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Age of seedling, nutrient management and microbial consortia on yield and nutrient uptake on rice

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Abstract
The experiment was conducted in Tamil Nadu Rice Research Institute, Aduthurai during summer season of 2023. Experiment field was laid out in Randomized Block Design with three replications and ten treatments. Machine transplanted with 12, 15, 18 and 21 days old manually transplanted seedlings where standardized and. Nursery was prepared for machine transplanting. Higher yield and yield attributes were recorded in T_4- Machine transplanted with fifteen days old seedling + 100% RDF and microbial consortia. Seed treated with microbial consortia attained good seedlings and abled to pick up by machine. Higher grain yield of 5747 kg ha^{-1} and straw yield of 7793 kg ha^{-1} was recorded. Yield attributes, *viz.*, 383 number of panicles m^{-2}, Panicle weight (g), panicle length (cm), Number of grains panicle (13.3 g, 27.3 cm, 277). Maximum uptake of nitrogen, phosphorus and potassium was recorded by treatment T_4- 15 days old mechanically transplanted seedling with 100% RDF + Microbial Consortia at harvest stage of crop. The result revealed that mechanized transplanting with 15 days old seedling with 100% RDF + Microbial consortia recorded higher plant height 114.7 (cm), number of panicles (383/m2), No. of grains/panicle (255/panicle) and grain yield (5747 kg/ha) whereas 21 days old seedlings with no fertilizer showed decrease in grain yield (3056 kg/ha).

Keywords: MC- microbial consortia, RDF- recommended dose of fertilizer

1. Introduction
In conclusion, this study highlights the positive impact of microbial consortia application on yield and yield attributes of machine-transplanted rice. The findings emphasize the potential of harnessing beneficial microorganisms to enhance rice production while adopting modern agricultural practices. Implementing microbial consortia as a sustainable agricultural strategy could contribute to increased rice productivity and food security, particularly in regions where rice is a staple crop. Further research is warranted to elucidate the specific mechanisms through which microbial consortia influence rice growth and development, thus providing valuable insights for optimizing crop management practices.

Microbial consortia, composed of various beneficial microorganisms, have shown potential in promoting plant growth, nutrient uptake, and disease resistance. In this research, a field experiment was conducted using a randomized complete block design with multiple treatments involving different combinations of microbial consortia. The experimental plots were machine-transplanted with a popular rice variety, and various yield attributes were assessed.

The results indicated that the application of microbial consortia significantly influenced several yield attributes of machine-transplanted rice. These attributes included plant height, tiller count, panicle length, number of grains per panicle, and grain weight per plant. Moreover, the microbial treatments demonstrated positive effects on the overall yield, with increased grain production observed in consortia-treated plots compared to control plots.

Jianhui *et al.* (2006) [6] reported that all agronomic practices influencing grain yield of mechanically transplanted rice, seedling age is the important factor. Seedling age is a critical factor in rice cultivation, as it directly influences crop establishment, growth and yield potential. The age at which seedlings are transplanted plays a significant role in determining plant vigor and productivity. Adequate nutrient supply is crucial for optimizing crop productivity and ensuring balanced plant development. However, different seedling ages may have varying nutrient uptake capacities and requirements.

Furthermore, the microbial consortia application exhibited potential benefits in terms of nutrient availability and utilization. Enhanced nutrient uptake, particularly nitrogen, phosphorus, and potassium, was observed in rice plants treated with microbial consortia. This suggests that the microbial inoculants facilitated nutrient mobilization and assimilation,

contributing to improved yield and yield attributes.

2. Material and Methods

The rice variety ADT 56 seeds were obtained from Tamil Nadu Rice Research Institute, Aduthurai. The seeds were sown at 60 kg ha^{-1}. Before sowing the seeds were soaked in water for 24 hours and incubated. The sprouted seeds were used for raising mat nursery. Seeds of one hectare required were treated with 125 ml each of biofertilizer *viz.*, *Azatobacter vinelandii* MAZO 36 + Phosphorus solubilizing bacteria + Arbuscular Mycorrhizae fungi + Potash releasing bacteria + Zinc solubilizing bacteria using rice gruel and shade dried for 30 minutes and sown in the nursery.

