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Research Article

Effect of Tillage and Residue Management on Productivity of Crops in Rice-Wheat Cropping System

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Abstract

A field experiment was conducted on a fixed site during rainy season (*kharif*) and winter season (*rabi*) of 2010-11 and 2011-12 at the research farm of Indian Agricultural Research Institute, New Delhi, to assess the effect of tillage and residue management practices on yield attributes and productivity of crops in rice (*Oryza sativa* L.) –wheat (*Triticum aestivum* L. emend Fiori and Paol.) cropping system. Direct seeding under unpuddled condition, transplanting nuder puddled condition, brown manuring and mungbean residue incorporation before sowing of direct-seeded rice were practiced in rice, while zero-till sowing, conventional till sowing and rice residue application with zero-till wheat were tested in wheat crop. During 2010 transplanted rice (TPR) produced significantly higher yield attributes and yield (5.37 t ha^{-1}). However during second year mungbean residue incorporation with DSR produced significantly at par yield attributes and yield (5.61 t ha^{-1}) than the TPR (5.75 t ha^{-1}). All the residue management treatments perform almost similarly with direct seeded rice, while lowest yield (5.01 t ha^{-1}) was recorded under DSR –ZTW.

In wheat, during first year all the treatments perform at par but in second year MBR+DSR-ZTW+RR-MB produced signifycantly higher yield (5.33 tha^{-1}) than the no-residue treatments and lowest yield (4.8 t ha^{-1}) was recorded under conventional till wheat (TPR-CTW), which was grown after transplanted rice. However all the residue management treatments perform almost at par.

Keywords: Direct-seeded rice, Transplanted rice, Brown manuring, Residue management, Zero-tillage, Productivity, Mungbean

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Introduction

Rice (*Oryza sativa* L.), and wheat (*Triticum aestivum* L. emend Fiori and Paol.) are major cereals contributing to food security and income in South Asia. These crops are grown either as a monoculture or in rotations in tropical and sub-tropical environments of South Asia. In the irrigated and favorable rainfed lowland areas, rice-rice (R-R) and rice-wheat (R-W) are the predominant cropping systems [1]. Rice –wheat is the most important cropping system for food security in South Asia (13.5 M ha), providing food for more than 400 million people. It gained prominence from the mid-1960s with the introduction of short-duration and high-yielding varieties of rice and wheat. At the moment, the rotation has spread in the most fertile regions and has covered about 10.3 million ha in the Indo-Gangetic Plain (IGP) of India [2]. It is more popular in the non-traditional rice-growing states of Punjab, Haryana and Uttar Pradesh, and less in traditional rice-growing states of Bihar and West Bengal. In India, it contributes 26% of total cereal production and 60% of total calorie intake [3]. The area under this system is static, and the productivity and sustainability of the system are threatened because of the inefficiency of current production practices, shortage of resources, such as water and labour, fuel and socio-economic changes [4].

Rice–wheat is the dominant cropping system in the north-western plain zone and a lot of research work has been done on various agronomic management practices for improving productivity but there is lack of information on resource-conserving techniques, such as direct-seeding of rice, brown manuring with *Sesbania aculeata*, zero-till sowing of wheat as well as effect of residue management on productivity, profitability and soil health. Comparative evaluation of direct-seeded and transplanted rice, and the performance of following crop of wheat under conventional and zero tillage conditions require a thorough investigation. Therefore, an attempt was made to study the effect of tillage and residue management on yield attributes and productivity of crops in rice-wheat cropping system.

