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Influence of Seedling Age and Number on Yield and Economics of Machine Transplanted Rice (*Oryza sativa* L.)

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Abstract Field experiment on "Influence of different age and number of seedlings on yield parameters, yield and economics of machine transplanted rice (*Oryza sativa* L.)" was conducted during *kharif*, of 2012 and 2013 in clay soil. Two years pooled data indicated that, planting of twenty five days old and 3-4 seedlings per hill recorded significantly higher number of grains panicle^{-1} (107.00 and 113.62, respectively), number of filled grains panicle^{-1} (94.44 and 104.01), lower number of unfilled grains panicle^{-1} (12.56 and 9.75, respectively), filling per cent (88.01 and 91.68, respectively), test weight (18.29 and 18.52 g, respectively), grain yield (5101 and 5330 kg ha^{-1}, respectively), straw yield (6335 and 6585 kg ha^{-1}, respectively). Higher gross returns (Rs 91,141 and 95,190 ha^{-1}, respectively), net returns (Rs 45,178 and 49,165 ha^{-1}, respectively) and B:C of 2.01 and 2.10, respectively were also noticed with planting twenty five days old seedlings. Planting of twenty five days old and 3–4 seedlings per hill by the self propelled machine transplanter were found suitable for higher rice yield.

Keywords Age of seedlings, Number of seedlings per hill, Machine transplanting, Gross returns, Net returns.

Introduction

Rice (*Oryza sativa* L.) is the major staple food for more than half of the global population and is considered as the "global grain". In rice production, India ranks second as it is grown in almost all the states of the country. Total estimated area under rice in India is 44.40 million hectares with a production of 104.32 million tonnes. West Bengal has the highest rice production, while Punjab has the highest productivity of rice among the different rice growing states of India. The world's total estimated area under rice production is 159 million hectares with a production of 670 million metric tonnes with an average yield of 3,889 kg per hectare [1].

Proper age of seedlings for transplanting varies with management practices, growth period, variety and growing season. In case of high yielding varieties, the seedlings should be transplanted at 4–5 leaf stage. Twenty days old seedlings were most suitable for transplanters namely QUAT, CRRI and Yanji [2]. Seedlings mat characteristics such as seedlings density ; mat moisture content and age of seedlings play a major role for efficient performance of the self-pro-

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pelled rice transplanter. Therefore, it is necessary to optimize the age of seedlings for minimizing root damage for proper functioning of the transplanters [2].

Number of seedlings per hill is another important factor that it can play an important role in boosting yield of rice. Because it influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of rice plant. Number of seedlings transplanted per hill varies from country to country. While in Burma, one to four seedlings are transplanted per hill, in Sri Lanka only one seedling is used. Usually, 5 to 7 seedlings are transplanted in Philippines. Results in India indicated that the number of fertile tillers were greater with 3–4 seedlings.

Mechanical transplanting not only facilitates better stand establishment of the rice crop at right time but also allows the genotype to exhibit phenotypic characteristics completely. Therefore, it is high time for mechanizing the transplanting operation in rice cultivation. Mechanical transplanter using self-propelled transplanter has been considered as the most promising option because it saves labor to the tune of 90% of that required in manual transplanting, minimizes stress and drudgery, ensures timely transplanting and attains optimum plant density contributing to higher productivity Behera et al. [3].

Materials and Methods

A field experiment was conducted at Agricultural Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka, during *kharif*, of 2012 and 2013. The experiment was laid in strip-plot design. The soil of the experimental site was medium deep black clay with soil reaction (8.2), electrical conductivity (2.1) determined following the procedure given by Jackson [4], available N (247.2 kg ha^{-1}) Subbaiah and Asija [5], available P_2O_5 (50.2 kg ha^{-1}) Olsen et al. [6] and available K_2O (357.6 kg ha^{-1}) Aswini et al. [2] at surface 0—20 cm soil depth.

