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Optimizing Nursery Trays for Minimizing Seedlings per Pick of Transplanter in SRI

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The System of Rice Intensification (SRI) revolutionizes rice cultivation through innovative practices. It is a methodology that enhances rice yields by optimizing plant growth and resource utilization. This study, conducted in 2023 at TNAU, Coimbatore, India, focuses on the optimization of nursery tray configurations for enhanced seedlings per pick during rice transplantation, contributing to more efficient SRI cultivation. The selection of nursery trays plays a crucial role in determining seedling distribution, impacting crop yield and agricultural efficiency. Through the manipulation of seed density, depth of filling, and tray configuration, the research aims to improve the seedlings' per-pick outcome during mechanized transplantation. The investigation involves 12 tray combinations with varying seed density (40 gm, 60 gm, 80 gm, and 100 gm) and depth of fillings with different heights in tray (15 mm, 20 mm, and 25 mm). Seedling growth parameters are meticulously assessed, including shoot length and root length to evaluate tray efficacy. The study also analyzes

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transplanter compatibility and the influence of seed density and depth of filling on seedling growth. Results highlight the tray configuration with an 80 gm seed density and 25 mm soil height as optimal, offering 1-3 seedlings per pick and minimal missing hills less than 1%. The endeavor to minimize picks per hill through precise tray combinations represents a crucial step in addressing the challenges of modern agriculture and shaping a more sustainable and productive future.

Keywords: Seedlings minimizing; rice intensification; nursery tray configurations.

1. INTRODUCTION

Rice, a staple food for over half of the world's population, holds immense global importance. It serves as a primary dietary source of energy and nutrition. Talking of India, Rice is the most important food crop of India, covering about one-fourth of the total cropped area and providing food to about half of the Indian population, and there are about 10,000 varieties of rice in the world out of which about 4,000 are grown in India, making it spectacularly diverse [1]. India contribute to 60% of world rice needs [2].

The System of Rice Intensification (SRI) is an innovative methodology for rice cultivation that focuses on optimizing plant growth by improving root and shoot development through practices such as transplanting single seedlings with wider spacing, promoting healthier plant growth, and enhancing resource efficiency [3].

Benefits include 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 [4]. Other advantages are water saving, enriched soil from the addition of organic matter, while using less agro-chemicals and less water. However, the disadvantages of SRI are labour intensive. Back breaking manual transplanting, the awkward postures assumed, and exposure to heat are some of the risk factors that reduce the productivity and efficiency of the farmers. Hence there is a need to mechanize those operations in order to reap the well documented benefits from SRI.

A rice transplanter is a mechanized agricultural tool designed to efficiently transfer young rice seedlings from nurseries to fields. It streamlines the labour-intensive process of manual transplantation, enhancing planting precision and overall crop productivity. The transplanter to align with SRI specifications, necessitating the identification of optimal transplanting spacing, seed rate, planting pattern and single seedling per pick. The research conducted by Shamshiri et al*.* [5] led to the conclusion that, in Malaysia, the SRI method should prioritize the practice of planting one seedling per hill to achieve maximum yield. This emphasis on single seedling per hill planting holds equal significance for its implementation in the context of India.

In the context of this research, the Hi-Tech walking-type transplanter with 4 rows was chosen as the experimental equipment. This selection was made due to its potential for modification to align with the System of Rice Intensification (SRI) method. It was deemed more suitable for optimization when compared to the other two available options: the Yanmar riding-type transplanter with 8 rows and the Yanji riding-type transplanter with 8 rows, as indicated by Suthakar et al*.* [6].

In SRI transplanter systems, various types of trays are employed for efficient seedling transplantation. These trays are designed to accommodate single seedlings per hill, ensuring uniformity and precision. Two primary types of trays are commonly used: single seedling trays and multiple seedling trays. Single seedling trays are designed to hold and transplant individual seedlings per hill, aligning with the SRI method's emphasis on one seedling per planting station. On the other hand, multiple seedling trays can accommodate more than one seedling per hill, which may not be suitable for SRI cultivation practices aiming for single seedling per hill planting.

While single seedling trays offer advantages, their higher cost can be a concern. However, integrating the benefits of single seedling trays, such as improved seedling quality and uniformity, into the design of multiple seedlings trays can yield cost-effective solutions [7].

The careful manipulation of seed density and depth of filling (soil media/mixture) within nursery trays offers a tangible pathway to achieving these goals. The significance of the seed density lies in its direct influence on seedling density and spacing within trays, determining not only the number of seedlings per pick but also the uniformity of distribution [8]. The depth of filling in the tray is of paramount importance as it directly influences seedling root development, mat formation, and overall tray quality. Adequate soil volume ensures robust root networks, enabling successful transplantation and contributing to healthy plant establishment and growth.