Materials and Methods

A field experiment was conducted on a fixed site during rainy season (June to October) and winter season (November to April) of 2010-11 and 2011-12 at the research farm of Indian Agricultural Research Institute, New Delhi (28.4^o N latitude, 77.1^o E longitude and 228.6 m above mean sea level). The mean annual rainfall of Delhi is 672 mm and more than 80% generally occurs during the monsoon season (July-September) with mean annual evaporation 850 mm. The soil at site was sandy clay loam with bulk density of 1.48 Mg/m^3 and field capacity of 25.4 % (w/w). It had 0.54 % organic carbon, 170.6 kg $KMnO_4$ oxidizable N/ha, 18.6 kg 0.5 N $NaHCO_3$ extractable P/ha, 275 kg 1.0 N NH_4OAc exchangeable K/ha, 8.0 pH and 0.36 dS/m EC in the top 15 cm of soil. The treatments comprised viz. direct-deeded rice – zero-till wheat (DSR-ZTW), direct-deeded rice – zero-till wheat + rice residue (DSR-ZTW+RR), direct–deeded rice + brown manuring–zero-till wheat (DSR+BM-ZTW), direct-deeded rice + brown manuring–zero-till wheat + rice residue (DSR+BM-ZTW+RR), mungbean residue + direct-deeded rice- zero-till wheat + relay mungbean (MBR+DSR-ZTW+MB), mungbean residue + direct-deeded rice –zero-till wheat + rice residue + relay mungbean (MBR+DSR-ZTW+RR+MB), transplanted rice – conventional till wheat (TPR-CTW) and transplanted rice – zero-till wheat (TPR-ZTW). The experiment was laid out in randomized block design and replicated thrice. Rice 'PRH 10'and wheat 'HD 2894', varieties were taken for experimentation. The sowing for direct-seeded rice and nursery raising was done in the second forth-night of june and transplanting of seedling was done in second week of july, while rice was harvested in the last week of October during both the years. Zero-till and conventional till wheat was sown in the second week of November and last week of November respectively and harvested in second week of April during both the years. For brown manuring practice seeds of *sesbania* @ 40kgha^{-1}, was broadcasted together with the sowing of direct-seeded rice as per treatments and than *sesbania* crop was knocked down at 30 days after sowing with 2,4-D ester. Sowing of relay mungbean was done into the respective treatments in the second forth-night of march by broadcasting in the standing wheat crop and after one picking of pods, it's residues was incorporated into soil in respective treatments through rotavator in june before sowing of direct-seeded rice. After harvesting of rice, it's choped residue was applied into respective treatments @ 5.0 t/ha before sowing of zero-till wheat. The cultivation of both season crops was done with the recommended package of practices. The number of irrigations applied in direct-seeded rice, transplanted rice, zero- till wheat, and conventional till wheat were 11, 21, 5, 5 and 17, 23, 6, 6 during 2010-11 and 2011-12 respectively. Comparatively higher number of irrigations was applied during 2011-12 in rice crop due to shortage of rainfall. All the growth parameters, yield attributes and yield were recorded as per standard methods at different intervals and at harvest.

Results and Discussion

Yield attributes and productivity of rice

The yield attributes viz. effective tillers/m^2, grains/panicle, panicle length, were significantly influenced by tillage, crop establishment methods and brown manuring during 2010. Transplanted rice under puddled condition produced significantly higher yield attributes than the direct-seeded rice and brown manuring + direct-seeded rice in 2010. Under brown manuring treatments the effective number of tillers was recorded significantly lower than others due to initial crowding effect of dhaincha. However, other yield attributes were recorded almost similar under direct seeded rice with brown manuring and without brown manuring treatments. During second year the yield attributes under mungbean residue incorporated treatments (MBR+DSR-ZTW+RR-MB and MBR+DSR-ZTW- MB) were recorded significantly similar with transplanted treatments (TPR). In second year, the treatments where rice residue was applied in previous zero-till wheat crop and brown manuring practice followed in rice were produced higher yield attributes than the without residue direct-seeded treatments. Tillage and different residue management practices were failed to produced any significant variation into test weight of rice during both the years. Productivity of rice in terms of grain, straw and biological yield was significantly influenced due to tillage and residue management. During first year the transplanted rice produced significantly higher yields than the rest treatments but in second year TPR produced significantly similar yields with the treatments where mungbean residue was incorporated. Mungbean residue incorporated treatments produced significantly higher yield than the rest residue treatments except DSR+BM-ZTW+RR treatment. Dhiman *et al.* (2000) [5] also reported similar findings. Lowest yield was recorded under the treatment (DSR-ZTW) where no-residue was applied during both the seasons. Residue management practices over time enhance the physico-chemical properties of soil, which results better yields. Under transplanted rice, better availability of water, nutrients and less weed infestation resulted comparatively higher yields [6]. Harvest index remained significantly unaffected due to tillage and residue management practices during both the years.

