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Effect of Different Establishment Methods and Sowing Schedules on Growth and Yield of Hybrid Rice (*Oryza Sativa*) and Their After Effects on Succeeding Wheat (*Triticum Aestivum*) in Rice –Wheat Cropping System

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ABSTRACT

A field experiment was conducted at Jammu during 2008-2009 and 2009-2010 to evaluate the effect of two establishment methods (conventional sowing and zero tillage) in wheat (*Triticum aestivum*) and four establishment methods (conventional transplanting of 25 days seedling, dry seeding @ 40 Kg/ha, wet seeding after puddling @ 40 kg/ha and SRI methods) and 4 sowing schedules (15th May, 25th May, 5th June and 15th June) in rice (*Oryza sativa*) under rice-wheat cropping system. Rice establishment methods and sowing schedules had significant impact on growth, yield attributes and yield of rice. Both the direct seeded methods of rice, being at par, recorded significantly higher mean grain yield and other growth parameters of rice as compared to conventional transplanting or SRI method. Similarly, 15th June rice sowing schedule resulted in marked increased in all the growth parameters, yield attributes and grain yield of rice as compared with other sowing schedules. However, both the establishment methods of wheat failed to cause any significant effect on growth and yield of succeeding wheat crop. Establishment methods of wheat and rice as well as sowing schedules of hybrid rice did not cause marked effect on soil physico-chemical parameters as well as available nutrient (N, P and K) content after completion of rice-wheat cycle. However, bulk density of soil at 0-15 and 15-30 cm depths was observed considerably higher with zero tilled wheat, while the minimum in system of rice intensification (SRI) method. Higher net returns and benefit cost ratio were recorded when wheat was established through zero tillage and rice through wet seeded sown on 15th of June in rice-wheat cropping system.

Introduction

Rice-Wheat Cropping System (RWCS) has a long history in Indian sub-continent, particularly in Indo-Gangetic Plains (IGP) with an area of about 10.5 million hectare (Gopal *et al*., 2010). However, stagnation in the productivity of RWCS has been a serious concern remains in the recent past from the view point of food security in India. Over the last decade there has been a concern about the equity in environmental variations and sustainability of resources in Rice-Wheat Cropping System. Zero tillage planting of wheat after rice has been the main success in the quest of resource conservation technologies that can save water, reduce production costs and improve productivity in the cereal bowl of South-East Asia. The alternative to puddling and transplanting could be direct seeding which besides labour engagement allows timely planting of the succeeding wheat crop because of earlier maturity than transplanted crop thus saving water, labour and fossil fuel consumption (Bushana *et al*., 2007). The rice-wheat system productivity has been reported to get reduced by 40 per cent when planting is delayed by 45-55 days (Rai, 2006). Timely planting of rice crop is also found to increase the rain water use efficiency as compared to the delayed planting. Moreover, the problems of repeated tillage operations *viz.* high energy requirement for wheat sowing after rice, less turn around period, low nutrient response and high cost of production are the main constraints for this production system. To overcome such problems adaptation of reduced tillage techniques can result in timely sowing of wheat and may help in saving energy units at the farm level. As regards the time of planting/sowing and methods of establishment for RWCS, specific package of practices need to be developed to realize the full genetic potential of high yielding varieties/hybrids in the future. The role of hybrid rice in self sufficiency of food grains has also been established by several workers (Singh *et al*., 2004 and Nayak *et al*., 2003). Therefore, the present investigation was undertaken to evaluate the impact of different establishment methods and sowing schedules on growth and yield of hybrid rice (*Oryza sativa*) and their effects on succeeding wheat (*Triticum aestivum*) in rice -wheat cropping system.

Materials and Methods

A field experiment was conducted at Jammu during 2008-2010 on a sandy loam soil analyzing low in organic carbon (0.51%) and available N (215.34 kg/ha) and medium in available P (15.65 kg/ha) and K (128.30 kg/ha) with pH 7.9. The experiment was laid out in split-plot design with establishment methods (conventional sowing and zero tillage) of wheat and (conventional transplanting, dry seeding @ 40 kg ha^{-1}, wet seeding after puddling @ 40 kg $ha^{-1}$and system of rice intensification) of rice clubbed in main plots and four rice sowing schedules (15th May, 25th May, 5th June and 15th June) in