Agricultural Research Station, Gangavathi is situated in the Northen Dry Zone of Karnataka between 15°15´40´´ North latitude and 76°31´40´´ East longitude at an altitude of 419 m above mean sea level and represents irrigated transplanted rice belt of Tungabhadra command area. The experiment consisted three different age of seedlings viz., A_1: Twenty days old seedlings, A_2 : Twenty five old seedlings and A_3 : Thirty days old seedlings and three different number of seedlings per hill planted by transplanter viz., N_1 : 3–4 seedlings per hill, N_2 : 5–6 seedlings per hill and N_3 : 7–8 seedlings per hill. The land was prepared using tractor drawn cultivator twice, followed by puddling twice with disc puddler and finally levelled using tractor drawn spike tooth harrow and kept ready for planting and the seedlings raised as per the seedling age treatments were planted on the same day. Recommended package of practices were taken up as per the time. The crop was harvested at physiological maturity, threshed and cleaned manually in both the years. Both grain and straw were sun dried for a week and dry weights were recorded. For computing the cost of cultivation, different variable cost of items was considered. The cost includes expenditure on seeds, fertilizers, irrigation, plant protection chemicals, hiring charges of transplanter, fuel cost and labor charges prevailed in market during 2012 and 2013.

Results and Discussion

Yield parameters

Age of seedlings

Seedlings age had significant influence on yield and yield parameters of machine transplanted rice. Significantly higher number of grains panicle^{-1} (107.00), number of filled grains per panicle (94.44), filling per cent (88.01), test weight (18.29 g) and lower number of unfilled grains panicle^{-1} (12.56) were recorded by planting of twenty five days old seedlings (Table 1). The higher grain yield (5101 kg ha^{-1}) and straw yield (6335 kg ha^{-1}) were also noticed by planting of twenty five days old seedlings over planting of twenty days old seedlings (Table 2) and it was followed by planting of thirty days old seedlings. Young seedlings had lower effective tiller production rate when compared

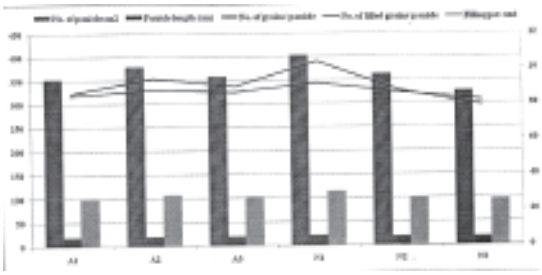

Fig. 1. Yield parameters of machine transplanted rice as influenced by age and number of seedlings.

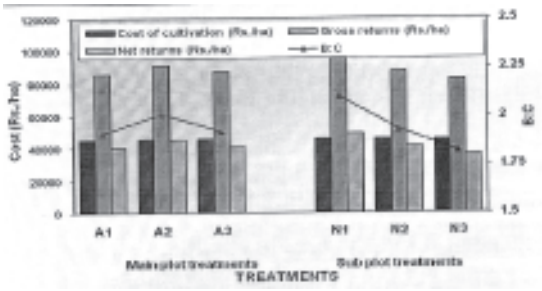

Fig. 2. Economics of machine transplanted rice as influenced by age and number of seedlings.

with more aged seedlings Kim et al. [7].This might be due to the production of secondary and tertiary tillers in the main field by low aged tillers which are incapable for production of panicle. Such increase in yield

Table 1. Number of panicles m^2, panicle length, number of grains $panicle^{-1}$, number of filled grains, unfilled grains $panicle^{-1}$ and filling per cent of machine transplanted rice as influenced by age and number of seedlings (pooled data of two years). NS–Non significant. A_1 : 20 days old seedlings, A_2 : 25 days old seedlings, A_3 : 30 days old seedlings, N_1 : 3–4 seedlings per hill, N_2 : 5–6 seedlings per hill, N_3 : 7–8 seedlings per hill.

