment especially in dry and semi-arid regions (Mondal, S., & Bose, B. 2019).

Experimental Details

The treatments comprised of various circular cavities with different heights and diameters as isolated cells, comprising of 10 treatments and three replications as shown in Table 1.

Experimental Design

The experiment was done using complete randomized design (CRD) with ten treatments and three replications as shown in Figure 2. Each replication consists of ten circular cavities.

Table 1. Details of the various treatments

S/No	Treatments	Description
1	T1	Control
2	T2	4 cm depth X 15.9 mm diameter
3	T3	3 cm depth X 15.9 mm diameter
4	T4	2 cm depth X 15.9 mm diameter
5	T5	4 cm depth X 11.8 mm diameter
6	T6	3 cm depth X 11.8 mm diameter
7	T7	2 cm depth X 11.8 mm diameter
8	T8	4 cm depth x 8.7 mm diameter
9	T9	3 cm depth X 8.7 mm diameter
10	T10	2 cm depth X 8.7 mm diameter

Sowing of Rice Seeds

The rice variety to be used in this experiment was faro-44. The sorted and primed seeds were sown individually in the ICCC using soil to compost ratio of 1:1. The experiment was done under shade at the nursery station of Umar Suleiman College of Education Gashua in Yobe State of Nigeria. The sown seeds were irrigated twice daily (morning and evening) using watering car up to 15 days after sowing (DAS) to prevent drought and to sustain moist soil condition.

T1R1	T1R3	T4R3	T5R4	T1R1	T8R3	T4R2	T10R1	T9R3	T6R2
T7R2	T9R1	T10R3	T2R3	T1R1	T9R2	T5R3	T6R3	T2R1	T3R3
T2R2	T5R1	T3R2	T10R2	T1R1	T8R2	T7R1	T1R2	T4R1	T8R1

T= Treatment and **R**= Replication

Figure 2 Layouts of ten treatments and 3 replications using CRD

Data Collection and Analysis

The heights of rice seedlings were measured from three rice seedlings which were randomly selected, measured and recorded from each replication at 8, 10, 12, and 15 DAS. The measurement was started from the base of the seedlings up to the tip of the leaf. The measurement was done using ruler. Statistical package for social sciences (SPSS) was used to analyze the data collected. In order to determine the relationship among the diverse treatments, Correlation analysis was used. Analysis of variance (ANOVA) was used to determine the significant differences among the various treatments and means were compared using Student-Newman-Keuls (SNK) assumption.

3.0 RESULTS AND DISCUSSION

Effect of ICCC on Rice Seedlings

Rice seeds were germinated and grow under healthy condition in the control (broadcasted) treatment as well as in all the various cavities as represented by all the ten treatments. The result has shown that the attempt to raise individual rice seedlings in isolated cell circular cavities is not impossible due to presence of healthy seedlings (Figure 3). Transplanting of single seedling per hill is among the components of SRI. But the control treatment, which is raising of seedlings using broadcasting method is not accepted in SRI due to seedlings roots interconnection (Figure 4) compare to the seedling raised using ICCC which can be easily removed for transplanting as shown in Figure 5. In order to separate one seedling from the seedlings raised using broadcasting practice, trauma affect the seedlings. Therefore, this allow the farmers to be transplanting traumatic seedlings which result to the delay of growth and development of the young seedlings due to time taken to regain its normal condition as a result of the negative effect caused by the trauma. This reduces the growth and development of the rice seedlings as well as the final rice grain yield during harvest. The use of ICCCsupports healthier rice seedlings by minimizing root disturbance during transplanting, unlike the conventional broadcasting method that causes root entanglement and transplanting shock Reduced transplanting trauma enhances early seedling establishment, growth and ultimately improves rice yield (Food and Agriculture Organization, 2022)

Figure 3. Seedlings raised in various isolated cell circular cavities

Figure 4. Seedling root interconnection using broadcasting practice

Figure 5. Non traumatic Single rice seedling raised using ICCC

Relationship between Diameter of ICCC and Seedling Height

The study showed that the ICCC with diameter of 15.9 mm under three different depth of 2 cm, 3 cm and 4 cm (T2, T3 & T4) gave positive relationship with the height of rice seedlings as indicated by Spearman correlation coefficient (r= 0.696). The result depicted that as the depth of ICCC increases, the heights of rice seedlings was also increased. This may be due to the increase in the amount of nutrient and water retained by the highest circular cavity which serves as food to the rice seedlings.

