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**Research Paper**

# Weed management in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system under conservation tillage

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## ABSTRACT

A field experiment was conducted during 2009–10 and 2010–11 at agronomical research farm of Birsa Agricultural University, Ranchi with four tillage management *viz.* Zero till rice (*Oryza sativa* L.) and zero till wheat {*Triticum aestivum* (L.) emend. Fiori & Paol}; zero till rice and conventional till wheat; conventional till rice and zero till wheat and conventional till rice and conventional till wheat, in main plots 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 @ 0.75kg/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 plots 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 7.4 t/ha (3.1 t/ha rice and 3.6 t/ha wheat) and net returns (₹ 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 @ 0.75kg/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 returns (₹ 62,258/ha and ₹ 60,498/ha)

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

Rice–wheat is the dominant cropping system in northern India covering about 10.5 million ha area, which contributes about 32% to the national food basket. In fact both rice and wheat are the two most important crops and the staple food of millions of Indian people (Sharma *et al*., 2008). This production system is labour, water and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce and costly (Pandey and Velasco, 2005). This situation is more aggravated on late harvesting of rice due to late transplanting or long duration cultivars. This pushes the seeding of succeeding wheat crop beyond November which decreases its productivity by 30–50 kg/ha/day (Chauhan *et al*., 2001). In recent days, farmers are shifting again to direct seeding because of its similar or even higher yields (Sarkar *et al*., 2003; Bhusan *et al*., 2007; Farooq *et al*., 2009), along with 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. Direct seeding of rice results 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–wheat in 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 from germination, resulting yield reduction by 50 to 100% (Rao *et al*., 2007). Similarly Jain *et al*., (2006) also reported 65 to 90% loss in grain yield of wheat due to weeds. In fact, weed management is a key component for success of rice–wheat production system. Keeping, these points in view, the present investigation was undertaken 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–wheat cropping system.

## MATERIALS AND METHODS

A field experiment was conducted in a split plots design at Birsa Agricultural University, 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

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on productivity and weed dynamics of rice and 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 plots 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) and 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. Rice 'Naveen' of 120–125 days duration and wheat 'K-9107' of 130–140 days duration was used. The total rainfall received during crop season was 1063.7 mm and 1177.0 mm in 2009 and 2010, respectively. Observations on weeds were recorded with the help of a quadrate 0.5 m × 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 inputs used and output obtained from each treatment. 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 grains, resulting in 25.5% higher grain and 27.9% higher straw yield compared to zero tilled rice (Table 1). Similarly the higher productive tillers/$m^2$, spike length, filled grains/spike and 1,000-grains weight under conventionally tilled wheat over zero tilled wheat resulted in 14.7% higher grain (3.52 t/ha) and 17.9% higher straw (4.94 t/ha) yield of wheat (Table 2).

Among weed control methods, two hand weeding in rice (20 and 40 DAS) produced 53.3% higher productive tillers, 5.1% higher panicle length, 36.0% higher filled grains/panicle as well as 7.0% higher 1,000-grains weight than weedy check, resulting 105.6% higher grain and 125.2% higher straw yields and was on par with application of recommended herbicides in rice, which also recorded 49.0% higher productive tillers, 3.4% higher panicle length, 34.0% higher filled grains/panicle, and 4.0% higher 1,000-grain weight compared to weedy check resulting 104.4% higher grain and 108.6% higher straw yields. 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% higher spike length and

**Table 1.** Effect of tillage and weed control on yield attributes and grain and straw yields of rice (Pooled data over two years)

