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Effect of crop establishment techniques on productivity of rice-wheat cropping system

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ABSTRACT

Five methods of rice establishment methods viz. zero tillage, row seeding in prepared bed, broadcast seeding of pre-sprouted seeds in puddle field, row seeding of pre-sprouted seeds with drum seeder and manual transplanting; 3 methods of wheat establishment viz. zero tillage, conventional tillage and bed planting were evaluated to assess the productivity and profitability of rice–wheat system to find out the suitable alternative to the standard transplanting method. Transplanted paddy resulted in significantly higher grain yield (3.98 tonnes ha^{-1}) followed by drum seeding (3.37 tonnes ha^{-1}), broadcast seeding of sprouted seeds (3.23 tonnes ha^{-1}), row seeding in prepared bed (2.92 tonnes ha^{-1}) and zero tilled rice (2.76 tonnes ha^{-1}). Conventional tillage in wheat produced 10 and 18 per cent more grain yield as compared to zero tilled and bed planted wheat, respectively. Net returns (Rs 30,819 ha^{-1}) and benefit: cost ratio (1.37) from rice-wheat cropping system were highest from broadcast seeding of pre-sprouted seeds in puddle field–zero tillage wheat, followed by Rs 30,069 ha^{-1}net return from RM$_3$ – conventional tillage wheat. Bed planting of wheat was least economical for all rice establishment methods except transplanting method. Transplanted method of rice can be profitably replaced with sowing of pre-sprouted seeds in puddle field with subsequent wheat established either by zero tillage or by conventional tillage.

Key words: *rice, wheat, cropping system, crop establishment methods*

Rice-wheat is one of the major cropping systems in India covering about 10-12 million hectare area and contributes to 22 per cent of total food grain production (Sharma, 2005). In this cropping system, rice is mainly grown as manually transplanted crop in puddled soil. Rice transplanting, usually done by hired labour, is labour-intensive which is becoming increasingly difficult due to its high cost and shortage of labourers during the peak season. Direct seeding of rice seeds or pre-sprouted seeds, is another method of crop establishment which may ensure better plant population and staggered use of labour. Sowing of wheat by traditional method requires excessive tillage, but that can be accomplished efficiently with the use of improved devices to save time and energy. Therefore, experiments were planned to work out the productivity and profitability of rice-wheat cropping system under different methods of crop establishment.

MATERIALS AND METHODS

Field experiments were conducted during 2003 to 06 at CSK Himachal Pradesh Krishi Vishvadyalaya Rice and Wheat Research Centre, Malan to evaluate 5 methods of rice establishment *viz*. zero tillage (RM$_1$), row seeding in prepared bed (RM$_2$), broadcast seeding of pre-sprouted seeds in puddle field (RM$_3$), row seeding of pre-sprouted seeds with drum seeder (RM$_4$) and manual transplanting (RM$_5$); 3 methods of wheat establishment v*iz.* zero tillage (WM$_1$), conventional tillage (WM$_2$) and bed planting (WM$_3$) to assess the productivity and profitability of rice–wheat cropping system. The soil of the experimental site was silty clay loam in texture (Typic Hapludalf), acidic in reaction (pH 5.7), medium in available nitrogen (432 kg N ha ha^{-1}), phosphorus (15.1 kg P ha^{-1}), potassium (140.8 kg K ha^{-1}) and organic carbon (0.54%). The experiment was initiated in the wet season of 2003 with five methods of rice establishment in the main plots and three methods of wheat establishment in subplots of split-plot design replicated 4 times. Direct seeding of rice cv. RP 2421 (RM$_1$ and RM$_4$), soaking of seeds in water (RM$_3$ and RM$_4$) and nursery sowing (RM$_5$) were accomplished