The conventional transplanters using multiple seedlings trays types are picking more than three seedlings per pick, which not suitable for SRI cultivation, during transplanting operation. Major paddy SRI cultivation is undertaken using multiple seedling trays type. As the trays are not standardized to single seedling per pick for transplanter in SRI cultivation. Not adhering to the practice of sowing a single seedling per hill in the System of Rice Intensification (SRI) carries several disadvantages. Firstly, overcrowding of seedlings leads to intense competition for resources like water, nutrients, and light, resulting in stunted growth and reduced yield potential. Secondly, the lack of spacing inhibits proper root development and ventilation, making plants more susceptible to diseases and pests. Additionally, the absence of uniformity hinders effective weed management and creates difficulties during post-transplanting activities such as weeding and thinning. Overall, deviating from the single seedling per hill guideline in SRI compromises plant health, productivity, and resource optimization.

Many attempts have been made on the suitable ways to mechanize transplanting of the young, single rice seedlings for SRI [9,10,11,5,12]. Most researchers were looking at finding a suitable machine to do job of transplanting the delicate young single seedlings, but less concerned about the tray configuration required by the mechanical finger of the transplanter for optimizing the seedling per pick. Planting a single seedling per hill offers advantages such as optimized resource allocation, reduced competition, and enhanced plant growth, resulting in improved crop yields and sustainable agricultural practices. Minimizing seedling per pick can be solved in two ways: firstly, by design of finger and secondly by modifying the tray which is to be feed into transplanter.

Despite the suitability of single seedling trays for SRI cultivation, due to lack of appropriate tray hinders the utilization of transplanters to its maximum potential. This research delves into the crucial aspect of optimizing nursery tray configurations to achieve single seedlings per pick in multiple seedlings trays type for rice transplantation. The study endeavours to adapt the multiple seedling tray type for SRI practices by standardizing seed density and depth of filling (tray height) to align with SRI standards.

2. MATERIALS AND METHODS

2.1 Introduction

The primary objective of this research was to investigate the seedlings picked per hill for the selection of an optimal tray configuration, within the niche scope of the System of Rice Intensification (SRI) method. This study aimed to enhance the precision and efficiency of seedling transplantation by identifying the tray combination that ensures accurate and consistent seedling placement, thus contributing to the advancement of SRI practices in rice cultivation.

2.2 Selection of Seed

The selection of seed is a foundational aspect of growing seedlings nursery in a tray. It involves careful evaluation and choice of high-quality, viable seeds to ensure uniform germination and robust seedling growth. The latest CO55 was chosen, variety released by TNAU in year 2022, to suit different kinds of agro-climatic conditions of Tamil Nadu and to the farmers to overcome the constraints like low yield, drought, pest and diseases and difficulties in farm mechanization. CO55 is a derivative of ADT 43 x GEB 24 and short duration superfine variety with 115 days. The average yield of the culture is 6050 kg/ha. It has milling of 66% and head rice recovery of 62%. This variety is suitable for Sornavari / Kar / Kuruvai / Navarai in Tamil Nadu. It is medium slender fine rice with cooking quality [13].

2.3 Parameter Selection & Design of Experiment

In this study, the importance of seed density and depth of filling as selection parameters for optimizing nursery tray configurations is underscored. Seed density directly affects the number of seedlings per pick, thereby influencing crop yield and uniformity. The depth of filling in a

