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Studies on physiology of growth and yield of rice (*Oryza sativa* L.) As influence by time of transplanting and varying leaf area index under Kharif Konkan condition

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Abstract
A field experiment was conducted during kharif seasons of 2016 to determine the effect of different transplanting dates and spacing on growth and yield of rice *(Oryza sativa* L.) under kharif condition of Konkan. The experiment was laid out as a strip plot design with three replications provided with four main treatments (Transplanting dates) T_1 -21 DAS, T_2 -31 DAS, T_3 - 41 DAS, T_4 - 51 DAS and three sub treatments Spacing, S_1 (20cm x 15cm), S_2 (15cm x 15 cm), S_3 (20 cm x 10 cm). Ratnagiri -24 variety of rice used for experiment and the experiment comprised of 12 treatments, *viz* T_1S_1, T_1S_2, T_1S_3, T_2S_1, T_2S_2, T_2S_3, T_3S_1, T_3S_2, T_3S_3, T_4S_1, T_4S_2, T_4S_3.Observations on number of panicle, length of panicle, no. of productive tillers, number of fertile grain per panicle,1000 grain weight, number of grains per plant, grain yield, straw yield and harvest index. Transplanting of 21 days old seedling T_1 recorded maximum value for grain yield (25.45g), straw yield (21.15g) and harvest index (56.20%). Spacing 20cmx15cm recorded grain yield/ plant (20.68g) and spacing 20cmx 10cm (19.37g) but maximum grain yield / plot obtained by closer spacing S_3 20cm x 10 cm.

Key words: transplanting, spacing, grain yield, straw yield.

Introduction
Rice (*Oryza sativa* L.) is most important food grain crops of the world. Rice is the staple food of most of the people in Asia. Therefore, rice is not only a staple food of the region but also a way of life. India is the world's second largest rice producer and consumer next to China. Rice is normally sown at the end of May and transplanted during the 2nd week of June. The exact sowing date for direct seeding of rice also play a vital role in improving its growth and increasing the yield. The sowing time of the rice crop is important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperatures and high levels of solar radiation. Secondly, the optimum sowing time for each cultivar ensures the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved (Farrell *et al*. 2003) [9]. Plant spacing has an important role on growth and yield of rice. Optimum plant density ensures the plant to grow properly with their aerial and underground parts by utilizing more solar radiation and soil nutrients (Miah *et al.* 1990) [13]. Alam (2006) [2] stated that optimum spacing gave a maximum number of total tillers m^{-2}, maximum number of fertile tillers m^{-2} which was dependent on temperature, moisture and other soil factors.

Material and methods
The present study comprised of four main treatment (transplanting) and three sub treatment (Spacing) with twelve treatment combination. A field experiment was conducted during *kharif* 2016 in Strip Plot Design, in three replication and standard practices were followed. Observations were recorded by 15 days interval. Five plants selected at random were tagged from each plot and observations on yield attributing characters (number of panicle, length of panicle, number of productive tillers, number of fertile grains per panicle, number of grains per plant,1000 grain weight, grain yield , straw yield, harvet index were recorded.

Results and Discussion

Effect of age of seedling at transplanting and varying leaf area index on yield attributing characters.

Data presented in Table no 1 and 2. Number of panicles per plant, number of productive tillers, 1000 grain weight and number of fertile grains per panicles are considered as the principle yield contributing characters and source and sink in rice. In the present investigation, amongst the four transplanting studied, transplanting with 21 days old seedling; exhibited significantly more number of panicle per plant (9.24), number of productive tillers (8.88), 1000–grain weight (21.60) and number of fertile grain per panicle (89.89) over transplanting of 51 days old seedling; (late transplanting) similar result reported by Kabir *et al*. (2014) [11], Safdar *et al*. (2006), Bashir *et al*. (2010) [6]. Wider spacing 20cm x15cm registered significantly more number of panicles per plant, number of productive tillers, 1000 grain weight and number of fertile grains per panicles than rest of spacing S_2 and S_3. Chakrabortty *et al.* (2014) [8]. Interaction of transplanting and spacing showed significance influence on number of panicles per plant, number of productive tillers, 1000 grain weight and number of fertile grains per panicles. The range of number of panicles tune of (5.97 to 9.87), number of productive tillers range from (6.4 to 9.7), 1000- grain weight from (14.93 to 23.26 gm) and number of fertile grains to the tune of (67.28to 91.17).