on the same date in first week of June. Seeds were soaked in water for 24 hours and kept in gunny bag for 30-36 hours to obtain sprouted seeds. The distance between the lines was 20 cm (RM_1, RM_2 and RM_4). Thirty days old seedlings were transplanted at 20 cm x 15 cm in RM_5. Seed rate used in RM_1, RM_2 and RM_3 was 100 kg ha^{-1}, 60 kg ha^{-1}in drum seeding (RM_4) and 30 kg ha^{-1} in transplanting method (RM_5). Recommended fertilizer dose (90 kg N, 17.4 kg P and 33.3 kg K ha^{-1}) was applied to rice. Half nitrogen and full phosphorus and potassium were applied basally and remaining nitrogen was applied in two equal splits at active tillering and panicle initiation stages. Effective weed control was maintained by Butachlor applied as pre-emergence in RM_1, RM_2 and RM_5. In pre-sprouted seed sown crop (RM_3 and RM_4), Pyrazosulfuron-ethyl was applied 8-12 days after sowing. The rice data were analyzed by using randomized block design. During dry season each plot was divided into three sub-plots and 3 methods of wheat sowing were cv. HS 240 evaluated. Ploughing was not needed after zero tilled rice or wheat. Weed control in wheat was ensured by the tank mix application of *Isoproturon* 1.0 kg ha^{-1}+ 2,4-D @ 0.5 kg ha^{-1}applied 35 days after sowing. Furthermore, one hand weeding was also done to keep the crop free from weeds. Wheat received the 120 kg N, 26.2 kg P and 24.5 kg K ha^{-1} as per recommendations.

RESULTS AND DISCUSSION

Methods of rice establishment influenced grain yield of rice significantly in all the years (Table 1). On mean basis transplanted paddy owing to its better growth (plant height), and higher panicle weight resulted in significantly higher grain yield (3.98 tonnes ha^{-1}). Paddy yields in broadcast seeding of pre-sprouted seeds in puddle field and drum seeding and row seeding of dry seeds in prepared bed and zero tillage were at par with each other. As puddling increases the availability of water and nutrients, ensures better germination/crop establishment, kills weeds and helps plants to grow vigorously (Prasad *et al.* 2001); the treatments involving puddling out yielded direct seeding in uplands. These results are similar to those of Samra and Dhillon (2000).

Plant height, panicles m^{-2}, panicle weight, 1000-seed weight, crop duration and straw yield (Table 1) were significantly affected by the methods of crop establishment. Broadcasting pre-sprouted seeds and

Table 1. Direct effect of methods of rice establishment on the performance of rice (RP 2421) –in rice wheat cropping system

Methods of rice establishment	Paddy yield (tonnes ha^{-1})				Straw (tonnes ha^{-1})	Harvest index	Plant height (cm)	Days taken to maturity	Panicles m^{-2}	Panicle weight(g)	Grains $panicle^{-1}$	1000 grain weight (g)
	2003	2004	2005	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Zero tillage	2.10	2.85	3.34	2.76	4.73	36.9	95.0	112	329.4	1.87	52	22.9
Row seeding in prepared bed	2.14	2.90	3.83	2.95	5.44	35.2	98.8	111	355.4	2.00	57	23.4
Broadcast seeding of pre-sprouted seeds in puddled field	2.35	3.25	4.09	3.23	5.94	35.2	106.0	109	383.3	1.94	54	23.4
Row seeding of pre-sprouted seeds with drum seeder in puddle field	2.42	3.39	4.31	3.37	5.28	39.0	102.7	109	272.1	2.80	68	23.7
Transplanting	3.57	3.51	4.84	3.98	4.98	44.4	107.4	114	238.8	2.92	76	23.8
CD (P=0.05)	0.48	0.50	0.88	0.28	0.53	-	3.25	0.8	37.3	0.29	6.4	0.6

transplanting produced significantly taller plants, whereas plant height of zero-tilled rice plants was significantly lowest. Number of panicles per unit area was significantly more in broadcast sown pre-sprouted seeds in puddle field, being at par with row seeding of dry seeds in prepared bed followed by zero tillage rice. Panicles per unit area were significantly less in transplanting and drum seeding methods. Transplanting and drum seeding methods, however, recorded higher panicle weight. Grain test weight was the highest in, being at par with row seeding of pre-sprouted seeds with drum seedes RM_4. Significantly highest number of spikelets panicle^{-1} was recorded in transplanted paddy followed by RM_4. More number of filled grains panicle^{-1}, 1000-seed and panicle weight well compensated the less number of panicles per unit area in transplanted paddy. Due to more tillers per unit area and plant height, the straw yield was more in broadcast sown pre-sprouted seeds in puddle field. Transplanted and zero tilled rice recorded equal straw yield. Harvest index was more (44.4%) in transplanted crop as the crop was at uniform crop geometry and all tillers were bearing large panicle. More crop duration (seed to seed) in transplanted paddy (M_5) may be attributed to transplanting shock.