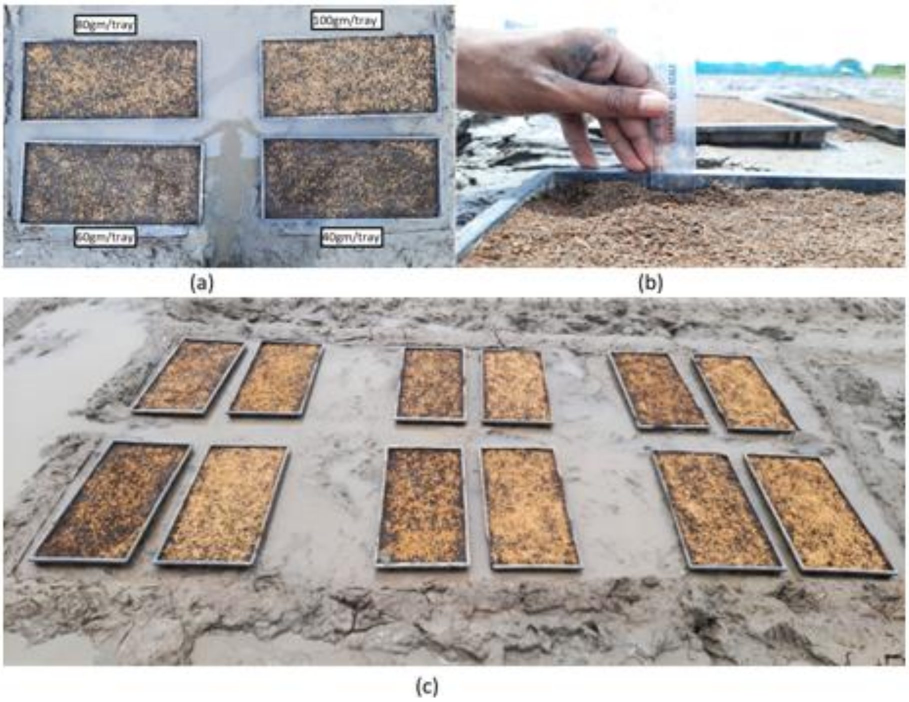

Fig. 1. Selection of Tray Parameters; each image depicts unique parameters: (a) Seed Density, (b) Depth of fillings and (c) Representation of 12 trays

tray, indicated by the depth of filling, plays a significant role in root development, mat formation, and seedling survivability, thereby impacting overall transplanting efficiency. The various treatment is evaluated by transplanters ability to dispense number of seedlings and recording missing hills.

In alignment with the studies conducted by [10,5], where the seed quantity per tray was approximately 100 gm, encompassing the range of 60-100 gm per tray, this research adopted four distinct seed density (40 gm/tray, 60 gm/tray, 80 gm/tray, and 100 gm/tray). Given the constraint of the maximum tray depth being 25 cm, the approach to varying soil volume involves adjusting the depth of filling at three distinct levels (D3, D2, D1): 25 cm, 20 cm, and 15 cm. This strategy allows for the exploration of soil depth's influence on seedling growth and distribution, given the available tray space, thus contributing to a comprehensive understanding of seedlings per pick during transplantation.

The experimental design selected for this study aims to assess the impact of seed density and depth of filling on optimizing nursery tray configurations. The variables under investigation are seed density, with four levels, namely, 40 gm/tray (S1), 60 gm/tray (S2), 80 gm/tray (S3), and 100 gm/tray (S4), and volume of soil, comprising three levels: 40 cm3 (D1), 700 cm3 (D2), and 100 cm3 (D3).

A full factorial design has been employed to comprehensively explore the combined effects of these two variables on the outcomes of interest. This design allows for the examination of all possible combinations of seed density and depth of filling levels. By incorporating all potential combinations, this approach ensures a thorough evaluation of the interactions between seed density and soil volume. Consequently, this design provides a comprehensive understanding of how these factors collectively influence nursery tray configurations.

The utilization of a full factorial design also facilitates the identification of main effects and potential interactions between the variables. This approach is particularly valuable for determining the individual influence of seed density and soil volume on metrics such as seedling count, crop yield, and uniformity. Furthermore, the experimental design aids in minimizing bias and confounding effects, as it systematically considers all possible scenarios. Each treatment is replicated three times to minimise error.

Seed Density Levels: S1, S2, S3, S4
Volume of Soil Levels: D1, D2, D3

Total Treatments = Number of Seed Density Levels × Number of Soil Volume Levels
Total Treatments = 4 (seed density levels) × 3 (soil volume levels)
Total Treatments = 12

2.4 Nursery Tray Preparation

The nursery tray was prepared using a soil mixture composed of field soil, Farm Yard Manure (FYM), and fibrous coir pith in the ratio of 7:2:1 [14], as described by previous studies [10]. Prior to tray preparation, rice seeds were soaked for 24 hours and 34 hours in a jute bag until sprouting occurred, following the conventional seed soaking method [15]. All aspects of nursery tray preparation and data collection were conducted at the Tamil Nadu Agricultural University, Coimbatore (Fig. 2).

Two key independent parameters *viz.,* seed density and depth of filling were varied during the tray preparation process. The nursery trays were prepared with four different seed density (40 gm/tray, 60 gm/tray, 80 gm/tray, and 100 gm/tray) and three distinct depths of filling (D1, D2 and D3) (Fig. 3).

The research utilized standard trays with dimensions of 440 × 220 × 25 mm for conducting the study. The tray was initially filled with the desired depth of filling minus five millimetres, leaving space for a 5mm layer of dry soil to be added later, with the assistance of a 30cm measuring scale. Following the filling of the mixture into the tray, a gentle water pour was conducted. Subsequently, the intended gram of seeds was sparsely distributed onto the bed and covered with a layer of dry soil, approximately 5mm thick. To complete the process, the bed was thoroughly drenched with water using a rose can. This sequence was iterated until the entire designated area was adequately covered. Resulting in a total of 12 unique tray, each representing a specific seed density and soil volume combination. Seeds were uniformly spread by hand across all trays to ensure consistent seeding density [16].

