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Influence of establishment methods and nutrient management on growth, yield attributes and yield of Kharif rice

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Abstract
Studies were conducted during kharif seasons, 2017 and 2018 to assess the growth and yield of kharif rice under four establishment methods viz. sowing of dry seeds by drum seeder (M_1), system of rice intensification (M_2), Transplanting by hand operated transplanter (M_3) and conventional transplanting (M_4) under three nutrient management treatments viz. organic management (OM) i.e. 100% RDN through organic sources (N_1), 100% RDF (100:50:50 N: P_2O_5 : K_2O kg ha-1) (N_2), integrated nutrient management (N_3) i.e. 50% RDF + 50 % RDN through organic sources. The maximum plant height, number of leaves m^{-2}, number of tillers m^{-2}, dry matter production m^{-2}, number of panicles m^{-2}, number of filled grains $panicle^{-1}$, panicle length, grain yield and straw yield were recorded under conventional and SRI method of transplanting during both the years of experimentation. Conventional transplanting method increased grain yield (43.42 q ha-1) by 22.76 % over drum seeded rice, respectively; whereas, the latter two treatments remained at par. Application of 100% RDF registered the highest grain yield of 42.23 q ha-1 which was higher by 10.32 % over organic and at par with INM.

Keywords: Rice, methods, nutrient management, growth, yield

Introduction
Rice (*Oryza sativa* L.) is the most important staple food crop of the world and India, feeding more than half of the world's population every day. Rice provides 20 per cent of the world's dietary energy supply, while wheat supplies 19 per cent and maize 5 per cent (FAO, International year of rice, 2004). In Asia, it has a special significance, where about 90% of the rice is produced and consumed as a staple food. It is a predominant crop in lowland ecosystem. Globally it is cultivated in an area of 161.28 million hectares with an annual production of 715.75 million tonnes (Anonymous, 2016a) [1]. Among the various rice growing countries of the world, India has the largest area under rice and in case of production it stands next to China. In India, rice is the most important and extensively grown food grain crop, occupying an area of 44.11 million hectares with production of 105.48 million tonnes. However, productivity of India (2.39 tonnes ha^{-1}) is lower than the world average yields (4.4 tonnes ha^{-1}) and is much behind than the rice productivity of Egypt, Japan and China (Anonymous, 2016b) [2]. Rice is also an important cereal food crop of Maharashtra State, which contributes 3.6 per cent of area and 2.8 per cent of production of rice at national level. Total area, production and productivity of rice were 14.71 lakh hectares, 25.17 lakh tonnes and 1.71 tonnes ha^{-1}, respectively. Rice is the main food crop grown in Konkan region, which occupies an area of 3.79 lakh hectares with production 9.94 lakh tonnes and productivity of 2.61 tonnes ha^{-1} (Anonymous, 2016c) [3]. Rice is grown either by direct seeding or by transplanting. In Konkan, rice is mostly grown by transplanting method. Method of crop establishment influences the performance of rice through its effect on growth and development. Although, transplanting has been reported to be the best establishment method (Jana *et al*., 1981 and Singh *et al*., 1997) [6, 15] but due to high water and labour requirement, some alternatives like dry and wet direct seeding are being explored to ensure optimum yield at a lower cost. The results revealed that both transplanted and direct seeded method needed nearly equal investment on cultivation, but transplanted rice required more initial expenditure as compared to direct seeded rice. Weed infestation and weed competition are more in direct seeded rice as compared to transplanted rice, because the land is exposed till the initial seedling establishment in direct seeded rice.
Nutrient management provides an approach for feeding the plants with nutrients as and when required. Integrated use of organic manures and chemical fertilizers has advantages over use of only organic manures or chemical fertilizers (Kumar *et al*., 2009) [7]. Since sourcing of organic manure is difficult and the crop response to them during initial stages is not as spectacular, compared to the chemical fertilizers (Deka *et al*., 1996) [5],

(Deka *et al*., 1996) [5], an integrated approach of plant nutrition involving the judicious mix of organic, chemical and microbial sources could be helpful to sustain optimum yield and to restore the residual soil fertility. Keeping this in view, the present study was undertaken to investigate the influence of establishment methods and nutrient management on growth, yield attributes and yield of Kharif rice.

Materials and Methods

The field experiment was conducted on plot Nos. 22, 23 of 'B' block of Agronomy Department Farm, College of Agriculture, Dapoli. Dist. Ratnagiri during Kharif 2017 and 2018. The soil of the experimental plot was uniform, levelled and well drained. It was sandy clay loam in texture, low in available nitrogen (214.42 kg ha^{-1}), phosphorus (9.62 kg ha^{-1}) and medium in potassium (207.31 kg ha^{-1}), moderately high in organic carbon (0.95%) and slightly acidic in reaction (5.86). The sowing of dry seeds by drum seeder was done at onset of monsoon as per the treatments. The nursery for conventional transplanting, transplanting by hand operated transplanter and SRI method was done on the same day of sowing of dry seeds by drum seeder. In 100 % RDF and 50% RDF dose of integration, 40% N and all P and K was applied as basal dose and remaining 60% N was applied in two splits i.e 40% at maximum tillering and 20% at panical initiation stages. In 100% RDN through organics and 50% RDN of integration, full doses were applied as basal as per the treatments. The other usual common packages of practices were followed time to time and periodical growth observations were recorded at an interval of 30 days. Crop was harvested at physiological maturity and data on yield attributes and yield were recorded.

