



Effect of tillage and weed control in direct-seeded rice-wheat cropping system

Sushma Saroj Surin*, A.B. Ekka, M.K. Singh and R.R. Upasani

Department of Agronomy, Birsa Agricultural University, Ranchi, Jharkhand 834 006, India

Email: sushmasarojsurin5@gmail.com

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ABSTRACT

The present experiment was carried out in a split-plot design with four tillage practices in the main plot and three methods of weed control practices in sub plot with four replications at agronomical research farm of Birsa Agricultural University, Ranchi during 2009-10 to 2010-11 to find out the effective tillage methods adopted in direct-seeded rice and wheat with different weed control methods. Results revealed that in direct-seeded rice density of grassy, broad-leaved weeds and sedges accounted for 23.1, 59.2 and 17.7% and in wheat, grassy and broad-leaved weeds accounted for 5.7 and 94.3% respectively of total weed density. Conventional tilled plots had more number of weeds per unit area as compared to zero tilled. Conventional tilled both rice and wheat produced 25.3, 11.9 and 11.4% higher mean rice equivalent yield compare to mean yield due to other tillage combination. Two hand weeding (20 and 40 DAS for rice and 25 and 50 DAS for wheat) and application of recommended herbicides being at par gave higher rice equivalent yield than weedy check.

INTRODUCTION

Rice (*Oryza sativa* L.) is grown in different ecosystems and physical condition of the soil. Cultivation of rice by transplanting in rice-wheat cropping system is most popular in northern India, but it is highly labour intensive and expensive method of cultivation for marginal farmers which account for 65% of total farmers. This method requires a large quantity of water for puddling, transplanting and establishment of rice seedlings. Direct-seeding eliminates the need of raising, maintaining and subsequent transplanting of seedlings, besides, it is cost effective can save water through earlier rice crop establishment and allows timely sowing of wheat (Singh *et al.* 2007). However direct-seeding is subjected to greater weed competition than transplanted rice (Rao *et al.* 2007). Similarly, loss in grain yield of wheat due to weeds was reported to be 65–90% (Jain *et al.* 2006). Hence, the present investigation was undertaken to study the impact of combinations of conventional and zero tillage in rice and wheat crops and weed control methods on weed dynamics and productivity of rice-wheat system.

MATERIALS AND METHODS

A field experiments were conducted in a split-plot design at agronomical research farm of Birsa Agricultural University, Ranchi during the rainy and winter season of 2009-10 and 2010-11. The

treatment consisted of combination of four tillage practices, *viz.* (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 the main plot and three methods of weed control practices, *viz.* (i) two hand weeding (20 and 40 days after sowing (DAS) for rice and 25 and 50 DAS for wheat) (ii) recommended herbicides butachlor at 1.5 kg/ha pre-emergence followed by 2,4-D at 0.5 kg/ha post-emergence for rice and isoproturon at 0.75 kg/ha + 2,4-D at 0.5 kg/ha post-emergence for wheat (iii) weedy check in sub plot and replicated 4 times. The soil was sandy loam having acidic in reaction (pH 5.43), low in, available nitrogen (242.23 kg/ha), available phosphorus (14.85 kg/ha) potassium (123.0 kg/ha) and medium in organic carbon (0.52%). The direct-seeded rice crop was fertilized with 100 kg N, 40 kg P₂O₅ and 30 kg K₂O/ha and wheat crop was fertilized with the recommended dose of 100 kg N, 60 kg P₂O₅ and 40 kg K₂O/ha. Half dose of N and a full dose of P₂O₅ and K₂O 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' and wheat 'K-9107' was used as test varieties during the study. The total rainfall received during crop season was 1063.7 mm and 1177.0 mm during 2009 and 2010, respectively. Pre-emergence herbicide *i.e.* butachlor

was applied just after sowing while post-emergence herbicides *i.e.* isoproturon and 2,4-D were applied at 25 DAS. Observations on weeds were recorded with the help of a quadrat 0.5×0.5 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 ($\sqrt{x+0.5}$) before statistical analysis. Data on the dry weight of weeds were recorded by cutting weeds at ground level, washed with tap water, sun-dried followed by oven drying at 65°C for 48 hours and then weighed. Weed control efficiency was determined by using standard formula.

