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Interactive effects of dry and wet tillage in rice (*Oryza sativa*) on puddle quality, water expense, weed infestation and rice yield on sandy-loam soil in Punjab*

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In India, rice (*Oryza sativa* L.) is grown on an area of about 42 million ha, of which 10.5 million ha is under rice–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system in the Indo-Gangetic plains. The ideal lowland rice paddies, with soil texture ranging from sandy clay loam to clay, have low percolation rates. However, with the availability of irrigation water, high-yielding and fertilizer-responsive varieties, and remunerative support prices, rice cultivation in the Indo-Gangetic plains has spread to even highly permeable coarse-textured soils, resulting in increased leaching losses of mobile nutrients. Puddling minimizes such losses, and softens the soil for easy transplanting of rice seedlings.

Puddling is energy intensive and consists of primary or dry and secondary or wet tillage. The dry tillage is aimed at mixing or burying stubbles and manures, levelling and preparing the land for effective puddling, and also reducing weed growth (Gajri *et al.* 1999). Chatha *et al.* (1994) reported that in the Indo-Gangetic plains 67% of farmers practice 4–8 pre-puddling harrowing and disking, and 2–4 puddling operations. However, information on the interactive effects of pre-puddling and puddling tillage on efficiency of resource management and yield of rice is lacking. Hence an experiment was conducted to assess the possible interactions between pre-puddling and puddling tillage operations with regard to their influence on percolation rate, weed growth and yield of rice.

The field experiment was conducted during summer 2000 on sandy-loam (Typic Ustochrept) soil at Punjab Agricultural University, Ludhiana, following split-plot design. The soil was non-saline with low organic carbon content (4 g/kg) (Walkley and Black 1934). The soil contained 77% sand, 13% silt and 10% clay in 0–30 cm soil layer having bulk density of 1.50–1.52 Mg/m^3. Treatments in the main plots included 3 levels of pre-puddling tillage, viz (*i*) no tillage (PP_0), (*ii*) 1 disking followed by a tine cultivator and planking (PP_1) 1 week before transplanting, and (*iii*) PP_1 repeated thrice — 1, 3 and 5 weeks before transplanting (PP_3). Subplot treatments included 1wet cultivation followed by planking (P_1), 2 wet cultivations and a planking (P_2) and 4 wet cultivations followed by a planking (P_4). These treatments imposed with tractor-drawn implements were replicated 3 times. Four weeks old seedlings of 'PR 108' rice were transplanted in 0.2 m wide rows with a distance of 0.15 m between plants on 9 June 2000. The crop received 120 kg N as urea, 20 kg P as single superphosphate, 20 kg K as muriate of potash, and 5 kg Zn as zinc sulphate/ha. All fertilizers except N were broadcast before puddling, and N was applied in 3 equal splits, viz at transplanting, 3 weeks and 6 weeks after transplanting. Continuous ponding of water (6.0 ± 3.0 cm depth) was maintained in the field for the first 3 weeks, while subsequent irrigations were applied 2 days after the disappearance of ponded water (Sandhu *et al.* 1980).

Puddling depth was measured 6 hr after puddling by gently pushing a 2.5 mm diameter steel rod into the mud until it hit hard ground. Daily water expense (percolation + E_t) were recorded periodically by measuring depth of the ponded water between 24 hr periods starting at 9 A M. For this purpose, permanent scales were fixed in each plot. Total water expense during the season of rice crop was computed from an account of total number of irrigations applied in each treatment, irrigation water depth and seasonal rainfall. Manual weeding was done 6 weeks after transplanting. Dry mass of the weeds, in each plot, was recorded after washing and drying a sample of the weeds at 60°C. The grain yield was computed at 15% grain water content after harvesting and threshing the crop manually.