Changing of the depth of ICCC contributed to about 48.4% to the variation of heights of the rice seedlings as indicated by coefficient of determination (r^2=0.484).

The study also showed that the ICCC with diameter of 1.18 cm under three different depth of 2 cm, 3cm and 4 cm (T5, T6 & T7) gave positive relationship with the height of rice seedlings as indicated by Spearman correlation coefficient (r= 0.929). The result depicted that as the depth of ICCC increases, the heights of rice seedlings was also increased. This may be due to the increase in the amount of nutrient and water retained by the highest circular cavity which serves as food to the rice seedlings. Changing the depth of ICCC contributed to about 86.3% to the variation of heights of the rice seedlings as indicated by coefficient of determination (r^2=0.863).

The result revealed that the ICCC with diameter of 0.87 cm under three different depth of 2 cm, 3cm and 4 cm (T8, T9 & T10) gave positive relationship with the height of rice seedlings as indicated by Spearman correlation coefficient (r= 0.911). The result depicted that as the depth of ICCC increases, the heights of rice seedlings was also increased. This may be due to the increase in the amount of nutrient and water retained by the highest circular cavity which serves as food to the rice seedlings. Changing the depth of ICCC contributed to about 83% to the variation of heights of the rice seedlings as indicated by coefficient of determination (r^2=0.830).

Relationship between Depth of ICCC and Seedling Height

The study showed that the ICCC with depth of 4 cm under three different diameters of 1.59 cm, 1.18 cm and 0.87 cm (T2, T5 & T8) gave negative relationship with the height of rice seedlings as indicated by Spearman correlation coefficient (r= - 0.844). The result depicted that as the diameter of ICCC decreases the height of rice seedlings increased. This may be due to the decrease in the amount of water taken away from the soil surface as a result of decrease in the surface area of the ICCC which reduces the area of contact with the soil surface in the ICCC. Because the water retained by the soil serves as food to the rice seedlings. Changing the diameters of ICCC contributed to about 71.2% to variation in heights of the rice seedlings as indicated by coefficient of determination (r^2= 0.712).

The study showed that the ICCC with depth of 3 cm under three different diameters of 1.59 cm, 1.18 cm and 0.87 cm (T3, T6 & T9) gave negative relationship with the height of rice seedlings as indicated by Spearman correlation coefficient (r= - 0.768). The result depicted that as the diameter of ICCC decreases, the height of rice seedlings increased. This may be due to the decrease in the amount of water taken away from the soil surface as a result of decrease in the surface area of the circular cavities which reduces the area of contact with the soil surface in the ICCC. Because the water retained by the soil serves as food to the rice seedlings. Changing the diameters of ICCC contributed to about 59% to variation in heights of the rice seedlings as indicated by coefficient of determination (r^2= 0.59)

The study showed that the ICCC with depth of 2 cm under three different diameters of 1.59 cm, 1.18 cm and 0.87 cm (T4, T7 & T10) gave negative relationship with the height of rice seedlings as indicated by Spearman correlation coefficient (r= - 0.640). The result depicted that as the diameter of ICCC decreases, the height of rice seedlings increased. This may be due to the decrease in the amount of water taken away from the soil surface as a result of decrease in the surface area of the ICCC which reduces the area of contact with the soil surface in the ICCC. Because the water retained by the soil serves as food to the rice seedlings. Changing the diameters of ICCC contributed to about 41% to variation of heights of the rice seedlings as indicated by coefficient of determination (r^2= 0.41).

Effect of Various ICCC Sizes on Seedling Height

The height of rice seedlings grown individually in a ICCC under treatment 1, 2 and 4 (T1, T2 & T4) revealed significant differences with treatment 5 and 6 (T5 & T6), but no significant difference found with the remaining treatments (T3, T7, T8, T9 & T10) as shown in Figure 6. Despite the fact that 15.9 mm with 4 and 3 cm depth (T5 &T6) depicted the highest result among the various treatments but still showed the same results with 2 cm depth X 15.9 mm diameter and 8.7 mm diameter with 4, 3 and 2 cm depth. Therefore, considering the area occupied by the ICCC, the number of seedlings raised with constant area and the result found after statistical analysis, it is economically and productively wise to use 2 cm depth X 8.7 mm diameter in designing and fabricating of SRI single seedling tray.

