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Short duration seedling age is more effective over the other SRI components on growth and productivity of puddled transplanted rice

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Abstract
The system of rice intensification (SRI) became very popular in terms of higher production, but it was also noticed that implementation of all the components of SRI is very difficult for the farmers. To investigate the most appropriate component of SRI the field experiment was conducted at research farm of Bihar Agricultural University, Sabour, Bhagalpur, India during *Kharif* 2019. The experiment was laid out in completely randomized block design with eight treatments replicated thrice. The first treatment was conventional puddled transplanted rice (CPTR), thereafter six treatments were also CPTR with an addition component of SRI in each treatment and the last treatment was sole SRI. Results revealed that all growth parameters i.e., plant height, leaf area index and dry matter accumulation obtained highest in the SRI at all growth stages. The highest grain yield (6020 kg ha^{-1}) was recorded in the SRI, which was statistically at par with CPTR with 12 days seedling (5693 kg ha^{-1}). The highest straw yield (6693 kg ha^{-1}) was recorded in the SRI, which was statistically at par with CPTR with 12 days seedling (6473 kg ha^{-1}), CPTR with 1 seedling/hill (6447 kg ha^{-1}), conventional PTR (6170 kg ha^{-1}), CPTR with spacing of 25cm × 25cm (5943kg ha^{-1}) and CPTR with N-Organic: inorganic (5873 kg ha^{-1}). Based on these findings the 12 days old seedling and single seedling/hill were found most effective among the SRI components in conventional puddled transplanted rice.

Keywords: SRI, rice, younger seedlings, yield

Introduction
The rice stands second position in area (216 Mha) and production 655 (Mt) worldwide. However, in India rice has an area of about 43.2 Mha with the production 110.1 Mt annually. The big challenge to the farmers and researchers is that to achieve the Country's needs of around 140 Mt of rice (Dinesh *et al*. 2017) [2] in the year 2025 considering the worsening condition of water scarcity and reduction in cultivable land (Shobharani *et al*. 2010) [12]. The traditional system of rice cultivation requires large quantity of water and the continuous water stagnation markedly reduce the water use efficiency. Researchers observed that the use of excess water and the transplanting shock by use of older seedlings are the major drawback of traditional transplanted system which leads to low productivity of rice. By continuous cultivation of rice through traditional method hampers the soil physical properties. On the other side the system of rice intensification has potential o sustain the productivity of rice, we have to practice cultivation methods in which all these challenges will be resolved. System of rice intensification (SRI) has that potential to sustain the productivity with better water use efficiency. The technique, SRI was firstly in Madagascar and in India this technology was spread with a goal of increasing the productivity of irrigated rice with better growth and yield attributing characters. The researchers also noticed the greater root growth with soil microbial abundance and diversity in SRI technique (Kumar and Shivay 2004) [5]. The SRI system is found to be an efficient alternative to increase the rice production as it requires less water, less seed, reducing cost of cultivation and saving labour over time. Basically under SRI technique the six components are very important *viz.* early transplanting (8-12 days seedlings), carefully transplanting with single seedling $hill^{-1}$, wider spacing (25cm × 25cm), weeding and aeration through mechanical rotating hoe/cono-weeder, water management by alternate wetting and drying) and application of farm yard manure or vermicompost. The single seedling transplanting provides the less competition of plants, better root development, more sunlight

interception, enhanced soil microbial population, high organic matter content and better nutrient and water availability. The weeds are also controlled easily with the help of mechanical hand weeder which helps in soil aeration, reduces the green house gases emissions and increases the productivity of rice in sustainable way. In SRI system the implementation of alternate wetting and drying (AWD) enhances the water use efficiencies and may reduces 30-40% of water wastages from traditional methods (Latif 2010) [6]. However, the use of organic manure results a high cultivation cost which leads to lower profit in SRI than the traditional system. Therefore, it is very important to identify the most important component of SRI technique which can be combined with traditional system for optimum productivity in sustainable manner. It was also observed that based on the water table and soil type, the AWD was found very complicated for the farmers as the water level lower down to about 5-10 cm and 5-15 cm from soil surface during before flowering and grain filling of rice, respectively (Bouman *et al*. 2007; Kishore *et al*. 2017) [1, 4]. So partial implementation of SRI technique in conventional practice may found to be beneficial in transplanted *kharif* rice (Palanisami *et al*. 2013; Reuben *et al*. 2016) [8, 10, 11].

