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Productivity and profitability of rice–wheat sequence under conservation tillage

Sushma Saroj Surin*, M.K. Singh, R.R. Upasani, R. Thakur and S.K. Pal
Department of Agronomy, Birsa Agricultural University, Ranchi, Jharkhand 834 006

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ABSTRACT

Field experiment was conducted during 2009-10 and 2010-11 at Agronomical Research Farm of Birsa Agricultural University, Ranchi with four tillage management (zero till rice and zero till wheat; zero till rice and conventional till wheat; conventional till rice and zero till wheat and conventional till rice and conventional till wheat) in main plot and three methods of weed control practices *viz.,*weedy check, recommended herbicides butachlor 1.5 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence for rice and isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha post-emergence for wheat and two hand weeding (20 and 40 DAS for rice and 25 and 50 DAS for wheat) in sub plot to assess the productivity and profitability of rice -wheat (cropping system under conservation tillage. Direct seeded rice–wheat sequence with conventional tillage produced maximum rice equivalent yield 7.44 t/ha (for 3.1 t/ha rice and 3.6 t/ha wheat) and net return (₹ 58,206/ha). Among weed control, rice-wheat either with butachlor 1.5 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence in rice and isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha post-emergence in wheat or, with two hand weeding in both crops produced maximum rice equivalent yield (7.4 t/ha and 7.8 t/ha) and net return (₹ 62,258/ha and ₹ 60,498/ha)

Key words: Conservation tillage, Direct-seeded rice, Economics, Rice-wheat system, Weed control

Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori and Paol) is the dominant cropping system in northern India covering about 10.5 million hactare area which contributes about 32% to the national food basket. Both rice and wheat are the two most important crops and the staple food of millions of Indian people (Sharma *et al*. 2008). In recent years, the rice-wheat has started suffering a production fatigue, in productivity. This production system is labour, water and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce and costly. Further, puddled rice soil produces more clods on ploughing and requires more fuel, labour and time to bring the soil to a reasonably good tilth for seeding wheat. Sometimes, all efforts to obtain a good tilth lead to soil moisture depletion and the farmers have to give a pre-sowing irrigation and wait for few days for sowing wheat. This situation is more aggravated on late harvesting of rice due to late transplanting or long duration cultivar. This pushes the seeding of succeeding wheat crop beyond November which decreases its productivity by 30-50 kg/ha/day (Chauhan *et al*. 2001). Hence the constraints related to both the crops must be tackled simultaneously to increase the productivity of the system.

Now, farmers are shifting to direct seeding because of its various benefits of similar or even higher yields (Bhusan *et al*. 2007, Farooq *et al*. 2009) and savings in irrigation water (Sharma *et al*. 2002, Singh *et al*. 2002), labour and production costs (Kumar *et al*. 2009), higher net returns and reduction in methane emission as well, which covers 28% of the total rice area in India. Direct seeding of rice aides in quick establishment and early harvest than transplanted rice and consequently facilitate timely wheat seeding (Singh *et al*. 2007) and thus enhances sustainability of both the rice and wheat in rice and wheat cropping system (Singh *et al*. 2005). However, direct seeding is subjected to greater weed competition than transplanted rice because both weed and crop seeds emerge at the same time and compete with each other resulting yield reduction by 50 to 100% (Rao *et al*. 2007). Jain *et al*. 2006 also reported 65 to 90% loss in grain yield of wheat due to weeds. Hence, the present investigation was undertaken to study the impact of combinations of conventional and zero tillage with weed control measures during on productivity and weed dynamics of rice and wheat cropping system

MATERIALS AND METHODS

Field experiments were conducted in a split plot design at Birsa Agricultural University Farm, Ranchi during the rainy and winter season of 2009-10 and 2010-11 to study the impact of combinations of conventional and zero tillage with weed control measures during *Kharif* and *Rabi* season on productivity and weed dynamics of rice and

***Corresponding author:** sushmasarojsurin5@gmail.com

wheat cropping system. Treatment consisted of combination of four tillage practices; (i) Zero till rice and zero till wheat (ii) Zero till rice and conventional till wheat (iii) Conventional till rice and zero till wheat (iv) Conventional till rice and conventional till wheat in main plot and three methods of weed control practices (i) Weedy check (ii) Recommended herbicides butachlor 1.5 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence for rice and isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha post-emergence for wheat (iii) Two hand weeding (20 and 40 DAS for rice and 25 and 50 DAS for wheat) in sub plot and replicated 4 times. The soil was sandy loam, acidic in reaction (pH 5.43), low in, available nitrogen (242.2 kg/ha), potassium (123 kg/ha) and medium in organic carbon (0.52) available phosphorus (14.85 kg/ha).