Treatments	Number of panicles m^2	Panicle length (cm)	Number of grains $panicle^{-1}$	Number of filled grains per panicle	Number of unfilled grains per panicle	Filling percent
Main treatments (A)						
A_1	352.45	18.36	101.25	85.89	15.36	84.67
A_2	378.22	19.54	107.00	94.44	12.56	88.01
A_3	358.11	18.97	103.04	89.93	13.24	86.63
SEm±	4.90	0.12	0.93	1.44	0.42	0.63
CD (p = 0.05)	19.24	0.49	3.65	5.65	1.65	2.47
Sub treatments (N)						
N_1	401.78	20.73	113.62	104.01	9.75	91.68
N_2	361.67	18.66	101.20	87.30	13.90	86.25
N_3	325.33	17.47	96.45	78.94	17.51	81.88
SEm±	9.37	0.24	1.17	1.96	0.92	1.14
CD (p = 0.05)	36.80	0.93	4.61	7.7	3.61	4.47
Interaction (A × N)						
A_1N_1	387.17	19.58	109.33	97.86	11.84	89.71
A_1N_2	424.67	21.75	119.72	111.10	8.62	92.93
A_1N_3	393.50	20.86	111.82	103.07	9.14	92.38
A_2N_1	351.34	18.14	99.02	83.54	15.48	84.36
A_2N_2	372.00	19.17	103.75	90.84	12.92	87.57
A_2N_3	361.67	18.68	100.83	87.51	13.33	86.84
A_3N_1	318.84	17.36	95.39	76.26	19.13	79.95
A_3N_2	338.00	17.69	97.52	81.37	16.15	83.52
A_3N_3	319.17	17.36	96.45	79.20	17.25	82.17
SEm±	9.84	0.45	2.76	1.96	0.71	1.49
CD (p = 0.05)	NS	NS	NS	NS	NS	NS

Table 2. Test weight, grain yield, straw yield, gross returns, net returns and benefit cost ratio of machine transplanted rice as influenced by age and number of seedlings (pooled data of two years). NS –Non significant. A_1 : 20 days old seedlings, A_2 : 25 days old seedlings, A_3 : 30 days old seedlings, N_1 : 3–4 seedlings per hill, N_2 : 5–6 seedlings per hill, N_3 : 7–8 seedlings per hill.

Treatments	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Gross returns (ha^{-1})	Net returns (ha^{-1})	B : C
Main treatments (A)						
A_1	17.19	4803	5996	85808	40307	1.91
A_2	18.29	5101	6335	91141	45178	2.01
A_3	17.65	4889	6122	87356	41371	1.92
SEm±	0.20	57	63	702	716	0.01
CD (p = 0.05)	0.80	226	247	2756	2812	0.04
Sub treatments (N)						
N_1	18.52	5330	6585	95190	49165	2.10
N_2	17.74	4869	6128	87030	41244	1.93
N_3	16.87	4595	5740	82085	36447	1.82
SEm±	0.16	67	85	946	977	0.02
CD (p = 0.05)	0.64	263	332	3715	3835	0.06
Interaction (A × N)						
A_1N_1	17.95	5117	6441	91444	45774	2.02
A_1N_2	19.15	5616	6773	100199	53977	2.20
A_1N_3	18.46	5258	6542	93925	47744	2.06
A_2N_1	17.09	4767	5988	85185	39703	1.90
A_2N_2	18.43	4971	6264	88903	43001	1.96
A_2N_3	17.70	4868	6131	87000	41026	1.92
A_3N_1	16.54	4526	5558	80793	35442	1.80
A_3N_2	17.30	4717	5968	84319	38555	1.87
A_3N_3	16.77	4541	5693	81143	35342	1.79
SEm±	0.49	100	142	1599	1774	0.05
CD (p = 0.05)	NS	NS	NS	NS	NS	NS

contributing parameters were also reported by Behera [3] and Maiti and Bhattacharya [8].

Number of seedling per hill

Planting of 3–4 seedlings per hill produced significantly higher number of grains per panicle (113.62), number of filled grains per panicle (104.01), filling per cent (91.68), test weight (18.52 g) and lower number of unfilled grains per panicle (9.75) (Table 1). Similarly higher grain yield (5330 kg ha^{-1}) and straw (6585 kg ha^{-1}) was also observed with planting of 3–4 seedlings per hill as compared to planting of 7–8 seedlings per hill (Table 2). This may be due to healthy and efficient individual plant growth at lesser seedling density. The higher yield with low seedling density might be due to higher percentage of productive total tillers and more interception of light. Hence, planting of fewer seedlings resulted in higher grain yield Rasool et al. [9] and Hamid et al. [10]. Such increase in yield contributing parameters with fewer number of seedlings per hill were also reported by Maiti and Bhattacharya [8].

Economics

Age of seedlings

Gross returns were higher with planting of twenty five days old and three to four seedlings per hill and (Rs 91,141 and 95,190, respectively), net returns (Rs 45,178 and 49,165, respectively) and B : C (2.01 and

2.10, respectively) as compared to planting of twenty days old and seven to eight seedlings per hill.

From the study it may be concluded that, planting of 25 days old seedlings and planting of 3–4 seedlings per hill was optimum for transplanting with self propelled mechanical transplanter.

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