Fig. 2. Media preparation: (a) Measuring of coco pit for media preparation (b) Mixing of soil, coco pit and FYM

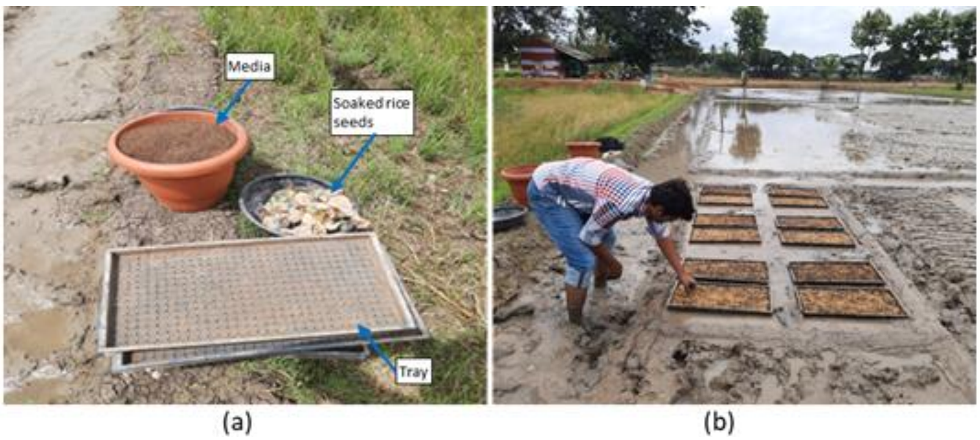

Fig. 3. Tray preparation (a) Image containing tray, soil media and soaked seeds

2.5 Nurturing of Tray

The nurturing of rice nursery trays forms a crucial phase in the cultivation of rice, laying the foundation for successful seedling growth and subsequent transplanting. The nursery was irrigated using a rose can as needed (two or three times a day) to preserve soil moisture. Precautions were taken during the initial 5 days after sowing (DAS) to shield the nursery from heavy rainfall. Starting from the 6th DAS, a thin layer of water was maintained around the seedling mats. The water was drained from the nursery 2 days prior to the removal of seedling mats for the transplanting process. Regarding the step of spraying the fertilizer solution, the application of a solution containing 0.5% urea and 0.5% zinc sulphate was carried out at 8-10 days after sowing (DAS).

2.6 Measurement of Physiological Parameters of Different Tray

Fig. 4. Measuring of shoot and root length

Physiological parameters of rice seedlings encompass vital aspects of growth and development. These parameters include shoot length, root length, and stem thickness, offering insights into seedling vigor, health, and potential for successful transplantation.

Shoot length and root length are the major physiological parameters that provide insights into seedling quality. Longer shoot length indicates robust aerial growth potential, while increased root length signifies efficient nutrient and water absorption capabilities. The choice of shoot length and root length as key physiological parameters holds significance due to their direct correlation with seedling vigor, establishment, and transplanting success, providing insights into overall plant health. These parameters are reliable indicators of both above-ground and below-ground growth dynamics, offering a comprehensive assessment of seedling quality and potential performance.

The various parameters of rice seedlings, including shoot length and root length were meticulously studied and recorded from the different trays. For each tray, 10 random samples were carefully selected and subjected to thorough washing to eliminate soil particles, after which precise measurements were taken. The length of shoot and root were measured using 30 cm scale.

2.7 Testing of Tray Nursery Using Transplanter

In accordance with the System of Rice Intensification (SRI) method, which recommends single seedling sowing per hill using the check row method, the number of seedlings per pick was closely examined. The transplanter is operated to transplant the seedlings from each tray onto the field by help of finger. The transplanter's fingers serve to gently grasp and hold individual seedlings from the nursery tray. They ensure precise and consistent placement of seedlings into the soil during transplantation, facilitating optimal spacing and uniformity for successful crop establishment. As the transplanter places the seedlings into the soil, the number of seedlings picked per hill is observed and recorded for each tray. This data provides valuable insights into the effectiveness of different tray configurations in achieving the desired single seedling per hill arrangement, essential for optimizing SRI cultivation. From the 12 trays with distinct combinations, the tray that best aligned with the requirement of sowing a single seedling per hill was selected. The selection process carefully considered both the absence of missed hills and the avoidance of sowing multiple seedlings in a single hill. The data pertaining to seedlings per pick was collected through visual observation and direct counting of the seedlings per hill after the transplantation process (Fig. 4).