Results and Discussion

Effect of establishment methods on growth, yield parameters and yield of *Kharif* rice

Conventional transplanting remained at par with SRI method and both the methods significantly increased all growth (plat height, number of leaves, number of tillers and dry matter production) yield (number of panicles m^{-2}, panicle length, number of filled grains $panicle^{-1}$ and test weight) parameters and yield of rice followed by planting the rice by hand operated transplanter. This could be attributed to the efficient weed management and favourable soil physical conditions for the transplanted methods due to puddling and maintainance of optimum plant population due to proper spacing and nutrition as compared to direct sown rice. The increased growth parameters under transplanted methods may also be attributed to the fact that each individual plant hill in transplanting methods got the advantage of more available and liberal nutrients, space, solar radiation and other growth resources. The other reason of high dry matter accumulation in transplanting methods may be traced to the significant increase in morphological parameters which are responsible for the photosynthetic capacity of the individual plant there by increasing the yield. Similar findings were also reported by Moharana (2015) [12], Kumar *et al*. (2018) [8] and Shendage (2018) [14].

Effect of nutrient management on growth, yield parameters and yield of *Kharif* rice

Data pertaining to the growth, yield parameters and yield (q ha-1) of rice as influenced by different treatments are presented in Table 1, 2 and 3 indicated that, growth parameters of rice, *viz*., plant height, number of functional leaves m^{-2}, number of tillers m^{-2} and dry matter accumulation (g) m^{-2}, yield parameters and yield recorded maximum under application of 100% RDF (N_2) over rest of the nutrient management treatments and was at par with integration in some of these parameters during both the years. Significantly higher plant height in fertilizer treatment (N_2) over organic manurial treatment might be due to quick release of nutrients and more availability of nitrogen. Nitrogen is associated with increase in protoplasm, cell division and cell enlargement resulting in taller plants (Tisdale *et al*., 1985) and also in increased chlorophyll content at all growth stages that might have increased the photosynthesis and resulted in increased plant height. Application of 100% RDF through inorganic (N_2) and Integrated nutrient management (N_3) recorded significantly higher grain and straw yield over organic treatment (N_1) during individual years as well as in pooled data. The increase in grain yield was might be due to application of mineral N, P and K that significantly increased growth and yield attributes which in turn, increased the rice yield compared to added levels of N and other nutrients in organic form. The similar findings were also reported by Dash *et al*. (2011) [4], Sujatha (2013) [16], Meena *et al*. (2014) [10], Patel (2014) [13], and Marskole (2017) [9].

Effect of establishment methods and nutrient management on yield of rice

Among the interactions the highest grain and straw yield (46.46 and 65.26 q ha^{-1}) were recorded with conventional transplanting method coupled with 100% RDF or INM and the lowest yield (35.21 and 51.40 q ha^{-1}) in drum seeded rice with 100% RDN through organic (N_1), respectively (Table 3). This can be ascribed to balanced nutrition of essential nutrients due to better physical, chemical and biological properties maintained under INM followed for transplanted rice. These findings corroborate the reports of Mohanty *et al*. (2014) [11] and Moharana (2015) [12].

Table 1: Growth of rice as influenced by establishment methods and nutrient management treatments

Treatments	Plant height (cm)		Tillers m-2		Number of leaves m^{-2}		Dry-matter accumulation (g m-2)	
	2017	2018	2017	2018	2017	2018	2017	2018
Establishment methods								
M_1	68.40	65.62	271	270	1169	1168	530	516
M_2	80.03	78.60	283	281	1192	1190	613	601
M_3	77.33	75.31	280	277	1187	1184	610	597
M_4	82.67	80.40	284	282	1230	1228	615	603
S.E m ±	0.63	0.94	0.97	0.59	0.99	0.86	0.77	0.72
C.D at 5%	2.19	3.25	3.35	2.06	3.41	2.97	2.68	2.48
N_1	74.78	72.50	277	275	1192	1190	589	576
N_2	79.46	77.40	282	279	1197	1195	594	581

N_3	77.08	75.05	280	278	1195	1193	592	579
S.E m ±	0.86	0.87	0.80	0.63	0.77	0.72	0.60	0.66
					3.02	2.83	2.36	2.59
C.D at 5%	3.38	3.43	3.13	2.48	Interaction effect			
S.E m ±	0.39	1.08	1.09	1.55	1.13	0.91	0.36	0.49
C.D at 5%	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

