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Production potential and economic analysis of direct-sown rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system as influenced by rice varieties, nutrient management and weed-control measures

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 1999–2000 and 2000–01 at Modipuram in Meerut district to identify the most suitable rice (*Oryza sativa* L.) variety for direct seeding under unpuddled conditions, and also to study the effect of sulphur and weed-control measures on rice-wheat (*Triticum aestivum* L. emend. Fiori & Paol.] system. Rice varieties 'DRRH 1' and 'Jaya' recorded mean yields of 71.5 and 66.7 q/ha respectively, which were significantly higher than of 'PAC 808' (50 q/ha) and 'Pusa Basmati' (45.8 q/ha). Application of sulphur @ 30 kg/ha and weed control did not influence the productivity of both the crops. However, application of isoproturon @ 1.25 kg/ha + 2, 4-D @ 0.8 kg/ha significantly affected the mean yield (49.3 q/ha) of wheat than hand-weeding (47.4 q/ha). Rice 'Jaya' - wheat (Rs. 39,094/ha) and rice 'DRRH 1'–wheat (Rs 38,828/ha) system gave significantly higher net returns than rice 'Pusa Basmati 1'–wheat (Rs 37,752/ha) and rice 'PAC 808'–wheat (Rs 33,871/ha) systems.

Key words : Basmati rice-equivalent yield, Weed dynamics, Rice varieties, Sulphur, Economics, Direct seeding (unpuddled), Net returns

Rice and wheat are two important cereal crops in India, which occupy nearly 4 million ha area in north-west India. Rice is predominantly grown by transplanting after puddling, which destroys soil structure and it is difficult to obtain a good tilth for the succeeding crop. Sometimes direct-seeded unpuddled crop equalizes transplanted rice if weeds are controlled effectively with good nutrient management at proper time. Among the factors, fertilizer is the costliest input that promotes the growth and development of rice crop. Nutrient-use efficiency can be increased through its proper time of application and weed-control measures. Under direct-sown unpuddled conditions, weeds pose serious competition to the crop in the early stage and cause heavy reduction in yield. Uncontrolled weeds reduce the yield up to 97% in the direct-sown rice (Saxena and Vaishya, 1993). There is need to identify a rice variety that can perform better under unpuddled environment. Therefore the present investigation was undertaken to find out a suitable rice variety for direct seeding under unpuddled conditions and also to study the effect of sulphur and weed-control measures on rice-wheat productivity.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 1999–2000 and 2000–01 at the research farm of Project Directorate at Modipuram. The soil was sandy loam, containing 65.7, 17.2 and 16.9% sand, silt and clay respectively. The soil pH, electrical conductivity, organic C, and the available P and K were 7.84, 0.43 dS/m, 0.41%, 3.32 and 36 mg/kg soil along with 10 mg S/ha. The experiment was laid out in split-plot design replicated thrice. The main plots comprised four rice varieties, viz. 'Jaya', 'DRRH 1', 'PAC 808' and 'Pusa Basmati 1', whereas subplot consisted of combination of two levels each of sulphur, viz. 0 and 30 kg/ha, and weed-control measures, viz. hand-weeding and herbicide application. Wheat variety 'PBW 226' was uniformly taken after rice. Uniform dose of fertilizers @ 150 kg N/ha, 60 kg P_2O_5/ha, 69 kg K_2O/ha and 25 kg $ZnSO_4$/ha was applied to all treatments. Full dose of P, K and $ZnSO_4$ and one-third N were applied basal, and the rest N was given in two equal splits at 25 and 50-55 days after sowing to rice and wheat. Herbicide (pendimethalin 30% EC @ 1 kg a.i./ha) was sprayed 2 days after sowing rice, and isoproturon @ 1.25 kg/ha + 2,4 D @ 0.8 kg/ha were sprayed 30-35 days after sowing wheat. Hand-weeding was done twice at 25-30 days and 45 days in both the crops. All the rice varieties were sown on 15 June and wheat on 15 November during 1999 and 2000 respec-