Number of productive tillers were counted from the five tagged plants and the mean number of productive tillers m^{-2} was calculated. Panicle length was measured from the base to the tip of the panicle obtained from five $hills^{-1}$. Mean length of panicle was calculated and expressed in cm. The weight of the randomly selected 10 panicles were recorded individually and the mean value was expressed in grams (g).1000 grains were counted at seed counter, weighed and expressed as test weight in grams. The harvested produce from each net plot was threshed, sun dried, winnowed separately and its grain yield was recorded at 14 per cent moisture content and expressed in kg ha^{-1}. Dry weight of the straw after sun drying to a constant weight was recorded and expressed in kg ha^{-1}.

2.1 Harvest Index (HI)

The ratio of economic yield to the total biological yield was expressed as harvest index. It was calculated by using the following formula suggested by Donald and Humblin (1976) [7].

$$HI = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

2.2 Plant nutrient uptake analysis

The plants were uprooted gently at active tillering, panicle initiation, flowering and at harvest stage and were dried at 70 ^0C and ground into fine powder with willey mill and analyzed for the NPK nutrient uptake. The nutrient uptake was worked out using the formula:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Percentage of nutrient (\%)}}{100} \times \text{Total dry matter production (kg ha}^{-1})$$

3. Result

3.1 Panicle length

The panicle length was affected by the age of seedlings. Fifteen days old seedlings transplanted by machine transplanter with 100% + Microbial Consortia recorded significantly higher panicle length (27.3 cm) than all other treatments. The lowest panicle length (22.4 cm) was recorded under control (T_{10}) – 21 days old manually transplanted seedling.

3.2 Panicle weight

The higher panicle weight (g) was recorded in machine transplanted with 15 days old seedling with 100% RDF + Microbial Consortia (T_4) attained its statistical supremacy by producing higher panicle weight (3.30 g) than the rest of the treatments followed by (T_3) Machine transplanted with 15 days old seedling with 75% RDF + Microbial Consortia and (T_2) 12 days old seedling with 100% RDF + Microbial Consortia. The lowest panicle weight was recorded (1.50 g) in control.

3.3 Number of panicles m^{-2}

The treatment T_4 (Machine transplanted with 15 days old seedling +100% RDF + Microbial Consortia) was found to be superior in registering higher number of panicles m^{-2} (383 m^{-2}) over all other treatments except Machine transplanted with 15 days old seedling with 75% RDF + Microbial Consortia. The treatment T_{10} (Control) was found to be inferior in registering the least number of panicles m^{-2} (152.3 m^{-2}). Irrespective of the recommended dose of fertilizer transplanting 18 and 21 days old seedling recorded significantly lesser number of panicle than 15 and 12 days old seedling.

3.4 Number of grains $panicles^{-1}$

Fifteen days old seedlings transplanted by machine transplanter recorded significantly higher number of grains / panicles than 12, 18, 21 days old seedling. Therefore, Machine transplanted with 15 days old seedling + 100% RDF+ Microbial Consortia (T_4) recorded higher number of grains $panicles^{-1}$ (255.2) and statistically different over other treatment. However lower number of grains $panicles^{-1}$ were recorded by transplanting 21 days old seedling (138.3). Transplanting 18 and 21 days old seedling produced significantly lower number of grains than 15 and 12 days old seedling transplanted crop.

3.4 Test weight

The test weight was not significantly influenced by age seedlings, fertilizer dose and microbial consortia. However, young seedlings coupled with 100% RDF + Microbial Consortia recorded increased in test weight in T_4 (16.9 g) which was statistically on par with T_3 - Machine transplanted with 15 days old seedling + 75% RDF + Microbial Consortia (16.3 g).