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sub-plots with 3 replications. The wheat crop was sown 22 November in 2008 and 18 November in 2009 in rows 20 cm apart using variety PBW 343. Wheat crop was grown with a uniform application of recommended NPK (120 kg N, 60 kg P_2O_5 and 25 kg K_2O ha^{-1}) in both conventional and zero tilled methods of sowing. Half of N and full dose of P and K were applied as basal dose at the time of sowing and the remaining amount of N was top dressed in two equal split doses, one at 30 days and the other at 60 days after sowing. Rice crop was grown with a uniform application of recommended NPK (120 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1}) in conventional transplanting after puddling, wet seeding after puddling and dry seeding established plots while in SRI established crop, 25 per cent of the recommended dose of NPK was supplied through well decomposed FYM on N content basis (0.62% on oven dry basis) and remaining amount of NPK was supplied through inorganic sources of nutrients *viz*; urea (46 % N), DAP (46 % P_2O_5 and 18 % N) and MOP (60 % K_2O), respectively. One third amount of N and full dose of P and K were applied as basal dose and remaining N in two equal splits at maximum tillering stage and panicle initiation stage of the crop in all the establishment methods .The other agronomical practices was followed as per the recommended package of practices for this region.

Results and Discussion

Effect of establishment methods on rice

Various establishment methods (conventional transplanting, dry seeding, wet seeding and system of rice intensification) significantly increased the growth attributes (plant height, dry matter accumulation and leaf area index) of rice during both the years (Table-1). Amongst the rice establishment methods, wet seeding after puddling and direct seeding after conventional tillage resulted into significantly more leaf area index (LAI) than conventional transplanting and system of rice intensification (SRI). Both the establishment methods (wet and dry seeding) being on par significantly increased the crop growth rate (CGR) over conventional transplanting and system of rice intensification (SRI) during 2009. However, the rice establishment methods had non-significant effect with respect to relative growth rate (RGR) of hybrid rice crop at all growth stages during the study. Wet seeding resulted into significantly more productive tillers per m^2 (271.98) than the conventional transplanting (247.93) and system of rice intensification (252.55) but recorded at par with direct seeding (265.62) during *kharif* 2009. However, wet seeding after puddling (53.14 q/ha) and direct seeding after conventional tillage (53.14 q/ha) resulted into significantly higher mean grain yield and proved superior to other two methods of establishment. It may be due to more number of effective tillers and vigorous vegetative growth under direct seeding. Similar findings have been made by Gill *et al*. (2006 a and b) in a study conducted at Ludhiana. Rice establishment methods did not show any significant variation on harvest index of hybrid rice crop during both the years of study.

Effect of sowing schedules on hybrid rice

Rice sowing schedules had significant influence on the growth attributes (plant height and LAI) of rice at all the growth stages during both the years of study. All the rice sowing schedules significantly differed with each other with respect to their effect on growth attributes. However, 15th June sowing schedule registered superiority over rest of the sowing schedules registering increase of 3.50, 6.52 and 11.20 per cent in plant height, respectively, at harvesting stage of the crop during *kharif* 2009. This may be lead to proper establishment of initial stand, growth and development of crop. These observations are in accordance with the findings of Dixit *et al*. (2004). Rice sowing schedules also had a non-significant effect on relative crop growth rate (RGR) at all the crop growth stages during both the years of study. Among various sowing schedules 15th June (275.26) gave significantly more effective tillers than other three sowing schedules. Among the rice sowing schedules, 15th June also recorded maximum and significantly higher panicle length (25.09 cm) than 5th June, 25th May and 15th May sowing schedules. Rice sowing schedule also had significant effect on grain yield during both the years of study. Significantly higher mean grain yield was recorded with 15th June sowing schedule (55.59 q/ha), which was superior to other sowing schedules (Table - 2). The 15th June sowing schedule registered increase in grain yield to the tune of 6.29, 12.89 and 17.88 per cent over rest of the sowing schedules of hybrid rice crop, respectively, during *kharif* 2009. These results are in accordance with the findings of Gill (2008). Better leaf area index accompanied by higher dry matter accumulation and yield attributes and favourable effect of weather conditions available during the crop cycle for 15th June sowing may have resulted in expression of better yield of hybrid rice. However, rice sowing schedules had non-significant effect on harvest index of hybrid rice during both the years of study.

Effect of wheat establishment method on succeeding hybrid rice

Wheat establishment methods namely conventional and zero tillage did not show any significant variation with respect to grain yield and yield attributes of wheat during *rabi* 2008-09. However, zero tilled wheat recorded slightly more system productivity than conventionally tilled wheat during both the years. Wheat establishment methods failed to show any significant effect on plant growth parameters on succeeding hybrid rice crop during both the seasons. Further, wheat establishment methods failed to cause any significant variation on grain yield of succeeding hybrid rice crop.