| Treatment | Productive tillers/m | Panicle length (cm) | Filled grains/ panicle | Unfilled grains/ panicle | 1,000-grains wt. (gm) | Grain yield (t/ha) | | | Straw yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2010 | Pooled mean | 2009 | 2010 | Pooled mean |
| *Tillage in rice–wheat sequence* | | | | | | | | | | | |
| Z–Z | 249 | 17.9 | 58 | 15 | 20.0 | 2.2 | 2.4 | 2.3 | 3.1 | 3.2 | 3.1 |
| Z–C | 277 | 18.2 | 60 | 15 | 20.4 | 2.4 | 2.6 | 2.5 | 3.3 | 3.5 | 3.4 |
| C–Z | 297 | 18.5 | 64 | 16 | 20.9 | 2.8 | 3.0 | 2.9 | 4.0 | 4.1 | 4.1 |
| C–C | 305 | 18.7 | 65 | 16 | 21.4 | 3.0 | 3.3 | 3.1 | 4.2 | 4.5 | 4.3 |
| SEm± | 8.7 | 0.4 | 1.3 | 0.2 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| CD (P=0.05) | 28.0 | NS | 4.1 | 0.7 | NS | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.3 |
| *Weed management in rice–wheat sequence* | | | | | | | | | | | |
| Weedy in both the crop | 210 | 17.8 | 50 | 12 | 20.0 | 1.5 | 1.6 | 1.6 | 2.1 | 2.1 | 2.1 |
| Butachlor + 2,4-D – Isoproturon + 2,4-D in wheat | 314 | 18.4 | 67 | 17 | 20.8 | 3.1 | 3.3 | 3.2 | 4.3 | 4.5 | 4.4 |
| Two hand weedings both in rice and wheat | 323 | 18.7 | 68 | 17 | 21.4 | 3.3 | 3.5 | 3.4 | 4.6 | 4.9 | 4.7 |
| SEm± | 8.9 | 0.3 | 1.6 | 0.3 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| CD (P=0.05) | 26.1 | 0.9 | 4.6 | 1.0 | 1.7 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.3 |

8.6% higher filled grains/panicle, resulting in 35.8% higher grain and 38.6% higher straw yields compared to weedy check and was on 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 grains/panicle with enhanced grain (31.4%) and straw yield (31.4%)) compared to weedy check.

### *Rice equivalent yield*

Conventionally tilled both rice and wheat produced 25.2, 11.9 and 11.4% higher mean rice equivalent yield compared to zero tilled both rice and wheat (5.94 t/ha); zero tilled rice-conventional tilled wheat (6.65 t/ha); and conventional tilled rice-zero tilled wheat (6.68 t/ha). The corresponding increase in rice equivalent yield was 23.8, 10.2 and 10.9% in first year and 26.7, 13.4 and 11.9% in second year respectively (Table 3). The results are in conformity with the findings of Pandey *et al*. (2008), who have reported that conventional methods of tillage in rice and wheat produced more yields than zero tillage in the system.

Two hand weeding at 20 and 40 DAS in rice and 25 and 50 DAS in wheat crop being similar to application of butachlor @ 1 kg/ha pre-emergence + 2,4-D @ 0.5kg/ha post-emergence in rice crop and isoproturon @ 0.5 kg/ha post emergence + 2,4-D @ 0.5kg/ha in wheat crop, produced 62.7% higher mean rice equivalent yield compared to weedy check. Similarly chemical weed control in both the crops had 54.8% higher rice equivalent yield than weedy check. This is in conformity with the results of Jha

**Table 2.** Effect of tillage and weed control on yield attributes and grain and straw yield of wheat (Pooled data over two years)