4. Yield

4.1. Grain yield

The grain yield was significantly influenced by age of seedling, nutrient application and microbial consortia. Higher grain yield of 5747 kg ha^{-1} was recorded in machine transplanter with 15 days old seedling along with 100% RDF and addition of microbial consortia (T_4) which established superior over other treatments except T_3 (Machine transplanted with 15 days old seedling + 75% RDF + Microbial Consortia) of 5436 kg ha^{-1}. The percentage increase in grain yield of T_4 over T_3, T_2, T_6 and T_9 were 3.3, 7.3, 7.9 and 16.4 respectively. The lowest grain yield (3056 kg/ha) was recorded by 21 days old manually transplanted seedling (control). Ali *et al.* (2013) [2] found that transplanting 15 days old seedling can lead to better growth, higher tillering and improved yield compared to older seedlings. Lowest grain yield was recorded without application of fertilizer in all crop stages. This was due to poor growth and metabolic process and lesser number of grain $panicles^{-1}$. The results are in accordance with Reddy *et al.* (2004) [3].

Table 1: Effect of age of seedling, nutrient dose and microbial consortia on number of panicles m^{-2}, panicle weight (g), panicle length (cm), number of grains $panicle^{-1}$ of rice

Treatments		Number of Panicles m^{-2}	Panicle Weight (g)	Panicle Length (cm)	Number of grains $panicle^{-1}$
T_1 -	Machine Transplanting with 12 days old seedlings + 75% RDF + MC	308.3	2.20	25.1	225.4
T_2 -	Machine Transplanting with 12 days old seedlings + 100% RDF + MC	339.7	2.90	25.3	257.8
T_3 -	Machine Transplanting with 15 days old seedlings + 75% RDF+ MC	370.7	3.10	26.3	261.3
T_4 -	Machine Transplanting with 15 days old seedlings + 100% RDF + MC	383.0	3.30	27.3	277.0
T_5 -	Machine Transplanting with 18 days old seedlings + 75% RDF + MC	304.3	2.20	25.3	229.6
T_6 -	Machine Transplanting with 18 days old seedlings + 100% RDF + MC	341.7	2.50	25.1	256.9
T_7 -	Manual Transplanting with 21 days old seedlings + 100% RDF alone	284.3	2.10	24.1	214.0
T_8 -	Manual Transplanting with 21 days old seedlings + 100% RDF + MC	298.0	2.20	25.1	228.2
T_9 -	Manual Transplanting with 21 days old seedlings + DAP foliar spray	290.3	2.20	24.4	212.0
T_{10} -	Manual Transplanting with 21 days old seedlings (No fertilizers)	152.3	1.50	22.4	178.4
	SE.d	9.76	0.10	0.16	3.75
	CD (P=0.05)	20.72	0.30	0.34	7.89

(RDF- Recommended Dose of Fertilizer, MC- Microbial Consortia, DAP- Diammonium Phosphate)

4.2. Straw yield

Marked difference of straw yield was manifested due to age of seedling, nutrient dose and microbial consortia. The higher straw yield was recorded in 15 days old mechanically transplanted seedling with 100% RDF + microbial consortia (8735 kg ha^{-1}) respectively than other treatments. It was statistically at par with treatment T_3 (Machine transplanted with 15 days old seedling + 75% RDF + Microbial Consortia) of 8455 kg ha^{-1}. The lower straw yield was recorded in 21 days old manually transplanted seedling (4557 kg/ha). Application of microbial consortia increases the straw yield. It may be due to several mineral components and biologically active substances that can benefit crops and soil (Adekiya *et al*., 2020) [4].

Table 2: Effect of age of seedling, nutrient dose and microbial consortia on grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index of rice

Treatments		Grain Yield kg ha^{-1}	Straw Yield kg ha^{-1}	Harvest Index
T_1 -	Machine Transplanting with 12 days old seedlings + 75% RDF + Microbial Consortia	5118	7531	0.39
T_2 -	Machine Transplanting with 12 days old seedlings + 100% RDF + Microbial Consortia	5362	7990	0.40
T_3 -	Machine Transplanting with 15 days old seedlings + 75% RDF+ Microbial Consortia	5463	8455	0.41
T_4 -	Machine Transplanting with 15 days old seedlings + 100% RDF + Microbial Consortia	5747	8735	0.42
T_5 -	Machine Transplanting with 18 days old seedlings + 75% RDF + Microbial Consortia	5127	7793	0.38
T_6 -	Machine Transplanting with 18 days old seedlings + 100% RDF + Microbial Consortia	5324	8092	0.39
T_7 -	Manual Transplanting with 21 days old seedlings + 100% RDF alone	4833	7346	0.40
T_8 -	Manual Transplanting with 21 days old seedlings + 100% RDF + Microbial Consortia	5037	7657	0.41
T_9 -	Manual Transplanting with 21 days old seedlings + DAP foliar spray	4936	7503	0.40
T_{10} -	Manual Transplanting with 21 days old seedlings (No fertilizers)	3056	4557	0.37
	SE.d	162	198	-
	CD (P=0.05)	344	422	-

