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Effect of Different Crop Establishment Techniques on Growth, Yield attributes and Yield of Rice under Puddled Condition

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A field experiment was conducted during July to November 2017 at Wetland farm of Tamil Nadu Agricultural University, Coimbatore to study the effect of different crop establishment techniques on growth, yield attributes and yield of rice under puddled condition. The results revealed that crop established through square planting (SRI) with single seedling has recorded significantly higher in growth attributes, root characters, leaf area index, number of productive tillers sq.m^{-1} (595), panicle length (23.4 cm), total number of grains panicle^{-1} (152.7), number of filled grains panicle^{-1} (137.7), fertility percentage (90.2), grain yield (6860 kg ha^{-1}) and straw yield (10180 kg ha^{-1}) compared to other establishment methods. The gross return, net return, B:C ratio and added benefit (₹ 102680 ha^{-1}, ₹ 47082 ha^{-1}, 1.85 and ₹ 10932 ha^{-1}, respectively) was higher in square planting (SRI) with single seedling under puddled condition.

Key words: Rice, Crop establishment, Square planting, Single seedling, Benefit cost ratio.

Rice (*Oryza sativa* L.) is one of the most important staple food crops of the world. More than two billion people in Asia are getting 60 to70 % of their energy requirement from rice and its derived products. Human consumption accounts 85 % of total production for rice and it deserves a special status among cereals as world's most important wetland crop. Worldwide, rice is being cultivated in an approximate area of 147 million hectares with a total production of 525 million tonnes and average productivity of 3571 kg ha^{-1}. Asia contributes 59 per cent of world population and accounts for 92 per cent of global rice production. Among many food grains cultivated in India, rice has the pride of being cultivated over an area of 43.49 million hectares with a production of 104.41 million tonnes which contributes to 41.5 % of total food grain production of our Country (Ministry of Agriculture and Farmers Welfare, 2016). Considering these facts "International year of Rice- 2004 AD" had the slogan of "Rice is life".

Manual transplanting is the most common practice being followed under lowland ecosystem. Non-availability of irrigation water, shortage of labour during peak period of transplanting and escalating labour cost make the transplanting technique more expensive which invariably leads to delay in transplanting and resulting in reduction of yield and less profit (Gangwar *et al*., 2008). To mitigate this problem, alternate methods need to be evolved to substitute manual transplanting method.

Good crop stand establishment is one of the key components for efficient use of resources, inputs and consequently for achieving desired level of productivity. Proper row arrangement and appropriate inter and intra row spacing are important for improving the crop growth, sink capacity and ultimately the yield of rice (Sridevi, 2011). Method of establishment is one of the cultural practices, which influences the rice crop through its effect on growth and development (Gopi *et al.,* 2006).

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Material and Methods

A field experiment was conducted in the Wetland farm of Tamil Nadu Agricultural University, Coimbatore during July to November of 2017. The experimental site was located in the Western Agro Climatic zone of Tamil Nadu at 1l^{o} N latitude, 77^{o} E longitude and at an altitude of 426.72 m above mean sea level. The experiment was conducted to study the effect of different crop establishment methods on growth attributes, yield attributes, root characters and economics of rice under puddled condition. The soil of experimental field was deep clay loam with moderate drainage. The soil is classified taxonomically as *Typic Haplustalf*. The soil with the pH of 8.23 and EC of 1.2 dS m^{-1}. The nutrient status of the soil was low in available nitrogen (265.6 kg ha^{-1}), medium in available phosphorus (20.9 kg ha^{-1}) high in available potassium (458.0 kg ha^{-1}) and medium in soil organic carbon content (0.61 per cent). The variety used for experiment was CO(R) 51 and experiment was carried out in randomized block design with nine treatments and three replications. The treatments were conventional transplanting (T_1), line transplanting (T_2), seedling throwing (T_3), square planting (SRI) with single seedling (T_4), square planting (SRI) with double seedlings (T_5), direct wet seeded rice (broadcasting) (T_6), direct planting system (DPS) (T_7), drum seeding (T_8) and drum seeding with green manure (T_9). The recommended dose of 150:50:50 kg NPK ha^{-1} was applied, as entire P, 25 % of N and K as basal and

remaining 75% N and K applied as three splits to all the treatment except drum seeding with green manure (T_9). In this treatment, N was applied as two equal splits at panicle initiation and heading stages, P and K applied as similar to other treatments. During tillering stage, dhaincha (30 DAS) was incorporated and the biomass produced by dhaincha was estimated. One split dose of N required by the treatment was met with incorporation of dhaincha. Observations on growth and yield parameters were recorded as per standard procedure. The grain and straw yield were recorded per plot and converted to t ha^{-1}.