2.8 Statistical Analysis

The experimental outcomes, including metrics such as seedling count, crop yield, and uniformity, will be subjected to a multivariate analysis. Descriptive statistics were employed to summarize the characteristics of the collected

Fig. 5. Field Trai of Transplanter with prepared nursery MAT

data from the experiment. Measures such as mean, median, and standard deviation were calculated to provide insights into the central tendencies and dispersions of the seedling pickup and missing hill outcomes for each combination of seed density and soil volume.

Furthermore, an analysis of variance (ANOVA) was conducted to assess the statistical significance of the observed variations in the outcomes. A two-way ANOVA, considering seed density and soil volume as factors, was employed to determine the main effects and interactions between these variables. This statistical technique allowed for the examination of whether the differences in the outcomes were significant and if they could be attributed to the levels of seed density and soil volume. The statistical analyses were executed with a predetermined significance level (e.g., $\alpha = 0.05$) to determine the statistical significance of the results. R programm was employed to ensure accurate computations, and graphical representations, such as interaction plots, were generated to visually depict the effects of the seed density and soil volume variables on the experimental outcomes.

3. RESULTS AND DISCUSSION

3.1 Effect of Different Density Of Seed & Depth of Filling on Shoot Length of Paddy

The Fig. 1 shows that the shoot length of paddy seedlings decreases with increasing seed density. The shoot length of paddy seedlings at densities of 40 grams/tray and 100 grams/tray is easily distinguishable; notably, the shoot length of the 40 grams/tray density is significantly greater than that of the 100 grams/tray density. At higher seed densities, there is more competition for resources, such as water and nutrients. This can lead to less taller plants, as they need more resources.

The depth of filling also affects the shoot length, with seedlings grown in deeper depth of filling (D2 and D3) having longer shoots than those grown in shallower depth of filling (D1). However, the effect of depth of filling is not as pronounced as that of seed density. The observed variation in shoot length due to the depth of soil filling can be attributed to the availability of a larger soil volume for root growth, leading to enhanced shoot development in deeper depth of filling (D2 and D3).

The experiment indicates that the optimal seed density for paddy seedlings is 80 grams/tray. While both D2 and D3 depths of filling are effective, D3 slightly outperforms. This combination presents an ideal setup for cultivating healthy paddy seedlings.

3.2 Effect on Root Length

The graph reveals intriguing patterns concerning root length in rice seedlings across varying conditions. Notably, root length decreases with escalating seed density, up to a threshold of 80 grams/tray. Beyond this point, at a density of 100 grams/tray, root length experiences a slight reduction compared to the 80 grams/tray density.

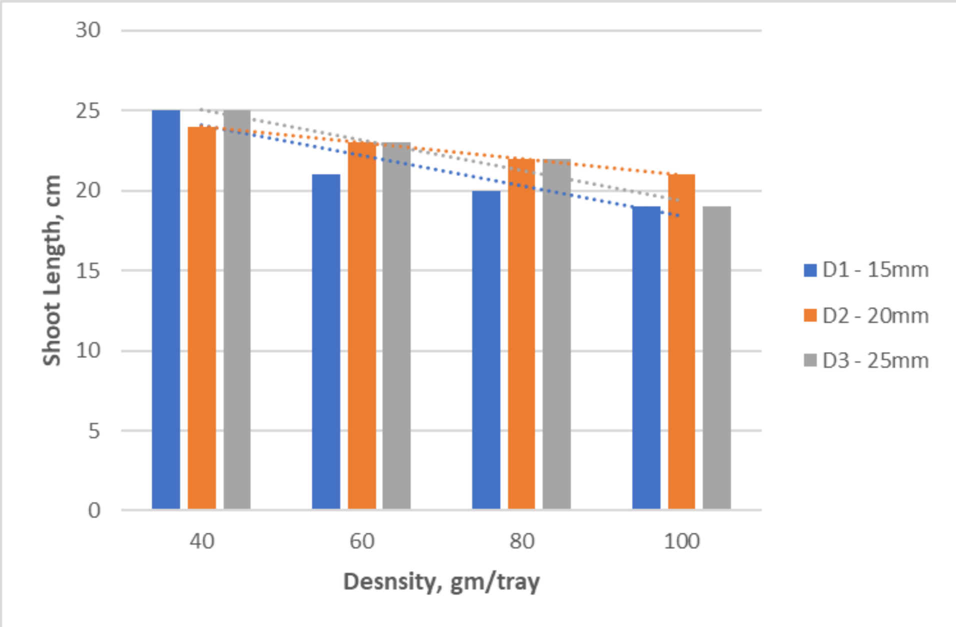

Fig. 6. Effect of different density of seed & depth of filling on shoot length of paddy