Soil fertility changes under wheat- rice cycle

Soil physico-chemical parameters viz. pH, EC and OC (%) did not show sizeable variation after completion of wheat- rice cycle due to establishment methods of both wheat and rice as well as sowing schedules of hybrid rice. However, zero tilled wheat - system of rice intensification (SRI) plots of hybrid rice recorded numerically higher OC content than other establishment methods. After the harvest of rice crop, bulk density of soil at 0-15 cm and 15-30 cm depths was found to be considerably higher in plots with zero tilled wheat as compared to conventionally tilled wheat across all rice establishment methods. The range of pH, EC and OC (%) after wheat-rice cycle ranged from 7.80 to 7.95; 0.22 to 0.24 dSm^{-1} and 0.50 to 0.52 per cent, respectively, under the different treatments after rice during both the years. Among various rice establishment methods, bulk density at 0-15 and 15-30 cm depths was the minimum in case where system of rice intensification (SRI) was adopted. This effect was more pronounced in the surface (0-15 cm) soil than the sub-surface (15-30 cm) soil.

Relative economics of rice-wheat system

Rice establishment methods significantly influenced the total productivity of the rice-wheat system (Table - 3). Among the rice establishment methods, wet seeding (90.71 q/ha/yr) gave the highest system productivity which was closely followed by direct seeding (90.14 q/ha/yr) and it proved significantly better than other two methods of establishment. Rice sowing schedules also had significant effect on the total productivity of rice-wheat system. Significantly higher rice equivalent yield was recorded with 15th June sowing schedule (93.34 q/ha/yr) which was superior to rest of the treatments.

Table 1. Effect of rice establishment methods and sowing schedules on growth parameters of hybrid rice under rice-wheat cropping system

Treatments	Plant height at harvest (cm.)		Dry matter accumulation at harvest (gm^{-2})		Leaf area index at 90 DAS		Crop growth rate ($g\ day^{-1}$)	
	2009	2010	2009	2010	2009	2010	2009	2010
Wheat establishment methods								
CTW	100.37	100.62	1133.35	1241.03	4.82	4.84	15.76	18.11
ZTW	100.35	101.02	1146.90	1249.08	4.81	4.86	15.91	18.21
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS
Rice establishment methods								
E1	98.95	99.64	1102.43	1140.04	4.76	4.77	15.62	16.95
E2	103.87	103.92	1182.34	1284.69	4.89	4.92	16.22	18.63
E3	102.56	102.91	1156.83	1265.69	4.87	4.91	15.93	18.45
E4	96.07	100.82	113.89	1180.32	4.75	4.80	15.57	18.60
CD (5%)	3.24	3.14	40.36	43.55	0.10	0.10	0.10	0.10
Rice sowing schedule								
S1	94.80	94.84	1020.66	1082.62	4.74	4.84	14.38	15.61
S2	98.51	97.98	1073.19	1170.29	4.87	4.77	14.88	17.00
S3	101.31	100.82	1195.53	1331.65	4.83	4.89	16.66	18.85
S4	104.63	105.00	1271.12	1395.77	4.87	4.92	17.42	20.31
CD (5%)	99.78	99.61	24.69	27.35	NS	NS	0.12	0.11

Where E_1 = Conventional transplanting after puddling; E_2 = Wet seeding after puddling;
E_3 = Direct seeding after conventional tillage and E_4 = System of rice intensification (SRI);
S_1 = 15th May; S_2 = 25th May;
S_3 = 5th June and S_4 = 15th June ;
CTW = Conventional tilled wheat and ZTW = Zero Tilled wheat

Table 2. Effect of rice establishment methods and sowing schedules on yield attributing characters of hybrid rice under rice-wheat cropping systems

Treatments	Effective tiller (No.)		Panicle length (Cm)		No. of grains / panicle (No.)		Grain yield (q/ha)		Straw yield (q/ha)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Wheat establishment methods										
CTW	257.32	259.81	25.04	25.08	100.39	103.25	50.09	52.34	66.39	68.54
ZTW	261.72	256.38	24.78	25.16	101.30	102.11	50.54	52.78	65.68	69.18
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice establishment methods										
E1	247.93	245.93	25.26	25.73	102.63	103.47	47.31	49.11	62.39	65.10
E2	271.98	272.33	24.68	24.62	99.25	101.80	53.14	55.81	69.90	72.44
E3	265.62	264.08	24.57	24.53	95.95	97.99	92.45	55.07	68.14	72.44
E4	252.55	250.04	25.15	25.60	105.56	107.45	48.36	50.25	63.72	66.07
CD (5%)	12.40	13.33	0.45	0.55	3.46	3.86	2.74	2.71	4.22	3.74
Rice sowing schedule										
S1	236.79	240.49	23.33	23.49	83.00	85.48	45.65	46.93	59.96	61.91
S2	249.40	253.00	23.96	23.04	86.63	89.64	48.42	50.13	62.92	65.12
S3	263.14	266.16	24.55	24.59	90.53	93.68	52.09	54.56	69.05	70.98
S4	275.76	278.61	25.10	25.13	94.46	97.24	55.59	58.22	73.07	76.58
CD (5%)	10.36	12.40	0.53	0.52	3.95	3.54	1.41	1.28	2.37	1.87