RESULTS AND DISCUSSION

Weed compositions

In rice, the experimental field was infested with all the three categories of weed species in weedy check throughout the crop growth in direct-seeded rice during 2009 and 2010. The total number of species was 20, out of which *Echinochloa colona*, *Sorghum halepense* Pers., *Sitaria glauca*, *Digitaria sanguinalis* Scop, *Cynodon dactylon*, *Elusine indica*, *Dactyloctenium aegyptium*, *Ischaemum rugosum*, among grasses, *Commelina benghalensis*, *Commelina diffusa*, *Ageratum conyzoides*, *Euphorbia hirta*, *Alternanthera sessilis* L, *Ludvigia parviflora*, *Phyllanthus niruri* and *Amaranthus viridis* among broad-leaved weeds and *Cyperus rotundus*, *Cyperus iria*, *Cyperus difformis* and *Fimbristylis miliacea* among sedges were prominent. Among all weed categories grassy, broad-leaved weeds and sedges accounted for 23.1, 59.2 and 17.7%, respectively of total weed density. In wheat during both the years, experimental plot was infested with only two categories *i.e.* broad-leaf weed and grassy weed in weedy check accounting for 94.3 and 5.7% of total weed density. The total number of species was 9, out of which *Coronopus didymus*, *Vicia hirsuta*, *Vicia sativa*, *Anagallis arvensis*, *Medicago denticulata* and *Chenopodium album* in broad-leaved weeds while *Cynodon dactylon*, *Avena fatua* and *Phalaris minor* in grassy weeds.

Weed density and weed dry matter

Conventional tilled rice after conventional tilled wheat had more number of total weeds (537.6, 321.6 and 199.7 no./m² at 30, 60 and 90 days after sowing respectively) and interestingly less total weed dry matter (53.5, 46.7 and 33.3 g m⁻² at 30, 60 and 90 DAS, respectively) than rice grown after zero tilled wheat. Similarly, conventionally tilled wheat after conventionally tilled rice had more number of total weeds (678.7, 562.4 and 156.1 no./m² at 30, 60 and 90 DAS, respectively) and less total weed dry matter

(25.8, 15.8 and 13.1 g/m² at 30, 60 and 90 DAS, respectively). Conventional tilled plots had more number of weeds competing with crops as compared to zero tilled plots (**Table 1** and **3**). In fact, undisturbed soil conditions induced dormancy in weed seeds present beyond surface layer which causes a decrease in emergence and establishment of weeds in comparison to that of conventional tilled soil (Verma and Srivastava 1989, Gopinath *et al.* 2007). However, under zero tillage condition weeds accumulated more dry matter than those under conventional tillage (**Table 2** and **3**). This might be due to the presence of perennial weeds particularly *Sorghum halepense* in rice and *Cynodon dactylon* in wheat, which grew faster prior to germination of the crop. However, in tilled plots, these weeds were killed at the time of ploughing and so they did not get a chance to grow and compete with rice/wheat.

Among the weed management practices, application of butachlor at 1.5 kg/ha pre-emergence followed by 2,4-D at 0.5 kg/ha post-emergence reduced total weed density (176.4, 118.3 and 66.9 no./m² at 30, 60 and 90 DAS, respectively) as well as dry weight (62.0, 29.6 and 23.2 g/m² at 30, 60 and 90 DAS, respectively) during both the years compared to two hand weeding at 20 and 40 DAS and weedy check. Similarly isoproturon at 0.75 kg/ha + 2,4-D at 0.5 kg/ha in wheat was found to be the most effective registering significantly lowest number (269.8, 93.9 and 69.5 no./m² at 30, 60 and 90 DAS, respectively) as well as dry matter (27.6, 9.8 and 13.7 g/m² at 30, 60 and 90 DAS respectively) of total weed at 30, 60 and 90 DAS. The results were in agreement with the findings of Chinnusamy *et al.* (2006) and Singh and Singh (2010).