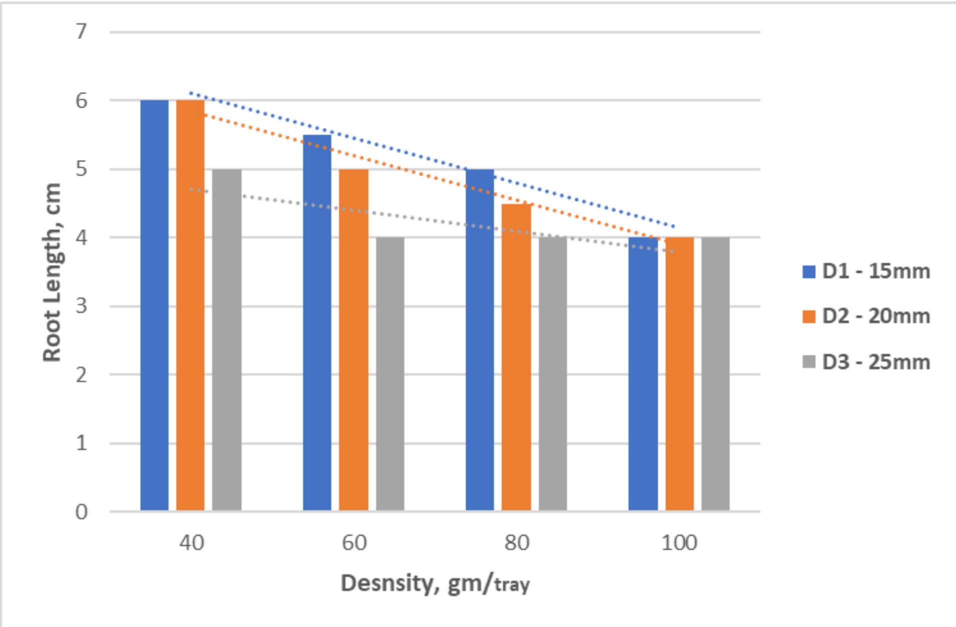

Fig. 7. Effect of different density of seed & depth of filling on root length of paddy

This observation implies the existence of an optimal seed density for achieving maximum root length, suggesting that excessively high densities might hinder root growth.

The depth of filling emerges as another influential factor impacting root length. The highest root length is observed at a depth of filling of 25 mm, with a marginal decrease at shallower depths. This suggests that a certain amount of space is essential for the seedlings to foster root development, indicating that a more expansive environment is conducive to longer root growth.

The findings underscore the significance of optimal conditions for cultivating rice seedlings in a transplanter's tray. An ideal setup involves a seed density of 80 grams/tray and a filling depth of 25mm, which promotes the development of seedlings with the highest root length. This knowledge can contribute to more effective agricultural practices and the enhancement of seedling growth.