Where E_1 = Conventional transplanting after puddling; E_2 = Wet seeding after puddling;
E_3 = Direct seeding after conventional tillage and E_4 = System of rice intensification (SRI);
S_1 = 15th May; S_2 = 25th May;
S_3 = 5th June and S_4 = 15th June ;
CTW = Conventional tilled wheat and ZTW = Zero Tilled wheat

Table 3. Effect of rice establishment methods and sowing schedules on relative economics of rice-wheat system

Treatments	Net return (Rs./ha)		B:C Ratio		Production efficiency (Kg/ha./day)
	2009	2010	2009	2010	Pooled
Wheat establishment method					
CTW	54932	66416	1.35	1.63	3.93
ZTW	59820	70561	1.61	1.91	31.71
CD (5%)					
Rice establishment method					
E1	53582	64439	1.40	1.69	29.83
E2	59898	72005	1.57	1.86	32.83
E3	59586	71190	1.52	1.82	32.44
E4	56439	66319	1.44	1.73	30.18
CD (5%)					1.33
Rice sowing schedules					
S1	50998	58281	1.33	1.61	29.45
S2	54617	61428	1.42	1.71	30.59
S3	59074	66170	1.54	1.84	31.98
S4	62953	70473	1.63	1.95	33.25
CD at 5%					1.12

Where E_1 = Conventional transplanting after puddling; E_2 = Wet seeding after puddling;
E_3 = Direct seeding after conventional tillage and E_4 = System of rice intensification (SRI);
S_1 = 15th May; S_2 = 25th May;
S_3 = 5th June and S_4 = 15th June ;
CTW = Conventional tilled wheat and ZTW = Zero Tilled wheat

Rice establishment methods had significant influence on production efficiency of rice-wheat system. Among the rice establishment methods wet seeding gave higher production efficiency (32.83 kg/ha/day) which was closely followed by direct seeding after conventional tillage (32.44 kg/ha/day) and both in turn were significantly higher than conventional transplanting (29.83 kg/ha/day) and (SRI) system of rice intensification (31.32 kg/ha/day).

Rice sowing schedules also had significant effect on production efficiency of rice- wheat system. Among various sowing schedules 15th June recorded significantly higher production efficiency of (33.25 kg/ha/day) than other sowing schedules and registered increase in production efficiency to the tune of 3.82, 8.00 and 11.43 per cent over rest of the sowing schedule of hybrid rice, respectively.

Among the establishment methods of both wheat and rice the highest net return was obtained in zero tilled wheat-wet seeding rice (Rs. 62371 and Rs. 73877 /ha respectively, during 2009 and 2010) which was followed by zero tilled wheat-direct seeding rice (Rs. 61557 and Rs. 73725 /ha), respectively, during both the years. Similar trend was observed with respect to B:C ratio with corresponding values of 1.71 and 1.99, 1.65 and 1.97 and 1.56 and 1.88 for wet seeded rice, dry seeded rice and SRI following zero tilled wheat during 2009 and 2010. As regards the rice sowing schedules and establishment methods, zero tilled wheat followed by 15th June sowing schedule of rice recorded maximum net return (Rs. 64786 and Rs. 70473 /ha) and benefit: cost ratio (1.76 and 2.1) than the other sowing schedules. This was ascribed to higher grain yield and minimum cost of production. Similar findings were reported by Gill (2008) and Jha *et al*. (2011). The direct seeding technique saves labour up to 50 per cent over transplanting; outwit the plant population constraint and saves substantial amount of precious water (Pandey and Velasco 1999).

Hence, zero-tillage and direct seeded was found to be most economical technique as it saved considerable energy besides saving labour component. Therefore, it can be concluded from the above literature that adoption of zero-tillage technique for wheat crop has proved beneficial for farmers as it reduces cost of cultivation without affecting crop yield and enables timely sowing.

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