The cost of cultivation, gross return, net return (gross return – cost of cultivation) and BC ratio were calculated on the basis of prevailing market price of different inputs and outputs.

Results and Discussion

Effect of different crop establishment methods

Growth attributes

Plant height (103.8 cm), number of tillers sq.m^{-1} (648), leaf area index (5.98) and dry matter accumulation (16989 kg ha^{-1}) was significantly higher under square planting (SRI) with single seedling method when compared to all other methods (Table. 1) and was comparable with square planting (SRI) with double seedling and seedling throwing. The tallest plants under square planting (SRI) with single seedling method might be due to optimum plant population and geometry which led to availability of more resources to plants. The increased LAI in square planting (SRI) with single seedling method was due to open plant structure giving more coverage to the ground area. Further, the lower angle of inclination of leaves in case of SRI from horizontal results in more spread than all other methods (Thakur *et al.,* 2011). The higher dry matter accumulation in square planting (SRI) with single seedling might be attributed due to wider spacing which resulted in more tiller production, number of leaves, LAI and improved root characters. In the presence of adequate nutrient availability and larger photosynthesizing surface, the dry matter accumulation proceeded at a rapid rate leading to its greater accumulation (Borker *et al.,* 2008).

Table 1. Effect of different crop establishment methods on growth attributes and root characteristics of rice at maturity stage

Treatments	Growth attributes				Root characteristics		
	Plant height (cm)	No. of tillers sq. m^{-1}	DMP (kg ha^{-1})	LAI	Root length (cm)	Root biomass (kg ha^{-1})	Root volume (cc)
T_1: Conventional transplanting	95.6	596	15548	5.57	23.6	778.9	16.0
T_2: Line transplanting	97.8	576	15280	5.65	22.4	809.0	16.3
T_3: Seedling throwing	99.1	612	16112	5.77	24.1	835.5	17.1
T_4: Square planting (SRI) with single seedling	103.8	648	16989	5.98	26.9	890.8	19.2
T_5: Square planting (SRI) with double seedlings	102.4	625	16508	5.93	25.7	857.8	18.8
T_6: Direct wet seeded rice (broadcasting)	87.6	497	13295	5.14	19.8	724.5	13.3
T_7: Direct planting system	94.7	552	14439	5.58	22.9	768.1	15.4
T_8: Drum seeding	92.5	544	14129	5.41	21.0	755.7	14.1
T_9: Drum seeding with green manure	90.3	523	13843	5.29	23.0	736.9	14.6
SEd	3.9	30	833	0.21	1.3	32.0	0.9
CD (P=0.05)	7.9	61	1772	0.42	2.7	64.8	1.8

Table 2. Effect of different crop establishment methods on yield attributes and yields of rice

Treatments	Yield attributes					Yield	
	Productive tillers sq.m^{-1}	Panicle length (cm)	Total no. of grains $panicle^{-1}$	No. of filled grains $panicle^{-1}$	Fertility (%)	Grain (kg ha^{-1})	Straw (kg ha^{-1})
T_1: Conventional transplanting	518	21.8	126.7	106.1	83.7	6080	8990
T_2: Line transplanting	531	22.0	130.3	111.2	85.4	6002	8890
T_3: Seedling throwing	552	22.4	133.8	115.7	86.4	6150	9280
T_4: Square planting (SRI) with single seedling	595	23.4	152.7	137.7	90.2	6860	10180
T_5: Square planting (SRI) with double seedlings	580	22.8	144.1	127.7	88.6	6670	9780
T_6: Direct wet seeded rice (broadcasting)	431	19.7	112.8	88.1	78.1	5020	8240
T_7: Direct planting system	502	21.4	129.8	108.4	83.5	5870	8720
T_8: Drum seeding	488	20.8	120.3	97.4	81.0	5820	8600
T_9: Drum seeding with green manure	461	20.2	117.5	94.1	80.1	5620	8480
SEd	21.4	0.9	6.6	5.4	3.3	473	708
CD (P=0.05)	43.9	1.9	13.2	10.8	6.7	965	1446

Root characteristics

Results (Table 1) revealed that square planting (SRI) with single seedling recorded the higher root length (26.9 cm), root dry weight (890.8 kg ha^{-1}) and root volume (19.2 cc) which were significantly more than all other methods, but comparable with square planting (SRI) with double seedling. The younger seedlings in SRI when carefully transplanted by keeping the roots straight (assuring that the roots do not assume 'j' shape) might have encouraged vigorous and deeper root system. Further, the provision of wider spacing between plants in SRI (16 plants sq.m^{-1}), alternate drying and wetting of soil and loosening of soil by running of cono weeder to control weeds might have helped rice seedlings to develop profuse root growth. Barison (2002) reported that because of alternate wetting and drying of soil,