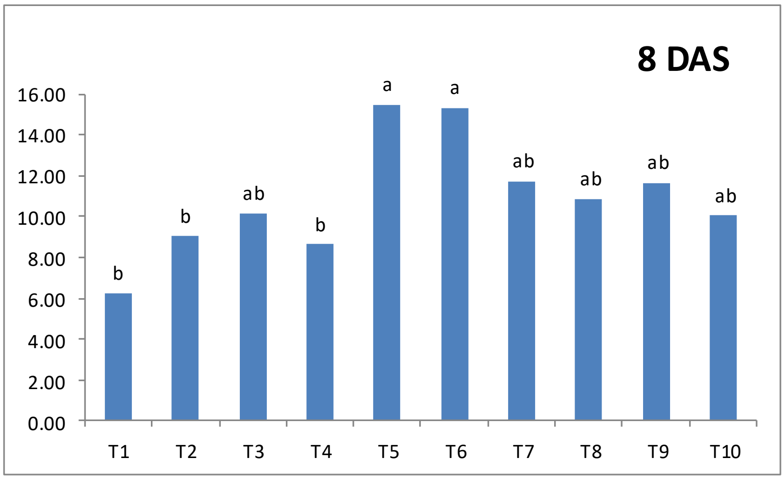

Figure 6. Height of rice seedlings raised using ICCC at 8 DAS

While at 10 DAS the height of rice seedlings grown individually in a ICCC under treatment 1, 2 and 8 (T1, T2 & T8) revealed significant differences with treatment 5 and 6 (T5 & T6), but no significant difference found with the remaining treatments (T3, T4, T7, T9 & T10) as shown in Figure 7. Despite the fact that the two (2) ICCC with diameter of 1.18 cm and depth of 4 & 3 cm (T5 &T6) depicted the highest result among the various treatments but still showed the same results with T3, T4, T7, T9 and T10 (i.e. 2 cm depth X 15.9 mm diameter and 8.7 mm diameter with 4, 3 and 2 cm depth). Therefore, considering the area occupied by the ICCC, the number of seedlings raised with constant area and the result found after statistical analysis, it is economically and productively wise to use 2 cm depth X 8.7 mm diameter in designing and fabricating of SRI single seedling tray.

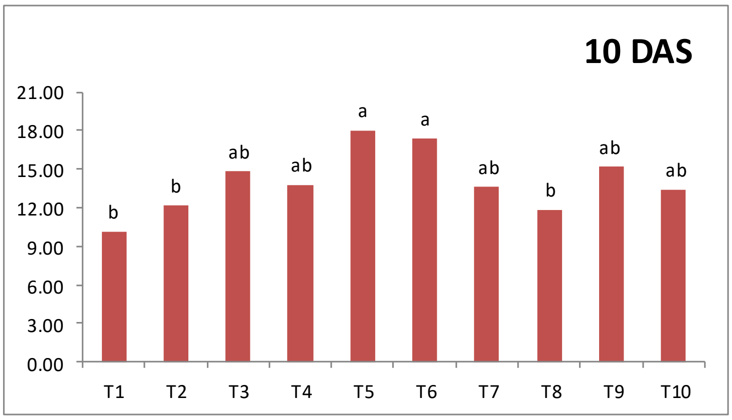

Figure 7. Height of rice seedlings raised in ICCC at 10 DAS

Also at 12 DAS, the height of rice seedlings grown individually in a ICCC under treatment 1, 3 and 4 (T1, T3 & T4) revealed significant differences with treatment 5, but no significant difference found with the remaining treatments (T2, T6, T7, T8, T9 & T10) as shown in Figure 8. Despite the fact that the cavity with diameter of 1.18 cm and depth of 4 cm (T5) depicted the highest result among the various treatments but still showed the same results with 4 cm depth X 15.9 mm diameter (T2), 3 cm depth X 11.8 mm diameter and 2 cm depth X 11.8 mm diameter (T6 & T7) and 8.7 mm diameter with 4, 3 and 2 cm depth (T8, T9 & T10). Therefore, considering the area occupied by the ICCC, the number of seedlings raised with constant area and the result found after statistical analysis, it is economically and productively wise to use 2 cm depth X 8.7 mm diameter in designing and fabricating of SRI single seedling tray.