Table 1 Yield attributes of rice as influenced by tillage, crop establishment, brown manuring and residue management

*Treatment	2010				2011			
	Effective tillers m^{-2}	Grains/ panicle	Panicle length (cm)	1000-grain weight (g)	Effective tillers m^{-2}	Grains/ panicle	Panicle length (cm)	1000-grain weight (g)
[1]DSR-ZTW	225.3	90.7	25.6	24.78	256.3	100.8	26.1	24.53
[1]DSR-ZTW+RR	223.4	88.8	25.3	24.72	267.4	104.5	26.3	24.59
[2]DSR+BM-ZTW	190.5	84.7	25.4	24.65	265.1	102.8	26.2	24.61
[2]DSR+BM-ZTW+RR	188.5	82.2	25.2	24.57	281.2	107.4	27.2	24.78
[1]MBR+DSR-ZTW+ MB	222.2	86.5	25.3	24.73	277.3	105.2	27.5	24.76
[1]MBR+DSR-ZTW+RR+MB	220.6	87.6	25.1	24.69	303.5	110.5	28.4	24.89
[3]TPR-CTW	297.0	109.4	28.8	24.94	300.7	109.6	28.3	24.84
[3]TPR-ZTW	294.8	106.5	28.4	24.88	306.8	115.2	28.7	24.72
SEm±	3.71	3.39	0.19	0.27	4.74	2.41	0.33	0.16
CD (P=0.05)	11.24	10.28	0.58	NS	14.36	7.32	1.01	NS

*Treatments with superscript 1, 2, and 3 were maintained similarly in 2010

Table 2 Productivity of rice as influenced by tillage, crop establishment, brown manuring and residue management

*Treatment	2010				2011			
	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
[1]DSR-ZTW	4.66	7.22	11.91	39.18	5.07	7.96	13.03	38.93
[1]DSR-ZTW+RR	4.62	7.16	11.78	39.26	5.18	8.10	13.28	39.01
[2]DSR+BM-ZTW	4.36	6.97	11.33	38.78	5.15	8.06	13.21	39.02
[2]DSR+BM-ZTW+RR	4.30	6.88	11.18	38.47	5.42	8.22	13.65	39.73
[1]MBR+DSR-ZTW+ MB	4.56	7.14	11.70	39.63	5.34	8.10	13.44	39.73
[1]MBR+DSR-ZTW+RR+MB	4.61	7.02	11.63	38.61	5.61	8.33	13.94	40.22
[3]TPR-CTW	5.37	7.97	13.34	40.27	5.57	8.37	13.94	39.94
[3]TPR-ZTW	5.30	7.93	13.24	40.17	5.75	8.58	14.33	40.11
SEm±	0.12	0.20	0.27	0.27	0.11	0.13	0.19	0.487
CD (P=0.05)	0.36	0.62	0.81	NS	0.32	0.38	0.58	NS