Table 3. Effect of different crop establishment methods on economics, labour utilization and partial budgeting of rice

Treatments	*Economics (₹ /ha)				*Labour utilization		*Partial budgeting				
	Cost of cultivation ₹ /ha	Gross Return ₹ /ha	Net Return ₹ / ha	BCR	Labour requirement (Nos./ha)	Labour productivity (₹ output/ ₹ input)	Added return (₹) (A)	Reduced cost (₹) (B)	Added cost (₹) (C)	Reduced return (₹) (D)	net change in income (₹) ((A+B) – (C+D))
T_1	55872	90940	35068	1.63	129	1.96	-	-	-	-	-
T_2	61992	89804	27812	1.45	146	1.71	-	2160	8280	1136	-7256
T_3	53612	92360	38748	1.72	122	2.10	1420	3960	1700	-	3680
T_4	55598	102680	47082	1.85	138	2.07	11740	7472	8280	-	10932
T_5	54006	99600	45594	1.84	133	2.08	8660	7264	6480	-	9444
T_6	55323	76720	21397	1.39	119	1.80	-	9710	9046	14220	-13556
T_7	53258	87880	34622	1.65	118	2.08	-	13716	7501	3060	3155
T_8	47668	86200	38532	1.81	101	2.38	-	8630	425	4740	3465
T_9	52166	84400	32234	1.62	108	2.18	-	12708	4621	6540	1547

*Data not statistically analyzed

T_1- Conventional transplanting; T_2- Line transplanting; T_3- Seedling throwing; T_4- Square planting (SRI) with single seedling; T_5- Square planting (SRI) with double seedlings; T_6: Direct wet seeded rice (broadcasting); T_7- Direct planting system (DPS); T_8- Drum seeding; T_9- Drum seeding with green manure

the SRI plants were capable of developing greater root penetration in comparison to traditionally grown plants.

Yield attributes and Yield

The rice crop establishment methods under study exerted significant influence on the yield attributes of rice (Table 2). From the present experiment, it was found that all the crop establishment methods were comparable to each other in recording number of productive tillers sq.m^{-1} (595), panicle length (23.4 cm), total number of grains panicle^{-1} (152.7), number of filled grains panicle^{-1} (137.7) and fertility percentage (90.2) were recorded in square planting (SRI) with single seedling. Though it was comparable with square planting (SRI) with double seedling and seedling throwing. Yield attributes are more in square planting (SRI) with single seedling might be due to optimum supply of irrigation water with mechanical weeding which might have resulted in higher nutrient availability, subsequently resulting in better source to sink conversion thereby enhanced the production of spikelets and filled grains/ panicle. The higher spikelet fertility in SRI might be due to availability of better light, optimum spacing and efficient translocation of photosynthates to spikelets. The higher microbial population in the rhizosphere might have mobilize more nutrients which in turn reflected in more yield attributes and yield (Krishna *et al*., 2008)

In cereal crops like rice both grain and straw are the valuable economic parts. In the present investigation, a higher grain and straw yields were obtained with square planting (SRI) with single seedling (6860 kg ha^{-1} and 10180 kg ha^{-1}, respectively) which was comparable to square planting (SRI) with double seedlings (6670 kg ha^{-1} and 9780 kg ha^{-1}, respectively) method (Table 2). Square planting (SRI) with single seedling had edge of 36.65 % and 23.54 %, of grain and straw yield, respectively over direct wet seeded rice (broadcasting). This might be due to the increased yield attributing characters like increased number of tillers sq.m^{-1}, panicle length, thousand grain weight and low sterility percentage (Jayapal Reddy and Sandhya Shenoy, 2013).

Economics, labour utilization and partial budgeting

The gross return, net return and B:C ratio (₹ 102680 ha^{-1}, ₹ 47082 ha^{-1} and 1.85, respectively) were higher in square planting (SRI) with single seedling under puddled condition (Table. 3). This might be due to higher yield and lesser cost involved in cost of cultivation. The higher total cost of cultivation was recorded under line transplanting due to utilization of more number of labours for transplanting and weeding. The higher added benefit of ₹ 10932 ha^{-1} was obtained in square planting (SRI) with single seedling this might be due to increased return, reduced cost of cultivation and higher labour

productivity.The higher labour productivity was obtained in drum seeding. This might be due to the less number of labourers were required for sowing of pre-germinated seeds under puddled condition and weeding operation (Senthilkumar *et al.,* 2007).

Conclusion

Among the different crop establishment methods in puddled condition, System of Rice Intensification (SRI) method provide higher productivity and profitability. For labour saving drum seeding method is found to the best.

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