Materials and Methods

The research was carried out at the research farm of Bihar Agricultural University, Sabour, Bhagalpur, India during 2019 *kharif* season. Bhagalpur stationed south of the river Ganges and representing of Agro-climatic Zone III-A which is situated at latitude of 25º15′40″ N and 87º2′42″ E longitude with altitude of 52.73 meter above mean sea level. The research station Sabour is characterized to sub-tropical climate with hot dry summer, and cold winter. The soil of the experimental plot was sandy clay loam in nature and low in fertility status (192.5 kg available N ha^{-1}, 17.8 kg available P ha^{-1} and 123.8 kg available K ha^{-1}). The experimental site is characterized to sub-tropical climate with hot summer, cold winter, and moderate rainfall. The coldest months are noted as December and January with the minimum temperature recorded as 3.2 °C. However, the hottest months are the May and June, having the average temperature ranged from 35 °C to 39 °C. Around 1207 mm annual average rainfall (averaged over 10 years) was recorded and mostly precipitating between middle of June to middle of September. The experiment was laid out in completely randomized block design with eight treatments replicated thrice. The first treatment was conventional puddled transplanted rice (CPTR), thereafter six treatments were also CPTR with an addition component of SRI in each treatment and the last treatment was sole SRI. The recommended dose of fertilizer was 120:60:40 kg $N:P_2O_5:K_2O$ ha^{-1} and the sources were Urea, Di Ammonium Phosphate, Muriate of Potash and Vermicompost. In CPTR the 22 days old seedlings were used with general spacing was maintained as 20cm × 15cm. The details treatment combinations are explained in table 1. In treatments T_5 and T_8 where the organic mabure was incorporated with chemical fertilizer, the 50% N (60 kg N ha^{-1}) was mitigated with vermicompost (1.75% N) and those plots were received @ 3.4 t vermicompost ha^{-1} during final land preparation. All the treatments received full dose of P_2O_5 and K_2O as basal dose at one day before transplanting. The N fertilizer was applied in three split i.e. 40% as basal and remaining was applied in two equal split (30%) at active tillering (25 DAT) and panicle initiation (45 DAT) stages. As the treatment T_5 and T_8 received vermicompost as basal, here the N was applied in split as 25% in both the active tillering and panicle initiation stages. In the treatment T_7 and T_8, the mechanical rotating hoe was used twice for weed management and the others received one hand weeding and herbicide application as post emergence during the course of investigation.

The crop variety 'Sabour Shree' was used in the experiment and this variety generally recommended for long duration (145-150 days) with an average potential yield about 45-55 q ha^{-1}. The maximum plant height, LAI, tiller count, plant samplings were recorded and collected and the economic yield was estimated at the time of harvest. The economic yield was estimated from an area of 5.0 m^2 of each plot. The data were analyzed statistically by applying "Analysis of Variance" (ANOVA) technique of completely randomized block design. The significance of different sources of variations was tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05. Standard error of mean (SEm±) and least significant difference (LSD) at 5% level of significance were worked out for each character.

Results and Discussion

Growth attributes

The plant height and LAI remained non significant among all the treatments in the experiment (Fig. 1). The highest number of tillers m^{-2} was recorded in the lone SRI (T_8) which was statistically at par with T_1, T_2, T_3, T_4 and T_5 at harvest stage (Fig. 2). These results are supported by Mohandas *et al*. (2015) [7] who found that SRI cultivation has resulted in higher effective tillers per m^2 than conventional and mechanized transplanting. Total biomass accumulation was also recorded highest in the lone SRI practice which was statistically at par with 12 days old seedling age in CPTR (T_2). These findings are in accordance with Praneeth *et al.* (2017) [9] who reported that growth parameters obtained in SRI were higher as compared to transplanted rice.