3.3 The Effect of Different Seed Densities and Depth of Filling on Seedling per Pick and Missing Hill

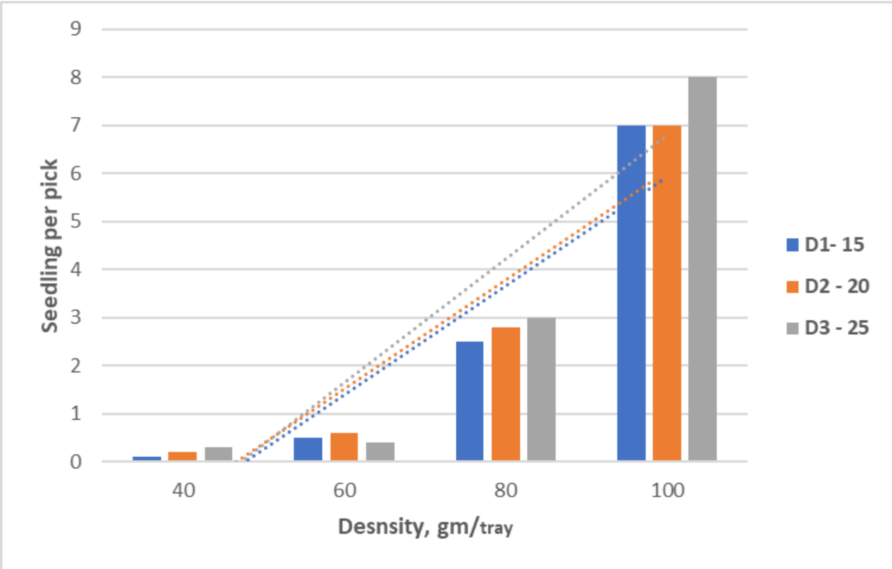

Fig. 8. Study of Seedling Per Pick with different seed density in tray

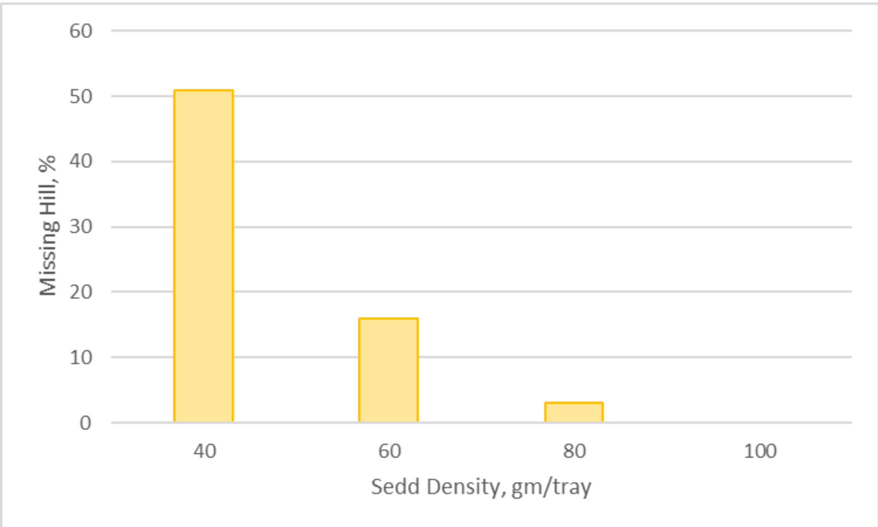

Fig. 9. Study of Missing Hill with different seed density in tray

The Fig. 9 provided presents several key observations regarding the relationship between seed density, depth of filling, seed pick, and missing hill percentage. One notable trend is the increase in seedling pick with higher seed densities. This outcome aligns with the expectation that more seeds would naturally lead to more seedlings. However, the increase in seed pick is not linear, as evident when comparing different seed density increments. For instance, elevating the seed density from 40 to 60 grams/tray results in a 50% increase in seed pick, while the increase from 60 to 80 grams/tray yields only a 25% rise.

The impact of the depth of filling on seed pick is also evident from the data. Generally, deeper filling depths lead to higher seed pick values. This correlation is attributed to the increased soil volume available for seedling anchoring and growth. Nevertheless, the effect of depth of filling is not as significant as that of seed density. In parallel, Fig. 4, the missing hill percentage, representing the percentage of hills devoid of seedlings, exhibits a decrease with rising seed density. A higher seed density reduces the likelihood of hills lacking seedlings. However, this reduction in missing hill percentage is less pronounced compared to the increase in seed pick. Notably, the depth of filling's impact on seed pick is minimal at seed densities of 40 and 60 grams/tray, but more significant at a seed density of 100 grams/tray, particularly with a deeper filling depth (D3). Moreover, a high missing hill percentage is evident at a seed density of 40 grams/tray, indicating that this density isn't sufficient to guarantee seedlings in all hills.

The seed pick and missing hill percentage are both affected by seed density and depth of filling. The effect of seed density is more pronounced than the effect of depth of filling. The optimum tray for single seedling pickup is the one with a seed density of 80 grams/tray and a depth of filling of D3 (25 cm).

The experiment highlights the optimal conditions for cultivating paddy seedlings using a transplanter's tray: a seed density of 80 grams/tray and a filling depth of 25mm (D2 or D3). This combination fosters seedling growth, particularly in root length. These findings contribute valuable insights for more effective agricultural practices. Both seed density and filling depth impact seed pick and missing hill percentage, with seed density exerting a more significant influence. For single seedling pickup, the recommended tray configuration involves a seed density of 80 grams/tray and a depth of filling at D3 (25 cm). The ANOVA analyses (Table 1) confirm significant effects on shoot length, root length, and seedlings per pickup, with seed density prominently affecting shoot and root lengths ($p < 0.001$). Filling depth primarily influences shoot length ($p = 0.003$) and to a lesser extent root length ($p = 0.027$). Notably, the interaction between seed density and filling depth is insignificant ($p > 0.05$), emphasizing the distinct roles of these factors. Overall, these findings underscore the importance of tailored seedling conditions for optimizing agricultural outcomes.

Table 1. ANOVA analyses of Influence on shoot length, root length, and seedlings per pickup

Parameter	P – Statistics	Confidence level
1. Shoot Length		
Seed Density	0.00327**	99.67 %
Depth of filling	0.21187	78.81 %
Seed Density x Depth of filling	1.00	00.00 %
2. Root Length		
Seed Density	0.0054**	99.46 %
Depth of filling	0.027*	97.30 %
Seed Density x Depth of filling	0.087	91.30 %
3. Seedling per pick		
Seed Density	2.85×10^{-7}***	100.0 %
Depth of filling	2.017	101.7 %
Seed Density x Depth of filling	0.7288	27.12 %

4. CONCLUSION

The comprehensive study aimed to optimize nursery tray configurations for improved seedlings per pick, facilitating enhanced rice transplantation efficiency. Through meticulous experimentation and analysis, the following key conclusions were drawn.