tively. The seed rate was 45 kg/ha for direct-seeded rice under dry condition and 120 kg/ha for wheat. Rice and wheat were sown in lines maintaining row to row distance 20 cm. Irrigation scheduling in rice was done with saturation to submergence (5 ± 2.5 cm) to physiological maturity. For wheat the first irrigation was given at crown-root initiation (CRI) stage (21 days after sowing) and subsequently at tillering stage (40-45 DAS), late-jointing stage (70-75 DAS), flowering stage (90-95 DAS) and dough stage (110–115 DAS). In each irrigation 5 ± 2 cm water was applied, which was measured with the help of metre scale. The net return (Rs/ha) was calculated by considering the sale prices of rice and wheat and the cost of cultivation during 1999–2000 and 2000–01 respectively (Table 3).

RESULTS AND DISCUSSION

Grain yield

'DRRH 1' and 'Jaya' rice gave similar yields which were significantly superior to those of 'PAC 808' and 'Pusa Basmati 1' (Table 1). The yield of succeeding wheat grown after 'Pusa Basmati 1' and 'PAC 808' was significantly higher than after other varieties, due to lower nutrient uptake by these varieties, as shown by lower grain yield. The weed-control methods did not influence the yield of rice, but affected significantly the wheat yield. Similarly yield of rice was affected significantly over no-sulphur control (59 q/ha at 30 kg S/ha).

However, wheat yield was not affected significantly, though its yield was numerically higher at 30 kg/ha sulphur. In Basmati rice-equivalent yield, cultivation of 'DRRH 1' rice followed by wheat gave the highest systems productivity. In yield attributes, 'DRRH 1' showed significantly higher plant height and number of effective tillers/m than other rice varieties. In wheat significantly higher plant height and number of effective tillers/m were recorded when it was grown after 'Pusa Basmati 1'. Interaction was found non-significant in yield contributors than after sulphur application and weed-control measures did not influence the plant height and number of effective tillers in rice and wheat crops. But in wheat sulphur application @ 30 kg/ha recorded significantly higher plant height than no sulphur application. Similar findings were reported by Sharma (2002). Panicle length of 'Pusa Basmati' was significantly higher than of other rice varieties, whereas in wheat variety 'PBW 226' panicle weight was significantly higher in rice 'DRRH 1', which was found highest in wheat taken after 'Pusa Basmati 1'. Rice 'Jaya' recorded the highest 1,000-grain weight as also wheat after 'PAC 808'.

Weed dynamics

Dominant weeds were *Cyperus rotundus, Echinochloa colonum, E. crus-galli, Cyperus iria, Setaria glauca* and *Celosia argentea* in rice; and *Cyperus rotundus, Phalaris minor, Anagallis arvensis, Chenopodium album, Melilotus* spp. and *Cynodon dactylon* in wheat. Among rice varieties, 'DRRH 1' resulted in fewer weeds/m^2 and lesser dry weight of weeds than 'Jaya'. 'PAC 808' and 'Pusa Basmati 1'. The rice 'Pusa Basmati 1'–wheat sequence had significantly less number of weeds and dry weight of weeds than rest of the sequences. Weed-control measures did not influence the number of weeds and dry weight of weeds in rice, but herbicide application affected it signifi-

Table 1. Grain yield, basmati rice-equivalent yield, plant height and effective tillers as influenced by rice varieties, sulphur application and weed-control measures in rice–wheat system (pooled data of 1999–2001)

Treatment	Grain yield (q/ha)			Plant height at maturity (cm)		Effective tillers/m row length	
	Rice	Wheat	BREY	Rice	Wheat	Rice	Wheat
Rice variety							
'Jaya'	66.7	45.5	99.0	105	102	79	72
'DRRH 1'	71.5	44.8	102.3	107	102	83	69
'PAC 808'	50.0	50.4	90.1	100	103	58	78
'Pusa Basmati 1'	45.8	52.8	97.2	104	104	79	80
CD (P=0.05)	6.7	4.9	5.9	1	1	5	10
Weed control							
Hand-weeding	58.5	47.4	96.1	104	102	75	73
Herbicide	58.5	49.3	98.2	104	103	75	76
CD (P=0.05)	NS	1.7	NS	NS	NS	NS	NS
S management							
0	57.9	47.8	96.1	104	102	75	74
30	59.0	48.9	98.2	104	103	75	76
CD (P=0.05)	1.9	NS	NS	NS	0.5	NS	NS