Yield attributes and yield

The highest number of panicles m^{-2} (308) was recorded in the lone SRI (T_8) which was statistically at par with T_1, T_2, T_3, T_4 and T_5 (Fig. 3). The highest number of grains $panicle^{-1}$ (127) was recorded using the 12 days seedlings in CPTR (T_2) which was found statistically at par with treatment T_8. No significant difference was noticed in test weight (g) among the treatments. However, the highest test weight (21.6 g) was also obtained in SRI technique rice cultivation treatment. All the yield parameters were recorded lowest in the T_6 where alternating wetting and drying method used in water management (Fifth component of SRI). These findings are in accordance with Duttarangvi *et al*. (2016) [3] where it was observed that yield parameters recorded in the SRI were significantly higher when compared to conventional and mechanized transplanting. The main reason behind this is that SRI method improves soil quality which leads to increase in the availability of nutrients and water to the crop. Spacing of 25×25 cm^2 enables leaves to intercept the maximum sun light which improves the photosynthetic ability of the crop. The highest grain yield was recorded in the lone SRI technique (T_8) (6020 kg ha^{-1}) which was statistically at par with 12 days used seedlings in CPTR (T_2) but differed significantly with all other treatments (Fig. 4). These results are in conformity with the findings of Sudhakar *et al*. (2017) [13] who reported that both grain yield and straw yield were recorded significantly higher in SRI method compared to conventional method. The saturation water management was found most difficult and that was why the lowest grain yield (4413 kg ha^{-1}) was recorded in the T_6. Use of the 12 days old seedlings (T_2) has also recorded the similar yield with lone SRI technique which might be due to transplanting of younger seedlings provided extra window in crop duration. These results were supported by Reuben *et al*. (2016) [10, 11] who reported that transplanting of rice seedlings at earlier age (8-12 days) had shown to be more potential in terms of higher number of tillers/hill which may lead into higher yield of rice. Similarly, the highest straw yield (6693 kg ha^{-1}) was recorded in the T_8 (Lone SRI) which was statistically at par with T_1, T_2, T_3, T_4 and T_5. Likewise grain yield the lowest straw yield (5337 kg ha^{-1}) was also recorded in the treatment T_6 using most difficult component of SRI i.e. water management. The harvest index remained similar among the treatment in the study.

Table 1: Treatment Details

T_1	Conventional puddled transplanted rice (CPTR)
T_2	CPTR using 12 days old seedlings (First component of SRI)
T_3	CPTR with spacing of 25cm × 25cm (Second component of SRI)
T_4	CPTR with single seedling/hill (Third component of SRI)
T_5	CPTR with N-Organic:inorganic::50:50 (Fourth component of SRI)
T_6	CPTR with Saturation water management i.e. alternating wetting and drying (Fifth component of SRI)
T_7	CPTR with weed management through Conoweeder / mechanical rotating hoe (Sixth component of SRI)
T_8	SRI (Spacing: 25cm× 25 cm), single seedling/hill, 12 days old seedling, N-Organic: Inorganic (50:50), Saturation water management, weed management through cono-weeder/ mechanical rotating hoe)