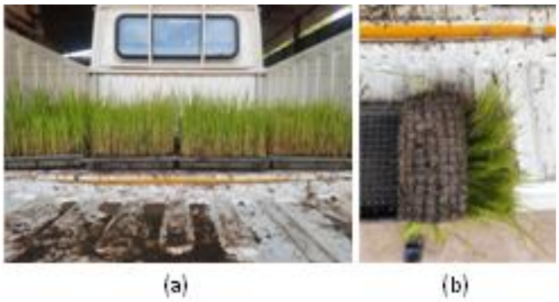

Fig. 10. Complete nursery MAT

The study optimized nursery tray configurations, identifying the 80gm/tray seed density with 25mm depth of filling as optimal for efficient rice transplantation, yielding seedlings per pick between 1-3 and less than 1% missing hills. Moreover, lower seed density (40 gm/tray and 60 gm/tray) led to increased shoot and root growth but high percentage (>16%) of missing hill, while trays with 15mm and 20 mm depth of filling showed limited root network due to low soil volume. This research enhances mechanized rice cultivation, contributing to improved transplantation efficiency and growth outcomes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kulmitra AK, Sahu N, Sahu MK, Kumar R, Kushram T, Sanath Kumar V. Growth of Rice blast fungus Pyricularia oryzae (Cav.) on different solid and liquid media. International Journal of Current Microbiology and Applied Sciences [Internet]. 2017;6(6):1154-1160.
2. Minhas A. Production volume of rice India FY 2010-2023;. Mar 22, 2023.
3. Uphoff N, Kassam A, Harwood R. SRI as a methodology for raising crop and water productivity: Productive adaptations in rice agronomy and irrigation water management. Paddy and Water Environment. 2011;9:3-11.
4. Bashar ZU, A Wayayok, M Amin, MR Mahadi. Single seedling nursery tray: An innovative breakthrough to quality seedling raising technique for SRI transplanting machine. Research Journal of Applied Sciences, Engineering and Technology. 2015;10 (11):1258-1265.
5. Shamshiri RR, Ibrahim B, Ahmad D, Man HC, Wayayok A. An overview of the system of rice intensification for paddy fields of Malaysia. Indian Journal of Science and Technology. 2018;11(18):1-16.
6. Suthakar B, Thiyagarajan R, Tajuddin A. Performance Evaluation of Commercially Available Rice Transplanters to Assess the Suitability to SRI. Int. J. Curr. Microbiol. App. Sci. 2020;9(4):359-364.
7. LIANG Xy, Feng G, Ye F, ZHANG Jl, Sha Y, MENG Jj, et al. Single-seed sowing increased pod yield at a reduced seeding rate by improving root physiological state of Arachis hypogaea. Journal of Integrative Agriculture. 2020;19(4):1019-1032.
8. Shaikh NY, Alam MA, Kamruzzaman M, Al Mamun MA, Islam AS. Effect of seeding density on Mat-type seedling quality for mechanical transplanting in dry season rice. Agricultural Sciences. 2021b;12(11): 1231-1243.
9. Sharif A. Technical adaptations for mechanized SRI production to achieve water saving and increased profitability in Punjab, Pakistan. Paddy and Water Environment. 2011;9(1):111-119.
10. Dhananchezhiyan P, CD Durairaj, S Parveen. Development of nursery raising technique for system of rice intensification machine transplanting. African Journal of Agricultural Research. 2013;8(29):3873-3882.
11. Ibrahim B, Ismail WIW, Ishak W. Development of system rice intensification (SRI) paddy transplanter. Asian Journal of Agricultural Sciences. 2014;6(2):48-53.
12. Imran M, Manan MA, Khalil A, Hamat S, Ahmad, R MdNaim M. The transplanter tools for small paddy fields: System of Rice Intensification (SRI) compliance. IOP Conference Series: Materials Science and Engineering; 2019.
13. Agritech_TNAU. 2022. TNAU Released New Crop Varieties for; 2022.

14. TNAU_Agritech. Crop Production :: Rice :: System of Rice Intensification (SRI) Cultivation; 2014. Available:https://agritech.tnau.ac.in/ta/Agriculture/agri_cropproduction_rice_sri.html
15. Wayayok A, Mohammed U, Zubairu UB, Soom MAM. Comparative study on the performance of rice seedlings raised by single seedling nursery tray method and conventional system. American Journal of Plant Biology. 2015;2(1):1-4.
16. Shaikh NY, Alam MA, Kamruzzaman M, Al Mamun MA, Islam A. Effect of Seeding Density on Mat-Type Seedling Quality for Mechanical Transplanting in Dry Season Rice. Agricultural Sciences; 2021a.

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