(RDF- Recommended Dose of Fertilizer, Microbial Consortia- Microbial Consortia, DAP- Diammonium Phosphate)

5. Plant Nutrient Uptake

The treatment effects on plant nutrient uptake were similar to that of grain yield. Total uptake increased significantly with age of seedling from 12 days to 15 days old seedling and from 75% RDF to 100% RDF with microbial consortia application. Total nutrient uptake was higher at 253.5 kg ha^{-1} in 15 days old machine transplanted seedling with 100% RDF and microbial consortia (T_4) followed by 236.9 kg ha^{-1} and 226.3 kg ha^{-1} in T_3 (Machine transplanted with 15 days old seedling + 75% RDF + Microbial Consortia) and T_2 (12 days old seedling with 100% RDF + Microbial Consortia), respectively. With respect to nitrogen uptake in plants 15 days old seedling with 100% RDF and microbial consortia (T_4) recorded 117.3 kg kg^{-1} significantly higher uptake than other treatments followed by 15 days old seedling with 75% RDF with microbial consortia (T_3) which was statistically at par with T_6 (18 days old seedling + 100% RDF + Microbial Consortia). In case of phosphorous uptake T_4- 15 days old seedling with 100% RDF + microbial consortia recorded significantly higher phosphorus uptake of 31.78 kg ha^{-1} than other treatments except T_2- (12 days old seedling with 100% RDF + Microbial Consortia) 28.69 kg ha^{-1}. Nutrient uptake was higher in inoculated treatments thorugh application of 75% RDF + MC (Shahane *et al.*, 2019) [5]. Positive effect of increase in dry matter seen in the present investigation, due to nutrient application and biofertilizer inoculation application (Prasanna *et al*., 2019) [5].

Table 3: Effect of age of seedling, nutrient dose and microbial consortia on total NPK uptake (kg ha^{-1}) of soil

Treatments		N	P	K
T_1 -	Machine Transplanting with 12 days old seedlings + 75% RDF + MC	92.64	26.10	91.00
T_2 -	Machine Transplanting with 12 days old seedlings + 100% RDF + MC	100.13	28.69	97.48
T_3 -	Machine Transplanting with 15 days old seedlings + 75% RDF+ MC	106.49	29.04	101.40
T_4 -	Machine Transplanting with 15 days old seedlings + 100% RDF + MC	113.79	31.78	107.90
T_5 -	Machine Transplanting with 18 days old seedlings + 75% RDF + MC	93.68	27.23	93.88
T_6 -	Machine Transplanting with 18 days old seedlings + 100% RDF + MC	103.82	28.86	99.03
T_7 -	Manual Transplanting with 21 days old seedlings + 100% RDF alone	90.86	24.94	88.59
T_8 -	Manual Transplanting with 21 days old seedlings + 100% RDF + MC	96.21	26.44	93.03
T_9 -	Manual Transplanting with 21 days old seedlings + DAP foliar spray	94.77	26.41	90.23
T_{10} -	Manual Transplanting with 21 days old seedlings (No fertilizers)	46.15	11.40	51.19
	SE.d	5.33	1.71	5.03
	CD (P=0.05)	11.26	3.63	10.61

(RDF- Recommended Dose of Fertilizer, MC- Microbial Consortia, DAP- Diammonium Phosphate)

6. Conclusion

It is concluded that machine transplanting with 15 days old seedling with 100% RDF + Microbial consortia recorded higher growth, physiological parameters, yield attributes and grain yield. Higher grain yield, straw yield and plant NPK uptake. Therefore, machine transplanted with 15 days old mechanically transplanted seedling with 100% RDF + Microbial Consortia may be recommended to get maximum grain yield, higher profitability and also sustain the soil productivity.

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