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Impact of Crop Establishment Methods on Growth, Yield and Economics of Rice

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ABSTRACT: A field experiment was conducted for two consecutive years during 2019-20 and 2020-21 starting with *kharif* rice in the Instructional farm of OUAT, Bhubaneswar. The experiment was carried out in a Randomized Block design having 3 treatment combinations and 18 replications. Treatments consists of rice establishment method such as Direct Seeded Rice (DSR), Non puddled Transplanted Rice (NPTR) and Puddled Transplanted Rice (PTR). The soil was sandy loam in texture and slightly acidic in reaction with pH 5.43, low in organic carbon (3.75 g kg^{-1}), low in available N (183 kg ha^{-1}), medium in available P_2O_5 (14.17 kg ha^{-1}) and high in K_2O content (297.2 kg ha^{-1}). In case of rice, higher yield was obtained under PTR method (5006 kg/ha) followed by NPTR (4841 kg/ha) and DSR (4643 kg/ha) method. But economically DSR was superior with B-C ratio of 1.79.

Keywords : Rice, Establishment method, Growth, Yield, Economics.

INTRODUCTION

Rice and rice based cropping systems are an integral part of agriculture whose spread and extent is predominant across the countries, more precisely in eastern India. Globally rice is grown in 163 Mha area with production of 758.9 Mt rough rice with a productivity of 3.2 t/ha (Rathan *et al.,* 2020). India occupies the world's largest area (44.5 Mha) under rice and is the second largest producer (121.26 Mt) followed by china, contributing 22% of global rice production. About 11.7 M ha area of India remains fallow after rice harvesting and it constitutes ~79% of total rice fallow areas of South Asia (15 M ha) (Kumar *et al.,* 2020). This condition is more evident in eastern India which accounts for about 63.3% of the India's total rice area. About 78.7% of rice area in these region is rainfed and rice is grown during rainy season (June–September) only. These areas are mostly mono cropped. It is estimated that 12.45 m ha in India is under rice-fallow, which constitute 79% of total rice-fallow area of South Asia is mainly concentrated in states like Uttar Pradesh, Bihar, Jharkhand, Odisha, Chhatisgarh, Madhya Pradesh, Tamil nadu, Andhra Pradesh , Karnataka etc.

Methods of crop establishment influences the performance of the rice crop and also has a great impact on field preparation and stand establishment of succeeding rabi crops (Pandey *et al.,* 2018). Rice in India is grown mostly through transplanting (44%). Puddled transplanted rice includes important and extreme form of tillage in standing water that reduces water percolation, suppresses weed, increases nutrient availability and promotes higher crop growth and yield attributing parameters and finally the yield (Jnanesha and Kumar 2017). But it encourages breakdown of soil aggregates, destruction of soil macropores and formation of hard pan (McDonald *et al*., 2019) for which farmers are switching over to alternate establishment methods like direct seeding which saves 35-55 % irrigation water and reduces labour requirement by 11-66% depending upon the region and season (Rashid *et al.,* 2009) by avoiding operations like nursery preparation and transplanting, saves 29% of cost of TPR and increases net return by 37% (Hongyan *et al*., 2015; Parameswari *et al.,* 2014).

MATERIALS AND METHODS

The field experiment was conducted at Instructional Farm of College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India. Geographically the experimental site is situated at 20° 26′ N latitude and 85.79′ E longitude at an elevation of 25.9 m above mean sea level, about 65

km away from the Bay of Bengal. The soil was sandy loam in texture and slightly acidic in reaction with pH 5.43, low in organic carbon (3.75 g/kg), low in available N (183 kg/ha), medium in available P_2O_5 (14.17 kg/ha) and high in K_2O content (297.2 kg/ha). Rainfall received during June to November in 2019 and 2020 was 1530 mm (83 rainy days) and 1304 mm (70 rainy days), respectively, which was sufficient enough for rice cultivation. The experiment was laid out in a split-split-plot design with three replications. Three establishment method in rice namely direct sowing, non puddled transplanting and puddled transplanting were allotted as the main-plots *in kharif*. Rice variety Swarna sub-1 was grown for experimental purpose. For DSR, Field was ploughed twice using cultivator followed by rotavator and levelling. In NPTR, field was prepared through dry ploughing twice by cultivator followed by rotavator and levelling. A week before transplanting weeds were killed by spraying glyphosate @ 2.5 kg/ha, which followed irrigation and planting, whereas in PTR, field was prepared thoroughly with dry ploughing twice followed by irrigation and puddling by power tiller. Transplanting was done one day after puddling. 25-30 days old seedlings were transplanted in the prepared plots under puddled and non-puddled condition. The spacing was maintained at 25cm × 10cm with 3-4 seedlings in each hill. The depth of transplanting was maintained a t2-3cm. An uniform dose of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O was applied per hectare area in the form of Urea, DAP and MOP. Rice was grown with the rainfall received during the crop period. Data related to LAI and dry matter accumulation were collected starting from 30 DAS with 30 days interval till harvest. Data on yield attributing characters and yield was collected at maturity. Economics of rice establishment methods was computed at the end of the cropping cycle.