Data presented in Table no 1 and 2. In the present investigation, among the four transplanting and three spacing studied, transplanting T_1, 21 days old seedling; and spacing S_1 recorded significantly more number of grains per plant (1170.01) and length of panicle (24.50 cm) over transplanting T_4-51 days old seedling; Amin *et al.* (2009) [3]. Interaction effect of transplanting and spacing for both these characters showed similar pattern as that of their individual effects. Number of grains per plant and length of panicle range from (914.40 to 1184.90) and (21.19 to 25.63) respectively.

Total biomass production by any crop is the efficiency of it to produce grain and straw yield. In the present investigation, significant variation in respect of these character was observed. Among the four transplanting, transplanting T_1, 21 days old seedling; exhibited significantly more grain yield (25.45) per plant and straw weight (21.15) per plant over transplanting of 51 days old seedling; Hasanuzzaman *et al.* (2014) [10], Amin *et al.* (2009) [3], Safdar *et al.* (2009), Asma *et al.* (2005), Abid *et al.* (2015) [1], Ram *et al.* (2014) [15], Mukesh *et al.* (2013) [12]. Wider spacing S_1 recorded maximum straw weight (19.89) per plant and grain yield (20.68) per plant than rest of the spacing. Asma *et al.* (2005), Chakrabortty *et al.* (2014) [8]. Similarly, interaction of transplanting and spacing had significantly influence the grain yield and straw yield. Transplanting T_1 – 21 days old seedling; with spacing 20cmx 15cm recorded maximum grain yield per plant and straw yield per plant than transplanting T_4 - 51 days old seedling; with spacing 20cmx10cm. Straw weight increased to the tune of 16.17 to 21.63 and grain yield increased to the tune of 15.12 to 26.45.

Data presented in Table no. 4. As compare to the normal recorded time of transplanting (T_1) and recorded spacing (S_1), the yield (Kg/plot) of Ratnagiri-24 was significantly high by T_1S_3 10.91 (%), T_1S_2 7(%), indicating scope for improvement yield with adapting closer spacing 15 cm x 15 cm and 20 cm x 10 cm while T_2S_1- 2.83 (%), T_2S_2-0.18 (%), T_2S_3 - 1.61 (%), T_3S_2 -0.38 (%),T_3S_3 - 0.45 (%), T_4S_2- 2.39 (%), T_4S_3 - 1.75(%) were significantly at par with T_1S_1 , indicating that if normal transplanting time is delayed due to delay in rainfall or breaks in rainfall , the normal yield could be achieved by adapting closer spacing 20 cm x 10 cm, 15 cm x 15 cm and T4S1 recorded 23. 35 (%) low yield (kg/ plot) by adapting spacing 20 cm x 15 cm.

The higher yield per plot recorded with closer spacing T_1S_3 and T_1S_2 on normal transplanting T_1 with spacing S_1 as well as at par yield is recorded by T_2S_1 , T_2S_2 , T_2S_3 , T_3S_2 , T_3S_3 , T_4S_2 , T_4S_3 could be attribute to the higher LAI achieved at the time of flowering initiation due to closer spacing with respect to transplanting dates and spacing . The similar benefit of closer spacing recorded by Pandey and Tripathi (2001) [14], Bhowmik *et al*. (2012) [7], Ashraf *et al*. (2014) [4].