| Treatment | Productive tillers/m$^2$ | Panicle length (cm) | Filled grains/ spike | Unfilled grains/ spike | 1,000–grains wt. (gm) | Grain yield (t/ha) | | | Straw yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2010 | Pooled mean | 2009 | 2010 | Pooled mean |
| *Tillage in rice–wheat sequence* | | | | | | | | | | | |
| Z–Z | 217 | 10.4 | 44 | 10 | 42.2 | 3.0 | 3.0 | 3.0 | 4.1 | 4.1 | 4.1 |
| Z–C | 233 | 10.8 | 46 | 10 | 42.4 | 3.4 | 3.5 | 3.4 | 4.8 | 4.8 | 4.8 |
| C–Z | 221 | 10.5 | 45 | 10 | 42.3 | 3.1 | 3.2 | 3.1 | 4.2 | 4.4 | 4.3 |
| C–C | 240 | 10.8 | 47 | 10 | 42.1 | 3.5 | 3.7 | 3.6 | 5.0 | 5.2 | 5.1 |
| SEm± | 6.9 | 0.2 | 0.9 | 0.25 | 0.7 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 |
| CD (P=0.05) | NS | NS | NS | NS | NS | 0.4 | 0.3 | 0.2 | 0.6 | 0.5 | 0.3 |
| *Weed management in rice–wheat sequence* | | | | | | | | | | | |
| Weedy in both the crop | 192 | 10.3 | 43.2 | 9.8 | 42.2 | 2.7 | 2.7 | 2.7 | 3.6 | 3.7 | 3.7 |
| Butachlor + 2,4-D – Isoproturon + 2,4-D in wheat | 239 | 10.7 | 46.3 | 10.2 | 42.1 | 3.5 | 3.6 | 3.5 | 4.9 | 4.9 | 4.9 |
| Two hand weedings both in rice and wheat | 252 | 10.9 | 46.9 | 10.3 | 42.4 | 3.6 | 3.7 | 3.7 | 5.0 | 5.2 | 5.1 |
| SEm± | 5.4 | 0.2 | 0.9 | 0.2 | 0.7 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| CD (P=0.05) | 16 | 0.5 | 2.6 | 0.6 | 2.0 | 0.3 | 0.3 | 0.2 | 0.4 | 0.4 | 0.3 |

**Table 3.** Rice equivalent yield, gross returns, net returns and B: C ratio as influence by tillage and weed management in rice–wheat system (Pooled data over two years)

| Treatment | Rice equivalent yield (t/ha) | | | Gross returns ( ×10$^3$ ₹/ha) | Net returns ( ×10$^3$ ₹/ha) | B:C ratio |
|---|---|---|---|---|---|---|
| | 2009–10 | 2010–2011 | Pooled | | | |
| *Tillage in rice–wheat sequence* | | | | | | |
| Z–Z | 5.9 | 6.0 | 5.9 | 74.3 | 44.7 | 1.49 |
| Z–C | 6.6 | 6.7 | 6.7 | 83.7 | 50.5 | 1.51 |
| C–Z | 6.5 | 6.8 | 6.7 | 83.6 | 51.9 | 1.62 |
| C–C | 7.2 | 7.6 | 7.4 | 93.6 | 58.2 | 1.64 |
| SEm± | 0.2 | 0.1 | 0.1 | 1.1 | 1.1 | 0.03 |
| CD (P=0.05) | 0.5 | 0.4 | 0.3 | 4.0 | 4.0 | 0.10 |
| *Weed management rice–wheat sequence* | | | | | | |
| Weedy in both the crop | 4.7 | 4.9 | 4.8 | 60.3 | 31.2 | 1.06 |
| Butachlor + 2,4-D – Isoproturon + 2,4-D in wheat | 7.3 | 7.6 | 7.4 | 93.1 | 62.3 | 2.02 |
| Two hand weedings both in rice- | 7.6 | 8.0 | 7.8 | 98.0 | 60.5 | 1.61 |
| SEm± | 0.1 | 0.1 | 0.1 | 1.2 | 1.2 | 0.04 |
| CD (P=0.05) | 0.4 | 0.4 | 0.3 | 4.0 | 4.0 | 0.1 |

*et al*. (2007), Gangwar and Singh (2010) and Jha *et al*. (2011).

### *Economics*

Conventionally tilled both rice and wheat recorded 25.9, 11.8 and 11.9% higher mean gross returns; 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 Gopinath *et al*. (2007) and Pandey *et al*. (2008).

Two hand weeding performed both in rice (20 & 40 DAS) and wheat (25 & 50 DAS) being similar to application of butachlor @ 1 kg/ha pre-emergence + 2,4-D @ 0.5kg/ha post-emergence in rice crop and isoproturon @ 0.5 kg/ha post-emergence + 2,4-D @ 0.5kg/ha in wheat crop recorded 62.5% higher gross returns, 94.2% higher net returns 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 returns 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).

Based on the study, it is concluded that conventional tilled direct seed rice and wheat sequence with two hand weeding was superior in terms of rice equivalent yield, weed content and net returns over other methods of tillers and weed on test.

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