*Treatments with superscript 1, 2, and 3 were maintained similarly in 2010

Yield attributes and productivity of wheat

The yield attributes (spikes m^{-2}, spike length, and grains $spike^{-1}$) were not influenced due to tillage and residue management practices and remained non significant during 2010-11. However during second year mungbean residue incorporation in previous rice crop and zero-till wheat with rice residue (MBR+DSR-ZTW+RR-MB) produced significantly higher yield attributes than the wheat which was grown after puddled transplanted rice (TPR). During second year poorest performance of the yield attributes were recorded under conventional till-wheat (TPR-CTW) which was grown after puddled transplanted rice. Tillage and residue management practices could not affect 1000-grain weight significantly. Tillage, residue management and brown manuring in previous crop could not affect grain, straw, and biological yields significantly during 2010-11. However, significantly higher yields were recorded under mungbean residue incorporated in previous direct-seeded rice and zero-till wheat with rice residue treatment (MBR+DSR-ZTW+RR+MB) than the no-residue treatments. During second year lowest yield performance was recorded under conventional till-wheat (TPR-CTW) which was grown after puddled transplanted rice. Tillage and reside management practices could not bring any significant change in harvest index during both the year of study. Mungbean cultivation and residue incorporation improves soil properties and fertility status which resulted better yields of succeeding crops [7]. Manguiat *et al*., (1997) [8] also reported positive effects of mungbean cultivation and residue incorporation. Similarly rice residue application increases organic matter into the soil over time, smoother weeds growth and maintain moisture in soil for longer time and finally owing to better yield of crops [2]. The yield of wheat after puddled transplanted rice was recorded lower than the wheat grown after direct-seeded rice, this might be due to deterioration of soil properties due to puddling in rice crop [9].

Table 3 Yield attributes of wheat as influenced by tillage, crop establishment, brown manuring and residue management

*Treatment	2010-11				2011-12			
	Spikes m^{-2}	Spike length (cm)	Grains $spike^{-1}$	1000-grain weight (g)	Spikes m^{-2}	Spike length (cm)	Grains $spike^{-1}$	1000-grain weight (g)
[1]DSR-ZTW	430.4	9.74	47.8	41.36	443.3	10.6	51.3	41.23
[2]DSR-ZTW+RR	423.2	10.04	46.3	40.77	448.5	11.0	52.2	41.31
DSR+BM-ZTW	414.2	9.75	46.7	41.29	444.8	10.7	50.5	41.47
DSR+BM-ZTW+RR	426.7	9.94	48.4	41.39	450.3	11.2	52.7	41.43
[1]MBR+DSR-ZTW+MB	428.9	10.03	48.7	40.87	453.7	11.3	53.0	41.62
[2]MBR+DSR-ZTW+RR+MB	421.4	9.82	45.4	40.57	455.2	11.5	53.3	41.55
TPR-CTW	430.5	9.78	46.8	41.43	434.5	10.2	49.3	41.74
TPR-ZTW	416.3	9.79	45.0	40.41	440.1	10.3	50.0	41.45
SEm±	3.88	0.12	0.80	0.26	4.13	0.22	0.84	0.24
CD (P=0.05)	NS	NS	NS	NS	12.53	0.65	2.55	NS

*Treatments with superscript 1 and 2 were maintained similarly in 2010-11

Table 4 Productivity of wheat as influenced by tillage, crop establishment, brown manuring and residue management

*Treatment	2010-11				2011-12			
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
[1]DSR-ZTW	4.62	6.82	11.44	40.40	4.95	6.70	11.65	42.48
[2]DSR-ZTW+RR	4.50	6.53	11.03	40.77	5.08	6.85	11.93	42.61
DSR+BM-ZTW	4.38	6.36	10.74	40.78	5.00	6.73	11.73	42.61
DSR+BM-ZTW+RR	4.48	6.49	10.97	40.88	5.12	6.89	12.01	42.70
[1]MBR+DSR-ZTW-MB	4.59	6.67	11.26	40.79	5.26	7.04	12.30	42.77
[2]MBR+DSR-ZTW+RR-MB	4.46	6.52	11.01	40.55	5.33	7.12	12.45	42.83
TPR-CTW	4.57	6.60	11.17	40.91	4.80	6.63	11.43	42.02
TPR-ZTW	4.40	6.55	10.94	40.26	4.91	6.68	11.59	42.34
SEm±	0.08	0.093	0.157	0.410	0.10	0.11	0.18	0.372
CD (P=0.05)	NS	NS	NS	NS	0.32	0.32	0.54	NS

*Treatments with superscript 1 and 2 were maintained similarly in 2010-11

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