Data presented in table no. 3. Amongst the four transplanting dates high HI was obtained from transplanting T_1-21 days old seedling; (56.20%) per plant over the transplanting T_4–51 days old seedling; (43.23 %) per plant. Spacing S_1 recorded high harvest index (50.53) per plant than other spacing S_2 and S_3. Also observed by Chakrabortty *et al*. (2014) [8]. Interaction of transplanting and spacing influences the harvest index, transplanting done with spacing 20 cm x15 cm of 21 days old seedling; recorded high harvest index (57.99%) per plant over late transplanting done with spacing 20cm x10cm (41.86%) per plant. Similar result observed by Asma *et al.* (2005), Abid *et al.* (2015) [1]. 21 days old seedling; recorded maximum harvest index due to high leaf area, high photosynthetic rate, these characters are closely associated with yield of crop. Vegetative growth was maximum in T_1, as compare to other transplanting. Late transplanting reduces the vegetative growth which may have direct effect on yield of crop.

Conclusion

Normally higher grain yield obtained by transplanting T_1 and spacing 20cm x 15cm. but when we consider whole plot yield then highest yield obtained by closer spacing 20cmx 10cm. The reduction in yield , due to delayed in transplanting by 10 days was not significant if closer spacing of 20 cm x 10 cm was adapted, similarly the lowest T4S1 beyond the transplanting even closer spacing 20 cm x 10 cm did not cover a yield when transplanted with late transplanting by 30 days.

Table 1: Number of panicle, length of panicle, number of productive tillers as influenced by time of transplanting and spacing.

Number of panicles					Length of panicle					Number of productive tillers				
	S_1	S_2	S_3	Mean		S_1	S_2	S_3	Mean		S_1	S_2	S_3	Mean
T_1	9.87	9	8.87	9.24	T_1	25.63	24.12	23.74	24.50	T_1	9.7	8.66	8.2	8.88
T_2	8.43	8.43	8.03	8.30	T_2	23.44	22.42	21.49	22.48	T_2	8.33	8.9	8.13	8.46
T_3	7.6	7.1	6.77	7.16	T_3	22.50	21.73	21.35	21.86	T_3	7.36	7	6.6	7.02
T_4	6.97	6.87	5.97	6.47	T_4	21.09	21.19	21.19	21.13	T_4	7.00	6.8	6.43	6.74
Mean	8.22	7.75	7.41		Mean	23.15	22.36	21.97		Mean	8.11	7.86	7.36	
	S.Em.±	C.D. (5%)				S.Em.±	C.D. (5%)				S.Em.±	C.D. (5%)		
T	0.20	0.71			T	0.42	1.47			T	0.07	0.25		

S	0.08	0.27		S	0.27	0.85		S	0.10	0.31	
TxS	0.48	1.48		TxS	1.24	3.83		TxS	0.88	2.72	

DAT – Days after transplanting

T_1 –Transplanting of 21 days old seedling T_3 - Transplanting of 41 days old seedling S_1 –Spacing 20 cm x 15 cm S_3 - Spacing 20 cm x 10 cm

T_2 -Transplanting of 31 days old seedling T_4 - Transplanting of 51 days old seedling S_2 - Spacing 15 cm x 15 cm

Table 2: Number of grains per plant, number of fertile grains per panicle, 1000 grain weight as influenced by time of transplanting and spacing during growth stages of rice.

Number of grains per plant					**Number of fertile grains per panicle**					**1000 grain weight**				
	S_1	**S_2**	**S_3**	**Mean**		**S_1**	**S_2**	**S_3**	**Mean**		**S_1**	**S_2**	**S_3**	**Mean**
T_1	1184.90	1176.67	1148.47	1170.01	T_1	91.17	90.25	88.25	89.89	T_1	23.26	21.60	19.56	21.60
T_2	1013.53	1008.03	1006.17	1009.24	T_2	83.57	86.50	79.92	83.33	T_2	19.50	19.10	18.27	18.96
T_3	974.97	972.50	970.90	972.79	T_3	79.34	77.34	75.81	77.50	T_3	18.20	17.37	17.27	17.61
T_4	920.27	919.00	914.40	917.89	T_4	72.56	67.86	67.28	69.23	T_4	15.79	15.27	14.93	15.33
Mean	1023.42	1019.05	1009.98		Mean	81.66	80.49	77.61		Mean	19.19	18.34	17.62	
	S.Em.±	(5%)				S.Em.±	C.D. (5%)				S.Em.±	C.D. (5%)		
T	2.14	7.40			T	1.61	5.56			T	0.78	2.71		
S	0.76	2.35			S	1.94	5.99			S	0.24	0.74		
T x S	20.28	62.49			T x S	4.26	12.93			T x S	1.48	4.55		