Puddling depth was significantly influenced by the puddling intensity but not by the pre-puddling tillage. It was 12.4 cm in P_1 compared with 14.1 cm in P_2. However, further increase in puddling intensity to P_4 did not significantly increase puddling depth. Mean water expense (Table 1), measured from the net decrease in floodwater depth was 3.3, 3.6 and 2.6 cm /day in PP_0, PP_1 and PP_3 respectively, while it varied from 4.5 cm/day in P_1 to 2.8 and 2.2 cm/day in P_2 and P_4 respectively. Total water expense (Table 1) decreased

* Short note

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Table 1 Mean and total water expense in rice as influenced by the intensity of pre-puddling and puddling tillage

Treatment	Mean water expense (cm/day)				Total water expense (cm)			
	PP_0	PP_1	PP_3	Mean	PP_0	PP_1	PP_3	Mean
P_1	4.4 ± 1.1	4.7 ± 1.7	4.4 ± 1.4	4.5	215	201	211	209
P_2	3.1 ± 1.0	3.1 ± 1.2	2.3 ± 1.3	2.8	173	173	163	170
P_4	2.5 ± 0.6	3.1 ± 1.2	1.1 ± 0.4	2.2	152	156	135	148
Mean	3.3	3.6	2.6		180	177	170	
LSD (P=0.05)								
Total water expense P		8.50						

PP_0, No tillage; PP_1, 1 disking followed by a tine cultivator and planking 1 week before transplanting;) PP_3 ,PP_1 repeated thrice —1, 3 and 5 weeks before transplanting; P_1, 1 wet cultivation followed by planking; P_2, 2 wet cultivations and a planking; P_4,4 wet cultivations followed by a planking

Table 2 Weed biomass in rice crop at 6 weeks after transplanting and unhusked rice yield as affected by the intensity of pre-puddling and puddling tillage

Treatment	Weed biomass (tonnes/ha)				Crop yield (tonnes/ha)			
	PP_0	PP_1	PP_3	Mean	PP_0	PP_1	PP_3	Mean
P_1	2.34	0.20	0.17	0.90	4.86	5.03	5.24	5.04
P_2	0.77	0.17	0.13	0.35	5.22	5.29	5.20	5.24
P_4	0.57	0.19	0.12	0.29	5.44	5.47	5.55	5.49
Mean	1.22	0.18	0.14		5.17	5.26	5.33	
LSD (P=0.05)								
PP	0.28	P		0.23				
P	0.11							
PP × P	0.19							

PP_0, No tillage; PP_1, 1 disking followed by a tine cultivator and planking 1 week before transplanting;) PP_3 ,PP_1 repeated thrice —1, 3 and 5 weeks before transplanting; P_1, 1 wet cultivation followed by planking; P_2, 2 wet cultivations and a planking; P_4, 4 wet cultivations followed by a planking

significantly with puddling intensity, the decrease being 19% from 1 puddling to 2 puddlings. With further increase in puddling intensity from P_2 to P_4, the water expense decreased by 13%. However, the effect of pre-puddling tillage on puddling depth and water expense was non-significant. Rachhpal-Singh *et al.* (1995) reported that irrigation water requirement decreased with an increase in the intensity of puddling on sandy-loam soil. They found that the total number of irrigations applied during the crop season were 16, 12 and 9 when the number of puddling operations were 0, 2 and 4 respectively.

Weed infestation was significantly reduced by both the pre-puddling and puddling treatments. Dry weight of weed biomass recorded 6 weeks after transplanting varied from 1.22 tonnes/ha in PP_0 to 0.18 and 0.14 tonne/ha in PP_1 and PP_3, respectively (Table 2). It decreased from 0.90 tonne/ha in P_1 to 0.36 tonne/ha in P_2 and 0.29 tonne/ha in P_4 treatments. Apparently, the differences between P_2 and P_4 and also between PP_1 and PP_3 treatments were not significant. Rice yield (Table 2) in P_4 was significantly higher than in P_1 and P_2, whereas it was not influenced by pre-puddling tillage. Rice yield increased only by 0.19 and 0.25 tonne/ha, when the intensity of puddling increased from 1 to 2 puddlings and from 2 to 4 puddlings respectively.

The results indicate that to decrease water expense, minimize weed growth and increase rice yield, the optimum tillage requirement may include 1 dry disking followed by tine cultivator and planking operations and 2 puddlings followed by a planking operation. Pre-puddling tillage influenced the weed infestation only and had no influence on soil-water-plant parameters.

SUMMARY

A study was carried out during the summer 2000 to find out the effect of 3 levels of dry tillage, viz no tillage, 1 disking followed by a tine cultivation and a planking once and thrice and wet tillage, viz 1, 2 and 4 wet cultivations followed by 1 planking each on sandy-loam soil. The effect of dry tillage on water expense was non-significant but it significantly reduced the weed infestation. The wet tillage comprising 2 cultivations was sufficient to decrease water expense and weed infestation, thereby increasing the rice yield.

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