

Improving wheat productivity in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system through crop establishment methods*

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Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol) is the most popular cropping system of India as well as of the world. It is practised on 24 million ha. In India, the area under this rotation is about 11.0 million ha; mainly concentrated in Indo-Gangatic Plains. Rice–wheat cropping system is very productive but it has fatigued natural resources resulting in decline in groundwater level, soil carbon stocks, and soil plant available nutrients and build-up of pest and diseases (Gupta *et al.* 2006). Further, intensive cultivation of rice–wheat with indiscriminate use of inputs led to decline in total factor productivity, increasing energy crises and decline in farm profitability. With deteriorating resources and eroding ecological foundation, sustainability of rice–wheat system is under question. To ameliorate its ill effect of traditional rice–wheat cropping system, efforts have been made to develop several resource conservation technologies. Zero tillage/ minimum tillage/reduced pre-planting tillage, furrow irrigated raised bed system, surface seeding, drip irrigation, crop residue management are few examples of resource conservation techniques. Conventional method of wheat sowing requires intensive pre-planting cultivation, which are labour, time and energy intensive. To make this practice, easier and cost effective, several crop establishment methods, viz zero till drill, roto drilling, strip till drill and surface seeding of wheat etc. have been developed (Yadav *et al.* 2006). Zero tillage with rice stubles retention may improve the soil physico-chemical condition by improving the organic matter in the soil (Rawat and Verma 2006).

The field experiment was conducted at the experimental plot of the Crop Research Centre at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during rainy (*kharif*) season of 2005–06 to winter (*rabi*) season of

2006–07. The soil was sandy loam (sand, silt and clay contents of 50.4, 33.2 and 16.4% respectively), having pH 7.8, organic carbon 0.67% and available NPK 263.4, 27.8, 246.4 kg/ha. The treatment consisting of four rice establishment methods (direct seeding, wet-sprouted rice, hand transplanting and machine transplanting) in main strip and four wheat establishment methods (conventional, bed planted, strip till drill and zero till drill) in sub-strip were replicated thrice in strip-plot design. The ‘Narendra 359’ rice was sown on 9 June 2005 and 13 June 2006 under direct seeding and wet-sprouted rice and transplanting done on 28 June 2005 and 7 July 2006 during both the years, respectively in main strips with 120 kg N/ha through urea, 60 kg P₂O₅/ha through single superphosphate, 40 kg K₂O/ha through muriate of potash and 20 kg ZnSO₄/ha. The ‘PBW 343’ wheat was sown on 20 and 22 November in 2005 and 2006, respectively. Wheat crop was fertilized by 150 kg N/ha through urea, 60 kg P₂O₅/ha through single superphosphate and 40 kg K₂O/ha through muriate of potash. Full dose of P₂O₅ and K₂O and ¹/₃ dose of N were applied as basal and remaining N was top-dressed at one and two months after sowing. Need-based irrigation and plant protection measures were given.

Direct-seeded rice gave significantly higher spike length as compared to wet seeded, hand transplanted and machine transplanted rice and more grains/spike than hand transplanted and machine transplanted rice during 2006–07. However, different rice establishment methods remained at par in rest of the growth and yield-attributing characters (Table 1). The better growth parameters and yield attributes of wheat recorded in the plots following direct-seeded rice were attributed to its effect on providing ideal seed bed for wheat sowing, which resulted in better growth of crop. Similar results were also reported by Singh *et al.* (2005).

Different rice establishment methods adopted in preceding rice crop did not affect wheat yield in any year. However maximum mean grain (4 237 kg/ha) and straw (6 235 kg/ha) yield of wheat was obtained from direct-seeded rice plots

*Short note

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(Table 1). This was mainly due to more number of effective ears/m and 1000- grain weight.

Nutrient uptake (NPK) by the wheat crop was highest under direct-seeded rice due to rice establishment methods. During 2005–06, uptake of N and P by wheat grain was statistically at par under different establishment methods. However, K uptake was significantly higher under direct-seeded rice. During 2006–07, NPK uptake by grain was significantly higher in direct-seeded rice than that of other methods. Nitrogen and phosphorus uptake by wheat straw due to rice establishment methods were significant only

during 2005–06 and potassium uptake was non- significant during both years. Nitrogen and phosphorus uptake by wheat straw after direct-seeded rice being at par with wet sprouted rice remained significantly higher than that of hand and machine transplanted rice, because under puddled condition loses of nitrogen and phosphorus due to leaching and fixation.

The zero till drilling produced significantly longer spikes and higher 1000-grain weight than that of other wheat establishment methods. The variations in spike length under conventional and bed planted wheat were non-significant.

Table 1 Effect of rice and wheat establishment methods on yield and yield attributes of wheat crop in rice-wheat cropping system

Establishment method	Tillers/m ²		Spike length (cm)		Spikes/m ²		Grain/spike		1000-grain weight (g)		Grain yield (kg/ha)	Straw yield (kg/ha)
	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	Mean	Mean
<i>Rice</i>												
Direct-seeded rice	432	426	8.6	9.8	421	617	49.9	52.2	43.0	43.6	4 237	6 235
Sprouted rice	417	416	8.5	9.6	407	616	49.3	51.1	40.5	42.5	4 182	6 039
Hand transplanting	412	407	8.4	9.6	400	601	47.3	50.2	39.9	41.6	4 130	5 852
Machine transplanting	385	400	8.3	9.2	375	587	45.6	49.6	38.8	41.2	3 865	5 620
SEm±	41	24	0.26	0.04	40	34	1.32	0.40	1.8	0.3		
CD (P= 0.05)	NS	NS	NS	0.15	NS	NS	NS	1.4	NS	0.9		
<i>Wheat</i>												
Conventional	401	397	8.67	9.3	392	589	47.3	50.4	40.5	39.8	3 960	5 733
Bed planting	393	389	8.28	9.0	380	572	45.9	49.3	39.4	41.6	3 831	5 580
Strip till drill	402	418	8.71	9.6	395	626	49.4	51.5	40.6	42.7	4 087	6 009
Zero till drill	450	445	8.73	10.1	438	637	49.9	51.9	41.6	45.0	4 535	6 423
SEm±	18	29	0.20	0.13	18.7	23.1	1.40	0.84	1.3	0.5		
CD (P=0.05)	NS	NS	NS	0.45	NS	NS	NS	NS	NS	1.6		