Pooled analysis of the 3 years data revealed that residual effect of methods of establishment of rice, significantly affected the plant height and grain yield of wheat. Plant height and grain yield were less in zero tilled rice. Grain yield in all other methods was statistically on par with each other. Singh *et al*. (2001) reported that puddling done for rice increased the grain and straw yield of succeeding wheat crop, however, contrarily to that of Singh *et al.* (2002).

The methods of wheat establishment significantly affected the plant height, ears m^{-2}, 1000-grain weight and grain and straw yield of wheat (Table 2). The pooled data revealed that plant height and number of ears per unit area were significantly more under conventional tillage followed by zero tilled wheat. Lowest number of ears per unit area under bed planting was primarily due to reduction in net planted area due to the utilization of the some space for making furrows. The number of grains per ear was not affected significantly by the establishment methods. Thus, wheat grain yield was highest in conventional tillage followed by zero tillage and raised bed methods. The ideal seed bed prepared under conventional tillage may have been responsible for better growth parameters and yield attributes under this method. Results are in conformity with Samra and Dhillon (2000) and Gangwar *et al.* (2004).

Considering the rice-wheat system as a whole, broadcast seeding of pre-sprouted rice in puddle field followed by zero tillage wheat resulted in highest net returns (Rs 30,819 ha^{-1}) and benefit : cost ratio (1.37)

Table 2. Effect of methods of establishment of rice and wheat on yield attributes and yield of wheat (HS 240) (pooled data, 2003-2006)

Methods of establishment	Plant height (cm)	Ears m^{-2}	Grains ear^{-1}	1000 grain weight(g)	Straw yield (tonnes ha^{-1})	Grain yield (tonnes ha^{-1})
Rice						
Zero tillage	87	192	42	37.2	4.13	1.89
Row seeding in prepared bed	88	186	43	37.9	4.30	2.29
Broadcast seeding of pre-sprouted seeds in puddle field	89	201	44	37.8	4.48	2.41
Row seeding of pre-sprouted seeds with drum seeder in puddle field	89	194	45	37.4	4.34	2.29
Transplanting	89	198	42	38.2	4.38	2.15
CD (P=0.05)	1.1	7.0	1.8	NS	NS	0.26
Wheat						
Zero tillage	88	199	43	38.3	4.39	2.19
Conventional tillage	89	211	43	38.0	4.53	2.44
Bed planting	88	173	44	36.8	4.06	1.99
CD (P=0.05)	0.8	4.8	NS	1.0	0.32	0.18

Table 3. Mean net returns and benefit: cost ratio of rice-wheat cropping system as influenced by methods of crop establishment

Method of rice establishment	Method of wheat establishment		
	Zero tillage	Conventional tillage	Bed planting
Net returns (Rs. ha^{-1})			
Zero tillage	21 242	22 935	18 161
Row seeding in prepared bed	24 869	25 155	21 006
Broadcast seeding of pre-sprouted seeds in puddle field	30 819	30 069	24 879
Row seeding of pre-sprouted seeds with drum seeder in puddle field	29 742	28 682	22 740
Transplanting	22 740	27 981	28 463
Benefit:cost ratio			
Zero tillage	0.99	0.99	0.74
Row seeding in prepared bed	1.04	0.97	0.78
Broadcast seeding of pre-sprouted seeds in puddle field	1.37	1.25	0.98
Row seeding of pre-sprouted seeds with drum seeder in puddle field)	1.32	1.18	0.89
Transplanting	1.11	1.06	0.88

(Table 3). Wheat grown through conventional tillage resulted in second highest net returns (Rs 30,069 ha^{-1}) but third highest benefit: cost ratio (1.25). Drum seeding of rice followed by zero tillage wheat accrued almost similar net returns (Rs 29,742 ha^{-1}) and second highest benefit:cost ratio. The best method of wheat establishment after transplanted rice was found to be bed planted wheat, recording the net return of Rs. 28,463 ha^{-1}.

Thus, on the basis of three years study, it is concluded that transplanted method of rice cultivation followed by conventionally tilled wheat can be profitably replaced with broadcast of pre-sprouted seeds broadcast or drum seededing in puddled field with subsequent wheat established, either by zero tillage or by conventional tillage.

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