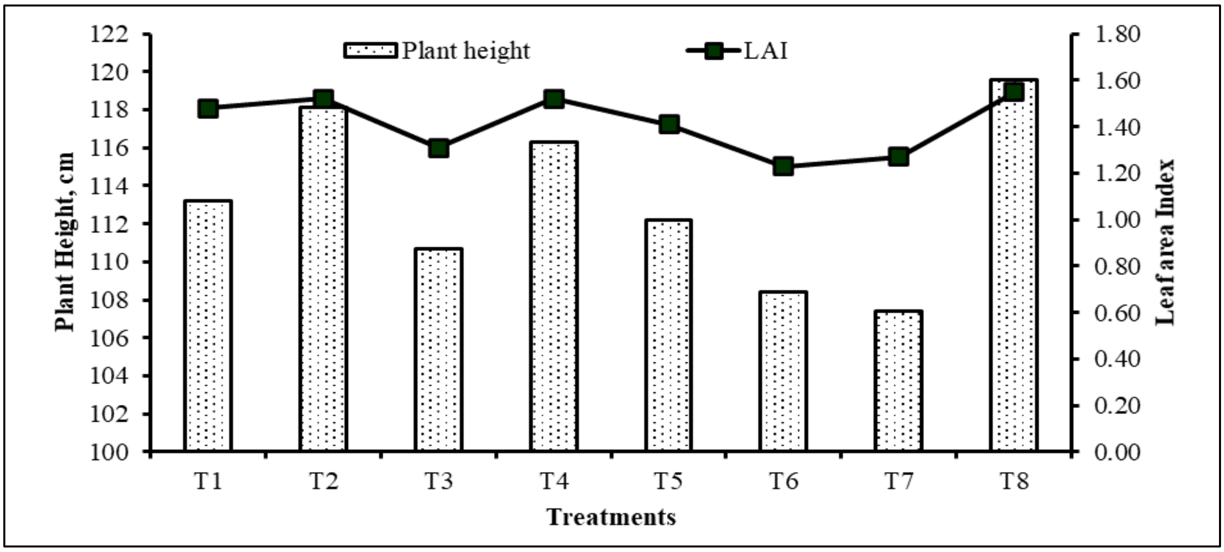

Fig 1: Effect of crop establishment method on plant height and leaf area index (LAI) of the rice crop T1: Conventional PTR (CPTR); T2: CPTR with 12 days seedling; T3: CPTR with spacing of 25cm×25cm; T4: CPTR with 1 seedling/hill; T5: CPTR with N-Organic:inorganic::50:50; T6: CPTR with Saturation water management as Alternate wetting and drying; T7: CPTR with weed management through mechanical rotating hoe; T8: System of rice intensification