RESULT AND DISCUSSION

Growth. On the perusal of two years pooled data presented in Table 1, it was found that crop establishment methods significantly affected the growth, yield and production of rice. Different establishment methods caused marked variation on LAI at all stages. A critical study of the data revealed that in general the value of leaf area index increased with the increase in age of the crop till 90 DAS and then decreased up to harvest. From the mean data, it is evident that the leaf area index ranged from 1.43 to 1.68 at 30 DAS, which increased to 4.17 to 4.46 at 60 DAS and reached its maximum of 4.52 to 4.86 at 90 DAS that decreased further to 2.86 to 3.24 at harvest. Till flowering the leaf growth was very active which must have resulted in accumulation of photosynthates for transmission to sink during the grain filling to ripening stage of the crop. The gradual decline in leaf growth after flowering might be due to death of some ineffective tillers resulting in shortage of solar radiation required to carry. The maximum value of LAI recorded at 90 DAS under PTR method (4.86) followed by NPTR (4.71) and DSR (4.52). Similar findings were given by Rahman *et al.* (2020). This might be due to the significantly higher tiller production in PTR method which led to production of higher number of leaves which were more efficient in harvesting solar radiation for better growth and yield. This corroborated the earlier findings of Kakul *et al.* (2014).

Variation in the dry matter accumulation (g/m^2) at different stages of crop growth as influenced by various treatments of crop establishment methods. (Table 2). It was observed that the dry matter Production increased gradually with advancement of phenophases of the crop and reached the highest at harvest in both the years of study. The rate of increase was slower during first 30 DAS which continued upto 60 DAS but got increment after that and reached its maximum at harvest during both the years of study. The mean data revealed that higher dry matter production was noticed under PTR method where it was 271 g/m^2 at 30 DAS which increased to 613 g/m^2 at 60 DAS and 992 g/m^2 at 90 DAS reaching its maximum of 1154 g/m2 at harvest. The maximum dry matter recorded under PTR method (1154 g/m^2) following NPTR (1094 g/m^2) and DSR (1058 g/m^2) method. The higher dry matter production attributed production of higher number of tillers and leaf area which were favoured under PTR method due to better availability of nutrients and water in the presence of impervious puddled layer which reduced the nutrient and water loss in turn increasing their uptake. More dry matter accumulation might also be attributed to low weed infestation in puddled condition as compared to DSR. These results are in accordance with the findings of Kumar *et al.* (2017); Rahman *et al.* (2020).

Yield attributes & yield. All the yield attributing characters as influenced by different rice establishment methods (Table 3). Mean data exhibited that maximum value of all yield attributing characters *viz.,* plant height (23.2 cm), number of panicles /m^2 (244), number of filled grains/ panicle (98.5) was obtained under PTR followed by NPTR. The lowest value of yield attributing characters are recorded for DSR method.

PTR method produced better growth which resulted in higher photosynthates accumulation and translocation of these photosynthates to the reproductive part thereby increasing the number of filled grains per panicle. Moreover the increase in panicle length also helped in accommodating higher number of grains per panicle (Sahoo, 2017).

The grain yield varied significantly under different establishment methods (Table 4). Maximum grain yield (5006 kg/ha) was recorded under PTR method which was 3.4% higher than the yield recorded under NPTR (4841 kg/ha) and 7.8% higher than DSR method (4643 kg/ha). It was probably due to higher growth and yield attributes resulted by better nutrient absorption from the soil, increased rate of metabolic process, rate of light absorption and photosynthetic activity as compared to other establishment methods

(Kumar *et al*., 2015). Similarly, maximum straw yield was also observed under PTR (5912 kg/ha) which was 1.4 % higher than NPTR (5829 kg/ha) and 5.2 % higher over DSR (5617 kg/ha), respectively. This could be possibly due to better availability of nutrient and water under puddled conditions and better initial establishment which resulted in higher dry matter accumulation in subsequent growth stages that produced more number of effective tillers, total grains, filled grains per panicle, test weight and lower sterility and ultimately resulting in highest grain and straw yield (Rahman, 2020; Sahoo, 2017). More space, sunlight and nutrients availability in transplanted crop produced highest LAI that might have built the capacity for higher photosynthesis rate resulting higher biological and economical yield whereas higher weed densities in direct seeded crop hinders the development of panicle length and other yield attributes.The results are in accordance with the findings of Choudhary *et al.* (2016); Kaur *et al.* (2023).

Table 1: LAI of rice as influenced by different crop establishment methods.