NS, Non-significant

Table 2 Effect of rice and wheat establishment methods on nutrient uptake (kg/ha) of wheat in rice-wheat cropping system

Establishment method	Grain						Straw					
	2005–06			2006–07			2005–06			2006–07		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
<i>Rice</i>												
Direct-seeded rice	66.8	9.4	20.9	93.3	15.8	29.1	20.6	3.1	81.2	27.8	3.9	120.2
Sprouted rice	66.3	9.3	20.4	91.04	14.3	27.9	19.8	2.9	77.9	26.1	3.6	116.9
Hand transplanting	65.7	9.1	20.0	88.5	13.8	27.1	19.2	2.7	76.7	24.7	3.1	111.6
Machine transplanting	61.1	8.4	18.5	82.8	12.8	25.2	18.2	2.5	73.9	25.1	4.8	106.3
SEm±	1.8	0.2	0.5	2.1	0.6	0.68	0.4	0.1	1.80	0.8	1.0	3.0
CD (P=0.05)	NS	NS	1.7	7.4	1.9	2.33	1.6	0.3	NS	NS	NS	NS
<i>Wheat</i>												
Conventional	65.1	9.2	21.0	91.0	14.7	29.7	20.3	3.1	76.7	29.2	3.9	113.0
Bed planting	57.8	8.2	18.6	84.6	13.5	26.8	17.6	2.8	73.4	23.5	3.2	109.8
Strip till drill	64.6	9.0	19.5	86.0	13.6	26.6	19.5	2.7	78.1	24.8	3.1	113.9
Zero till drill	72.3	9.8	20.7	99.3	14.9	26.1	22.4	2.6	81.4	26.1	5.1	118.4
SEm±	2.2	0.3	0.7	1.3	0.7	0.4	0.5	0.1	2.2	0.5	1.0	2.0
CD (P=0.05)	7.5	1.0	NS	4.4	NS	1.43	1.7	0.3	NS	1.8	NS	NS

NS, Non-significant

However, wheat establishment methods did not significantly affect number of spikes/m and number of grains/spike during both years. The mean grains/spike under zero till drill wheat was 0.79, 6.93 and 4.09% more than that of strip till drill, bed planted and conventionally wheat, respectively. The average 1 000-grain weight was 3.84, 9.34 and 5.35% higher in zero till drill wheat over strip till drill, bed planted and conventionally wheat (Table 1). The better crop growth under zero till wheat might be due to favourable soil condition, viz soil bulk density, infiltration rate and deeper root system than conventional system. The higher yield attributes in zero till drill wheat may be due to the fact that zero till wheat crop uptake more nutrient (Table 2). These results collaborate the findings of Singh *et al.* (2006) who also noted higher yield attributes in zero till wheat crop.

The wheat yield was influenced significantly due to different wheat establishment methods during both the years. Maximum mean grain (4 535 kg/ha) and straw (6 423 kg/ha) yields were obtained under zero till drilling which was significantly higher than rest of the methods. The quantum increase in zero till drill wheat was 12.24, 25.97 and 15.98% over strip till drill, bed planted and conventional wheat during 2005–06, respectively. The respective increase during 2006–07, was 10.09, 13.49 and 11.51% (Table 1). The marked increase in grain yield in the above treatment may be owing to overall improvement in yield attributes.

Nitrogen uptake by wheat was influenced significantly due to different wheat establishment methods during both the years. Zero till drill wheat exhibited significantly higher nitrogen uptake by wheat grain than that of other methods. During 2005–06 nitrogen uptake by wheat straw was significantly higher in zero till drill wheat than other methods (Table 2). However during 2006–07 nitrogen uptake by wheat straw was significantly more under conventional wheat than that of other methods. Phosphorus uptake by wheat was influenced significantly during 2005–06 only. Phosphorus uptake by wheat grain was significantly higher under zero till drill than bed planted wheat, being at par with strip till drill and conventional wheat. During 2006–07 potassium uptake by wheat grain was affected significantly and conventional planted wheat recorded significantly higher

potassium uptake than that of bed planted, strip till drill and zero till drill wheat. However, potassium uptake by straw during both years was non-significant.

SUMMARY

To ameliorate the ill effects of traditional rice–wheat cropping system efforts have been made to develop several resource conservation technologies. Conventional method of wheat sowing requires intensive pre-planting cultivation, which are labour, time and energy intensive. The field experiment was conducted at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during rainy season of 2005–06 to winter season of 2006–07. Maximum mean grain (4 237 kg/ha) and straw (6 235 kg/ha) yields of wheat were obtained from direct-seeded rice plots. Nutrient uptake (NPK) by the wheat crop was highest under direct-seeded rice due to rice establishment methods. Maximum mean grain (4 535 kg/ha) and straw (6 423 kg/ha) yields were obtained under zero till. The mean wheat grains/spike under zero till drill wheat was 0.79, 6.93 and 4.09% more than that of strip till drill, bed planted and conventional wheat, respectively. Zero till drill wheat exhibited significantly higher nutrient uptake than that of conventional, bed planted and strip till drill wheat.

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