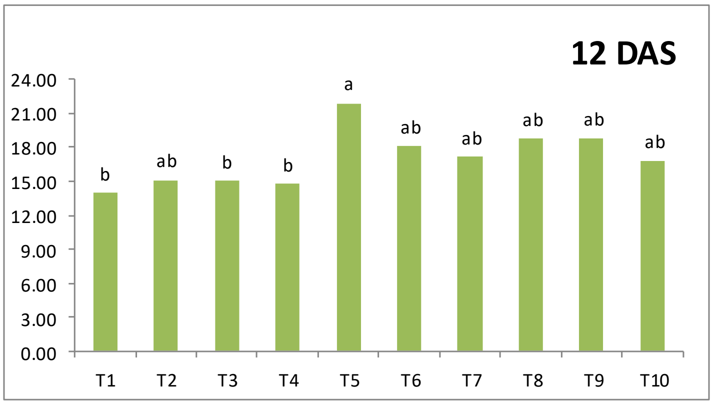

Figure 8. Height of rice seedlings raised in ICCC at 12 DAS

Finally, at 15 DAS, the height of individually grown rice seedlings in a ICCC under treatment 1, 3 and 4 (T1, T3 & T4) revealed significant differences with treatment 5 (T5), but no significant difference found with the remaining treatments (T2, T6, T7, T8, T9 & T10) as shown in Figure 9. Despite the fact that the ICCC with 4 cm depth X 11.8 mm diameter (T5) depicted the highest result among the various treatments but still showed the same results with 4 cm depth X 15.9 mm diameter (T2), 2 cm depth X 11.8 mm diameter (T7) and 3 cm depth X 8.7 mm diameter (T9). Therefore, considering the area occupied by the ICCC, the number of seedlings raised with constant area and the result found after statistical analysis, it is economically and productively wise to use 2 cm depth X 8.7 mm diameter (T10) in designing and fabricating of SRI single seedling tray.

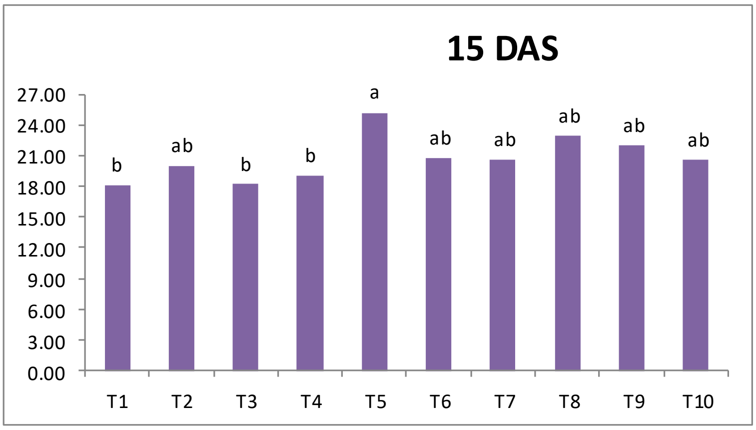

Figure 9. Height of rice seedlings raised in ICCC at 15 DAS

4.0 CONCLUSIONS

The study confirmed the possibility of raising rice seedlings using ICCC individually. The relationship between the height of rice seedlings and both the depth and the diameter of ICCC permit the identification of the best size (depth and diameter) of the ICCC. The study finally showed that it is economically and productively wise to use 2 cm depth X 8.7 mm diameter (T10) in designing and fabricating of SRI single seedling tray. This will allow the farmers to raise and transplant non traumatic seedlings in paddy fields which will lead to getting higher number of tillers per hill, harvesting higher rice yield per hectare as well as higher income and better livelihood.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of Tertiary Education Trust Fund for providing funding for this research. Appreciation is also extended to the Department of Agricultural Education for granting access to the laboratory facilities and experimental farm used in the course of this study.

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