(M_1- sowing of dry seeds by drum seeder, M_2- SRI method, M_3- Transplanting by hand operated transplanter and M_4- conventional transplanting, N_1- 100% RDN through organic, N_2- 100% RDF and N_3- 50% RDF through inorganic + 50% RDN through organic)

Table 2: Yield attributes of rice as influenced by establishment methods and nutrient management treatments

Treatments	Total number of panicles (m^{-2})		Length of panicle (cm)		Number of filled grains Panicle $^{-1}$	Test weight (g)		
	2017	2018	2017	2018	2017	2018	2017	2018
Establishment methods								
M_1	260	259	20.20	18.20	101	100	22.25	21.20
M_2	274	272	23.12	22.55	115	113	27.68	25.36
M_3	272	269	21.52	19.60	111	108	25.13	22.07
M_4	276	274	23.64	23.12	117	115	28.13	26.72
S.E m ±	0.79	0.62	0.31	0.28	0.79	1.05	0.57	0.47
C.D at 5%	2.74	2.15	1.08	0.98	2.72	3.62	1.97	1.63
Nutrient management								
N_1	268	266	20.37	19.35	107	106	24.17	22.65
N_2	273	271	23.82	21.95	113	111	27.03	24.89
N_3	271	269	22.18	21.31	111	109	26.19	23.98
S.E m ±	0.72	0.67	0.17	0.20	0.47	0.47	0.54	0.41
					1.86	1.83	2.13	1.60
C.D at 5%	2.82	2.63	0.65	0.78	Interaction effect			
S.E m ±	1.06	1.55	0.72	0.67	1.24 0.77		0.33	1.09
C.D at 5%	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

(M_1- sowing of dry seeds by drum seeder, M_2- SRI method, M_3- Transplanting by hand operated transplanter and M_4-conventional transplanting, N_1- 100% RDN through organic, N_2- 100% RDF and N_3- 50% RDF through inorganic + 50% RDN through organic)

Table 3: Grain and straw yield (q ha-1) of rice as influenced by different treatments during *Kharif* 2017, 2018 and in pooled data

Treatments	Grain yield (q ha-1)			Straw yield (q ha-1)		
	2017	2018	Pooled	2017	2018	Pooled
Establishment methods						
M1: Sowing of dry seeds by drum seeder	35.82	34.93	35.37	53.35	50.59	51.97
M2: SRI method	43.10	41.60	42.35	60.14	58.04	59.09
M3: Transplanting by hand operated transplanter	42.30	40.07	41.18	56.34	53.03	54.68
M4: Conventional transplanting	43.97	42.87	43.42	62.89	61.58	62.23
S.Em. ±	0.39	0.38	0.22	0.83	0.48	0.45
C.D. at 5%	1.35	1.32	0.75	2.86	1.65	1.55
Nutrient management treatments						
N1: 100% RDN through organic	38.63	37.93	38.28	55.51	52.63	54.07
N2: 100% RDF through inorganic	43.15	41.32	42.20	59.71	57.93	58.82
N3: 50% RDN through organic+50% RDF	42.11	40.36	41.23	59.32	56.87	58.09
S.Em. ±	0.30	0.41	0.34	0.81	0.28	0.43
C.D. at 5%	1.18	1.60	1.32	3.16	1.12	1.69
Interaction effect						
S.Em. ±	1.27	0.98	1.09	1.90	1.75	1.60
C.D. at 5%	3.90	NS	3.36	NS	NS	4.93
General mean	41.30	39.87	40.58	58.18	55.81	56.99

Table 4: Interaction effects between of establishment methods and nutrient management on grain yield (q ha^{-1}) of rice during *Kharif* 2017 and pooled mean

	Grain yield (q ha^{-1})							
	2017				Pooled mean			
	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4
N_1	35.21	39.32	39.37	40.62	34.85	39.23	38.33	40.72
N_2	36.79	45.50	43.86	46.46	36.24	44.28	42.73	45.69
N_3	35.45	44.49	43.67	44.82	35.04	43.54	42.50	43.86
S.Em. ±.	1.27				1.09			
C.D. at 5%	3.90				3.36			

Table 5: Interaction effect of establishment methods and nutrient management treatments on straw yield (q ha^{-1}) of rice in pooled analysis

	Straw yield (q ha^{-1})			
	Pooled mean			
	M_1	**M_2**	**M_3**	**M_4**
N_1	51.40	55.85	51.74	57.30
N_2	53.03	60.69	56.30	65.26
N_3	51.48	60.74	56.00	64.15
S.Em.±	1.60			
C.D. at 5%	4.93			

Conclusion

From the results of the present investigation, it can be concluded that to get higher growth, yield parameters and yield, *Kharif* rice should be grown by conventional transplanting method with application of 100% RDF or INM (50% RDF + 50% RDN through organic).

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