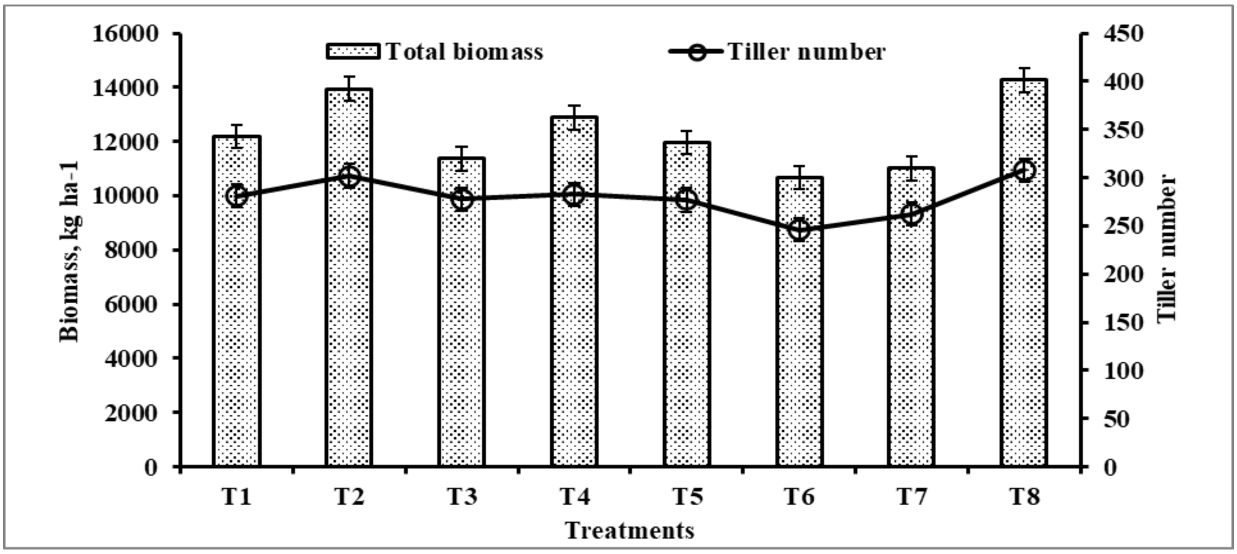

Fig 2: Effect of crop establishment method on tiller number and total biomass of the rice crop; the vertical line indicates the standard error of mean T1: Conventional PTR (CPTR); T2: CPTR with 12 days seedling; T3: CPTR with spacing of 25cm×25cm; T4: CPTR with 1 seedling/hill; T5: CPTR with N-Organic:inorganic::50:50; T6: CPTR with Saturation water management as Alternate wetting and drying; T7: CPTR with weed management through mechanical rotating hoe; T8: System of rice intensification

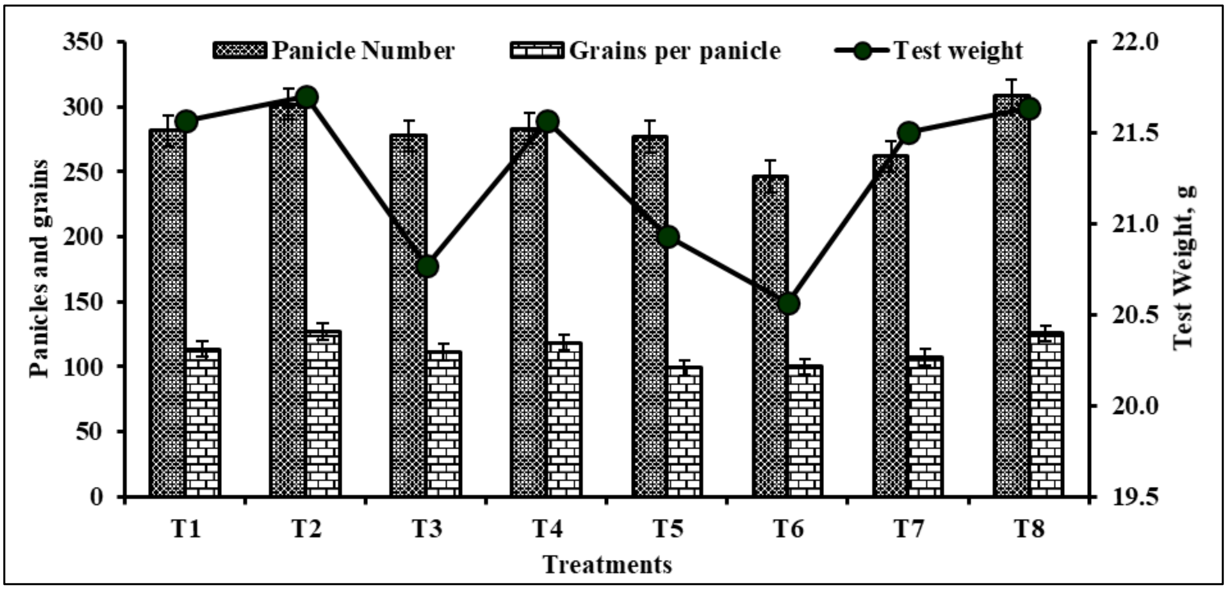

Fig 3: Effect of crop establishment method on panicles m^{-2}, grains panicle^{-1} and test weight (g) of the rice crop; the vertical line indicates the standard error of mean T1: Conventional PTR (CPTR); T2: CPTR with 12 days seedling; T3: CPTR with spacing of 25cm×25cm; T4: CPTR with 1 seedling/hill; T5: CPTR with N-Organic:inorganic::50:50; T6: CPTR with Saturation water management as Alternate wetting and drying; T7: CPTR with weed management through mechanical rotating hoe; T8: System of rice intensification