DAT – Days after transplanting

T_1 –Transplanting of 21 days old seedling T_3 - Transplanting of 41 days old seedling S_1 –Spacing 20 cm x 15 cm S_3 - Spacing 20 cm x 10 cm

T_2 -Transplanting of 31 days old seedling T_4 - Transplanting of 51 days old seedling S_2 - Spacing 15 cm x 15

Table 3: Grain yield / plant, straw weight / plant and harvest index as influenced by time of transplanting and spacing during growth stages of rice.

Grain yield/plant (g)					**Straw yield/plant (g)**					**Harvest index (%)**				
	S_1	S_2	S_3	Mean		S_1	S_2	S_3	Mean		S_1	S_2	S_3	Mean
T_1	26.45	25.42	24.50	25.45	T_1	21.63	21.57	20.26	21.15	T_1	57.99	55.49	55.12	56.20
T_2	20.57	20.50	20.13	20.40	T_2	21.27	21.20	19.01	20.52	T_2	51.65	51.65	51.54	51.62
T_3	19.07	18.40	17.72	18.39	T_3	19.4	19.10	18.13	18.88	T_3	47.80	47.34	47.03	47.39
T_4	16.63	16.10	15.12	15.95	T_4	17.27	16.67	16.17	16.70	T_4	44.67	43.16	41.86	43.23
Mean	20.68	20.10	19.37		Mean	19.89	19.63	18.42		Mean	50.53	49.41	48.89	
	S.Em.±	C.D. (5%)				S.Em.±	C.D. (5%)				S.Em.±	C.D. (5%)		
T	0.58	2.0			T	0.23	0.79			T	0.59	2.03		
S	0.32	0.99			S	0.21	0.66			S	0.55	1.71		
T x S	0.80	2.47			T x S	0.86	2.66			T x S	1.87	5.91		

DAT – Days after transplanting

T_1 –Transplanting of 21 days old seedling T_3 - Transplanting of 41 days old seedling S_1 –Spacing 20 cm x 15 cm S_3 - Spacing 20 cm x 10 cm

T_2 -Transplanting of 31 days old seedling T_4 - Transplanting of 51 days old seedling S_2 - Spacing 15 cm x 15 cm

Table 4: Grain and Straw Yield kg/plot

Treatment	**Grain yield g/ plant**	**Kg/ plot**	**q/ ha**	**Straw yield g/ plant**	**Kg/ plot**	**q/ ha**
T_1S_1	26.45	17.85	8.55	21.63	14.60	6.99
T_1S_2	25.42	23.05	11.04	21.57	19.56	9.37
T_1S_3	24.50	25.05	12.00	20.26	20.73	9.93
T_2S_1	20.57	14.0	6.65	21.27	14.36	6.88
T_2S_2	20.50	18.37	8.90	21.20	19.23	9.21
T_2S_3	20.13	20.04	9.86	19.10	19.54	9.36
T_3S_1	19.07	12.87	6.16	19.4	13.10	6.27
T_3S_2	18.40	17.33	7.99	19.10	17.32	8.30
T_3S_3	17.72	18.46	8.68	18.13	18.55	8.88
T_4S_1	16.63	11.09	5.38	17.27	11.66	5.58
T_4S_2	16.10	14.60	6.99	16.67	15.12	7.24
T_4S_3	15.12	15.46	7.41	16.17	16.54	7.92

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