HW, Hand weeding; CW, chemical weed control; BREY, Basmati rice-equivalent yield

Table 2. Panicle length, panicle weight, 1,000-grain weight, no. of weeds and dry weight of weeds as influenced by rice varieties, sulphur application and weed-control measures in rice–wheat system (pooled data of 1999–2001)

Treatment	Panicle length (cm)		Panicle weight (g)		1,000-grain weight (g)		Weed density (No./m²)		Dry weight of weeds (g/m²)	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Rice variety										
'Jaya'	25.73	15.63	3.41	3.06	26.27	35.01	13.75	47.79	41.62	149.50
'DRRH 1'	27.92	15.60	3.63	3.05	25.54	34.96	13.13	47.33	39.48	141.73
'PAC 808'	23.33	15.38	3.36	3.13	25.14	35.25	16.71	42.79	50.27	133.87
'PB 1'	29.33	15.66	2.39	3.15	22.11	35.23	18.46	36.54	54.59	115.06
CD (P=0.05)	0.11	0.34	0.05	0.05	0.65	0.14	3.30	10.99	8.53	28.18
Weed control										
Hand-weeding	26.53	15.57	3.18	3.08	24.72	35.07	16.34	63.44	51.21	189.39
Herbicide	26.63	15.58	3.21	3.11	24.81	35.16	14.65	23.80	41.95	80.70
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S management										
0	26.49	15.48	3.19	3.08	24.68	35.11	15.54	42.32	47.30	134.32
30	26.67	15.66	3.21	3.10	24.85	35.11	15.48	44.92	45.86	135.76
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Cost of cultivation, net returns and benefit : cost ratio as influenced by rice varieties, sulphur application and weed-control measures in rice-wheat system (pooled data of 1999–2001)

Treatment	Cost of cultivation (Rs/ha)			Net returns (Rs/ha)			B : C ratio		
	Rice	Wheat	Total	Rice	Wheat	Total	Rice	Wheat	Total
Rice variety									
'Jaya'	16,253	13,466	29,719	20,026	19,068	39,094	2.23	2.44	4.67
'DRRH 1'	18,653	13,466	32,119	20,316	18,512	38,828	2.09	2.40	4.49
'PAC 808'	15,953	13,466	29,419	11,317	22,554	33,871	1.71	2.70	4.41
'PB 1'	16,853	13,466	30,319	13,499	24,254	37,752	1.81	2.83	4.63
CD (P=0.05)	NS	NS	NS	3,621	3,570	4,217	0.22	0.27	0.29
Weed control									
Hand-weeding	17,909	14,575	32,484	15,288	19,255	34,542	1.85	2.32	4.17
Herbicide	15,947	12,356	28,303	17,292	22,939	40,231	2.08	2.86	4.93
CD (P=0.05)	NS	NS	NS	1,062	1,266	1,635	0.07	0.09	0.11
S management									
0	16,756	13,294	30,050	16,154	20,873	37,027	1.97	2.60	4.56
30	17,100	13,638	30,738	16,425	21,321	37,746	1.96	2.59	4.55
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

cantly than hand-weeding in wheat. Chemical weed control significantly reduced the number of weeds and dry weight of weeds compared with hand-weeding in both the crops. Behra and Jena (1998) reported that application of pendimethalin @ 1.0 kg a.i./ha was superior to other weed-control treatments. Singh *et al.* (1999) reported that isoproturon @ 1.25 kg/ha brought about effective control of weeds, leading to increased wheat yield compared with that of weedy check. Sulphur application did not influence the number of weeds and dry weight of weeds in rice and wheat crops.

Economic analysis

Rice 'Jaya'-wheat and rice 'DRRH 1'–wheat systems resulted in significantly higher net returns and benefit: cost (B:C) ratio than other rice-wheat systems. Weed-control methods influenced the net returns and B : C ratio, which were highest under chemical weed control but sulphur application did not influence these. However, a higher net return was recorded under 30 kg sulphur application.

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