Treatment	30 DAS			60 DAS			90 DAS			HARVEST		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
DSR	1.63	1.74	1.68	4.11	4.23	4.17	4.50	4.55	4.52	2.84	2.89	2.86
NPTR	1.39	1.47	1.43	4.28	4.38	4.32	4.68	4.74	4.71	3.06	3.17	3.12
PTR	1.48	1.55	1.51	4.43	4.49	4.46	4.82	4.91	4.86	3.21	3.26	3.24
SEm(±)	0.08	0.09	0.08	0.04	0.08	0.06	0.09	0.05	0.03	0.07	0.04	0.05
CD (0.05)	0.24	0.27	0.24	0.12	0.24	0.18	0.27	0.15	0.09	0.21	0.12	0.15

Table 2: Dry matter (g/m^2) of rice as influenced by different crop establishment methods.

Treatment	30 DAS			60 DAS			90 DAS			HARVEST		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
DSR	253	261	257	575	581	578	936	941	938.5	1051	1065	1058
NPTR	258	266	262	598	614	606	972	986	979	1106	1122	1114
PTR	265	277	271	618	622	620	995	998	996.5	1150	1158	1154
SEm(±)	2.9	3.8	3.6	5.2	6.5	5.9	6.3	7.6	7.2	7.8	8.4	8.1
CD (0.05)	8.7	11.4	10.8	15.6	19.5	17.7	18.9	22.8	21.6	23.4	25.2	24.3

Table 3: Yield attributes of rice as influenced by different establishment methods.

Treatment	Panicle Length (cm)			No. of panicles/m^2			No. of filled grains/ Panicle			Test Weight		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
DSR	21.3	21.9	21.6	236	238	237	91	93	92	22.9	23.1	23.0
NPTR	22.0	22.8	22.4	239	242	240	94	96	95	23.2	23.2	23.2
PTR	22.9	23.5	23.2	243	245	244	95	96	95.5	23.5	23.7	23.6
SEm(±)	0.32	0.41	0.48	3.61	3.28	3.44	1.53	2.02	1.86	0.32	0.56	0.45
CD (0.05)	0.32	0.41	0.48	0.74	0.84	0.81	1.12	1.24	1.15	0.32	0.56	0.45

Table 4: Yield of rice as influenced by different crop establishment methods.

Treatment	Grain yield (Kg/ha)			Straw yield (Kg/ha)			Harvest Index		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
DSR	4611	4674	4643	5576	5658	5617	45.26	45.23	45.2
NPTR	4802	4881	4841	5796	5862	5829	45.31	45.43	45.4
PTR	4962	5049	5006	5845	5924	5912	45.91	46.01	45.8
SEm(±)	46.9	62	57.7	52.5	61.8	56.6	0.68	0.31	0.35
CD (0.05)	140.7	186	173.1	157.5	185.4	169.8	2.04	0.93	1.05

Production economics. The maximum gross return (101074 Rs/ha) and net return (43309 Rs/ha) was observed under PTR method followed by NPTR method. DSR method registered the minimum gross return (93981 Rs/ha) and net return (41598 Rs/ha). This might be owing to higher yield and returns associated with the respective treatments (Nayak, 2018). However, DSR recorded higher B/C ratio (1.79) as compared to NPTR (1.78) and PTR (1.75). This is because of higher cost of production in PTR and NPTR as compared to DSR. Saving of labour and water in turn results in higher B/C ratio in DSR (Jnanesa and Kumar 2017). The increase in cost of production was due to higher cost involvement during nursery raising, land preparation, transplanting and irrigation (Ahmed and Latiful 2018). Net labour savings with direct seeded rice compared with transplanting averaged 27 days/ha and the additional benefit that no nursery is needed, reduced the cost of cultivation of DSR methods (Sahoo, 2017; Nayak, 2018).

Table 5: Production economics of rice as influenced by different crop establishment methods.

Treatment	Gross Return (Rs/ha)			Net Return (Rs/ha)			B:C ratio		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
DSR	92066	95897	93981	40014	43181	41598	1.77	1.82	1.79
NPTR	95856	100067	97962	41539	45046	43292	1.76	1.81	1.79
PTR	98839	103308	101074	41418	45199	43309	1.72	1.77	1.751
SEm(±)	245.2	335.4	382.3	245.2	335.4	382.3	0.01	0.03	0.02
CD (0.05)	735.6	1006.2	1146.9	735.6	1006.2	1146.9	0.03	0.09	0.06

CONCLUSIONS

From the above study, it can be concluded that Puddled transplanted rice performed superiorly in terms of growth parameters, yield attributes and yield over Non puddled transplanting method and Direct seeded rice was recorded with the lowest value. However, higher B/C ratio was obtained under DSR method probably due to lower cost of production as compared to the other methods.

FUTURE SCOPE

The effect of other various rice establishment methods on growth parameters, yield and production economics of rice are need to be studied. Furthermore, the impact of establishment methods on the soil characteristics are need to be examined and the most suitable extablishment method is needed to be found out with respect to maximizing the resource use efficiency of the succeeding crop followed and the cropping system as a whole.

Conflict of Interest. None.

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