A uniform fertilizer dose of 100- 40- 30 kg N- P_2O_5-K_2O/ha for direct seeded rice and 100- 60- 40 kg N- P_2O_5-K_2O/ha for wheat was applied. Half dose of N and full amount of P and K were applied at the time of seeding and remaining nitrogen was applied in two equal splits at maximum tillering and panicle initiation in direct seeded rice and at crown root initiation and at panicle initiation in wheat. The veriety '*Naveen*' of 120-125 days duration for rice and for wheat '*K-9107*' of 130- 140 days duration were used. The total rainfall received during crop season was 1063.7 and 1177.0 mm in 2009 and 2010, respectively. Observations on weeds were recorded with the help of a quadrate 0.5 x 0.5 m placed randomly at two spots in each plot at 30, 60 and 90 DAS.

The data on weeds were subjected to square root transformation ($\sqrt{x + 0.5}$) to normalize their distribution. Weed control efficiency was calculated using weed dry weight data at 60 DAS which was maximum during weed growth period irrespective of treatments. Economic analysis was done on the basis of prevailing market price of input used and output obtained from each treatment. The data were analysed separately for the year 2009 and 2010 and both the year's data were subjected for pooled analysis to obtain a trend among results over the years.

RESULTS AND DISCUSSION

Yield attributes and yield

Conventionally tilled rice produced 14.6% higher productive tillers, 3.0% higher panicle length, 9.3% higher filled grain, resulting in 25.5% higher grain and 27.9% higher straw yield compared to zero tilled rice (Table 1). Similarly, higher productive tillers/m^2, spike length, filled grains/spike and 1000 grain weight under conventionally tilled wheat over zero tilled wheat resulted 14.7% higher grain (3.52 t/ha) and 17.9% higher straw (4.9 t/ha) yield of wheat (Table 2).

Among weed control method, two hand weeding in rice (20 and 40 DAS) produced 53.3% higher productive tillers, 5.1% higher panicle length, 36.0% higher filled grain/panicle as well as 7.0% higher 1000 grain weight than weedy check resulting 105.6% higher grain and 125.2% higher straw yield and is at par with application of recommended herbicides in rice which also recorded 49% higher productive tillers, 3.4% higher panicle length, 34% higher filled grain/panicle, and 4% higher 1000 grain weight compared to weedy check resulting 104% higher grain and 108.6% higher straw yield. Hand weeding at 25 and 50 DAS in wheat crop recorded higher yield attributing parameters like 31.3% higher productive tillers/m^2, 5.3%

Table 1. Effect of tillage and weed control on yield attributes and grain and straw yield of rice (pooled data)

Treatment		Productive tillers (m^2)	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/ panicle	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage								
Rice	Wheat							
Zero	Zero	249	17.9	58	14.5	20.0	2.3	3.1
Zero	Conventional	277	18.2	60	14.9	20.4	2.5	3.4
Conventional	Zero	297	18.5	64	15.9	20.9	2.9	4.1
Conventional	Conventional	305	18.7	65	16.2	21.4	3.1	4.3
LSD (P=0.05)		28	NS	4	0.7	NS	0.3	0.3
Weed management								
Rice	Wheat							
Weedy check	Weedy check	210	17.8	50	12	20.0	1.6	2.1
Butachlor + 2,4-D	Isoproturon + 2,4- D	314	18.4	67	17	20.8	3.3	4.4
Hand weeding	Hand weeding	323	18.7	68	17	21.4	3.3	4.7
LSD (P=0.05)		26	0.9	5	1.0	1.7	0.2	0.2

Table 2. Effect of tillage and weed control on yield attributes and grain and straw yield of wheat (pooled data)