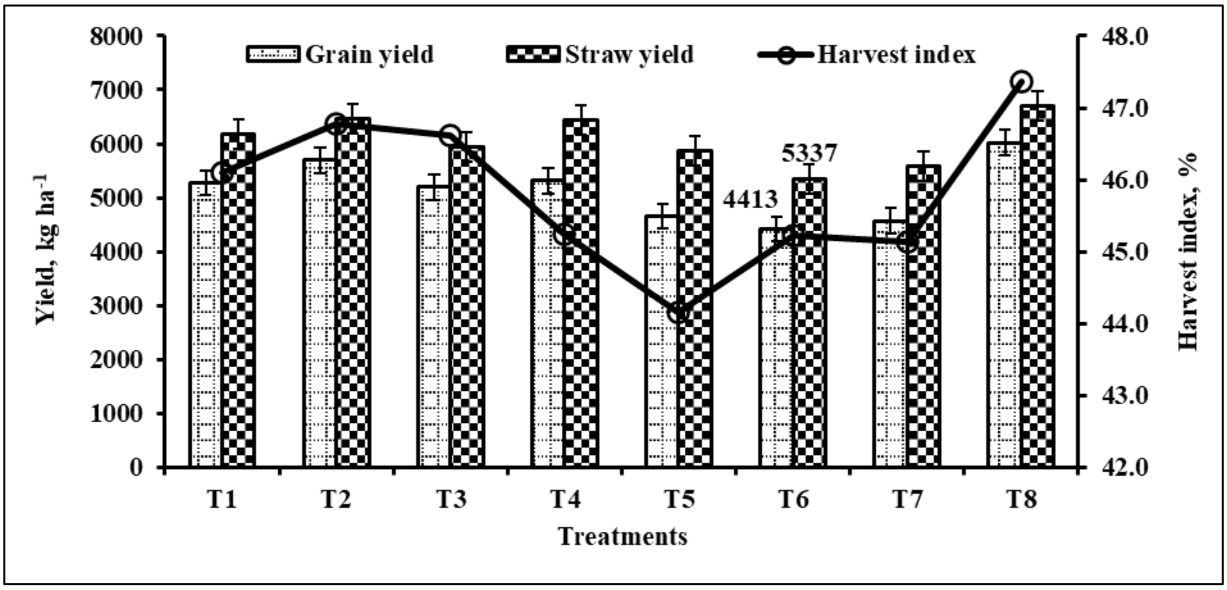

Fig 4: Effect of crop establishment method on the grain yield, straw yield and harvest index of the rice crop; the vertical line indicates the standard error of mean T1: Conventional PTR (CPTR); T2: CPTR with 12 days seedling; T3: CPTR with spacing of 25cm×25cm; T4: CPTR with 1 seedling/hill; T5: CPTR with N-Organic:inorganic::50:50; T6: CPTR with Saturation water management as Alternate wetting and drying; T7: CPTR with weed management through mechanical rotating hoe; T8: System of rice intensification

Conclusion

The conventional puddled transplanted rice (CPTR) served well for the production however, researchers said that system of rice intensification (SRI) can be far better if all components of SRI are implemented. It was difficult to find out the more useful component and here our investigation focused on each SRI components in combination with CPTR. The growth parameters as well as yield parameters were found maximum in the SRI lone technique which was statistically at par with CPTR using 12 days old seedlings (SRI component) in most of the parameters. Similar trend was observed in grain yield as well as straw yield. The 12 days old seedlings and single seedling/hill in combination with CPTR have performed well and were found next to only SRI in terms of growth parameters, yield parameters and yield. Transplanting 12 days young seedlings in CPTR would be able to increase the grain yield by 7.2%, over the conventional transplanted rice having 21 days old seedlings. The SRI technique is superior regarding grain yield over the conventional practice (14% higher) but following all principles of SRI is a herculean task for farmers in some regions because of the unavailability of resources. Based on these findings, it can be concluded that, the farmers can go for partial implementation of SRI *i.e.*, 12 days old seedling with single seedling/hill in combination with transplanted *kharif* rice where all principles of SRI is not possible.

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