Treatment		Productive tillers (m^2)	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/ panicle	1000 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage								
Rice	Wheat							
Zero	Zero	217	10.4	44	10	42.2	3.0	4.1
Zero	Conventinal	233	10.8	46	10	42.4	3.4	4.8
Conventional	Zero	221	10.5	45	10	42.3	3.1	4.3
Conventional	Conventinal	240	10.8	47	10	42.1	3.6	5.1
LSD (P=0.05)		NS	NS	NS	NS	NS	0.2	0.3
Weed management								
Rice	Wheat							
Weedy check	Weedy check	192	10.3	43.2	9.8	42.2	2.7	3.7
Butachlor + 2,4-D	Isoproturon + 2,4-D	239	10.7	46.3	10.2	42.1	3.5	4.9
Hand weeding	Hand weeding	252	10.9	46.9	10.3	42.4	3.7	5.1
LSD (P=0.05)		16	0.5	2.6	0.6	2.0	0.2	0.3

Table 3. Economics and rice equivalent yield as influence by tillage and weed management in rice–wheat system (pooled data)

Treatment		Gross return ($x10^3$ ₹/ha)	Net return ($x10^3$ ₹/ha)	B:C ratio	Rice equivalent yield (t/ha)
Tillage					
Rice	Wheat				
Zero	Zero	74.32	44.66	1.49	5.9
Zero	Conventional	83.74	50.49	1.51	6.8
Conventional	Zero	83.62	51.86	1.62	6.7
Conventional	Conventional	93.56	58.21	1.64	7.3
LSD (P=0.05)		3.53	3.53	0.10	0.4
Weed management					
Rice	Wheat				
Weedy check	Weedy check	60.31	31.15	1.06	4.8
Butachlor + 2,4-D	Isoproturon + 2,4-D	93.13	62.26	2.02	7.4
Hand weeding	Hand weeding	97.98	60.50	1.61	7.8
LSD (P=0.05)		4.37	3.56	0.1	0.4

higher spike length and 8.6% higher filled grains/panicle, resulting in 35.8% higher grain and 38.6% higher straw yield compared to weedy check and is at par with application of recommended herbicides in wheat producing 24.5% higher productive tillers/m^2, 3.4% higher spike length and 7.2% higher filled grain with enhanced grain (31.4%) and straw yield (31.4%) compared to weedy check.

Rice equivalent yield

Conventionally tilled both rice and wheat produced 25.23, 11.9 and 11.4% higher mean rice equivalent yield compared to zero tilled in both rice and wheat (5.9 t/ha); zero tilled rice-conventional tilled wheat (6.7 t/ha); and conventional tilled rice-zero tilled wheat (6.7 t/ha). The corresponding increase in rice equivalent yield was 23.8, 10.2 and 10.9% in first year while 26.7, 13.4 and 11.9% respectively in second year (Table 3). The results are in conformity with the findings of Pandey *et al*. (2008) who have reported that conventional methods of tillage performed in rice and wheat produced more yields than zero tillage in the system.

Two hand weeding at 20 and 40 days after sowing in rice and at 25 and 50 days after sowing in wheat crop being similar to application of butachlor 1 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence in rice crop and isoproturon 0.5 kg/ha post-emergence + 2,4-D 0.5 kg/ha in wheat crop produced 62.70% higher mean rice equivalent yield compared to weedy check. Similarly, chemical weeding in both the crops had 54.79% higher rice equivalent yield than weedy check. This is in conformity with the results of Jha *et al.* (2011).

Economics

Conventionally tilled both rice and wheat recorded 25.9, 11.8 and 11.9% higher mean gross return; 30.3, 15.3 and 12.2% higher mean net return than zero-zero, zero-conventional and conventional **-** zero tillage performed in rice and wheat, respectively. However, conventional **-** zero tillage and conventional-conventional recorded similar B: C ratio indicating marginal reduction in grain yield (11.4%) compensated with reduced cost of tillage operation under zero tillage performed in wheat crop. Higher economic returns due to conventional tillage in rice and wheat have also been reported by Pandey *et al*. (2008).

Two hand weedings performed both in rice (20 and 40 DAS) and wheat (25 and 50 DAS) being similar to application of butachlor 1 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence in rice crop and isoproturon 0.5 kg/ha post-emergence + 2,4-D 0.5 kg/ha in wheat crop recorded 62.5% higher gross return, 94.2% higher net return as well as 51.9% higher B:C ratio compared to weedy check in rice and wheat crops. Similarly, chemical weeding to both the crops had 99.8% higher net return and 90.6% higher net benefit cost ratio. This is in conformity of the results of Pandey *et al*. (2005), Mishra *et al*. (2009) and Singh *et al*. (2010).

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