Yield attributes of rice and wheat/rice equivalent yield

Conventionally tilled rice produced 14.6% higher productive tillers; 3.0% higher panicle length; 9.3% higher filled grain; resulting 25.5% higher grain (3.0 t/ha) and 27.9% higher straw yield (4.2 t/ha) compared to zero tilled rice (2.4 t grain and 3.2 t straw/ha). Similarly, conventionally tilled wheat produced higher productive tillers/m², longer spike, grains/spike, and bolder grains; resulting 14.7% higher mean grain (3.5 t/ha) and 17.9% higher mean straw (4.9 t/ha) yield than zero tilled wheat.

Among the weed control method, two hand weeding in rice at 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 test weight resulting 105.6% higher grain (3.2 t/ha) and 125.2% higher straw yield (4.7 t/ha) than weedy check and at par with application of butachlor

at 1.5 kg/ha pre-emergence followed by 2,4-D at 0.5 kg/ha post-emergence. Similarly, in wheat two hand weeding at 25 and 50 DAS crop recorded higher yield attributing parameters like 31.3% productive tillers/m², 5.3% spike length and 8.6% filled grains resulting 36.1% higher grain (3.6 t/ha) and 38.6% higher straw

yield (5.1 t/ha) compared to weedy check and at par with application isoproturon at 0.75 kg/ha + 2,4-D at 0.5 kg/ha. The direct seeded rice-wheat sequence with conventional tillage produced higher rice equivalent yield 7.4 t/ha (for 3.1 t/ha rice and 3.6 t/ha wheat).

Table 1. Effect of tillage and weed control on weed density (no./m²) in direct-seeded rice

Treatment	Weed density											
	Grasses				Sedges				Broad-leaved weeds			
	30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
<i>Tillage</i>												
<i>Rice – Wheat</i>												
ZT - ZT	6.71 (52.7)	6.05 (48.1)	7.90 (73.5)	7.37 (65.5)	5.89 (46.6)	5.81 (42.4)	4.27 (21.8)	3.95 (16.8)	13.11 (206.9)	13.12 (206.3)	7.53 (63.3)	7.15 (55.9)
ZT – CT	8.07 (70.2)	7.86 (74.8)	7.34 (62.3)	7.00 (56.8)	6.68 (52.6)	6.3 (47.2)	4.53 (24.3)	4.2 (19.4)	13.80 (222.2)	13.55 (217.0)	8.36 (85.8)	7.54 (63.3)
CT – ZT	10.66 (118.5)	9.95 (105.3)	5.83 (37.7)	5.57 (34.2)	8.81 (90.5)	7.87 (70.5)	5.37 (30.6)	4.89 (25.8)	15.10 (255.3)	14.89 (256.0)	10.38 (119.2)	8.57 (79.9)
ZT – ZT	11.67 (155.5)	10.8 (126.9)	5.11 (30.6)	4.97 (27.6)	10.19 (123.5)	9.23 (104.1)	5.48 (33.8)	5.33 (30.9)	16.05 (285.9)	15.53 (279.3)	10.48 (124.5)	9.27 (93.3)
LSD (p=0.05)	2.11	1.20	1.56	1.44	1.72	1.50	0.76	0.65	1.10	1.04	1.97	0.95
<i>Weed management</i>												
Rice	Wheat											
Weedy check	Weedy check											
	11.96 (158.3)	11.79 (147.6)	17.06 (295.6)	15.98 (264.4)	12.14 (161.5)	11.3 (136.8)	7.08 (50.6)	6.36 (41.9)	22.02 (486.2)	22.51 (508.8)	13.34 (184.1)	11.24 (130.4)
Butachlor 2,4-D	Isoproturon +2,4-D											
	7.54 (62.2)	6.60 (56.1)	7.96 (65.9)	7.73 (62.0)	4.68 (24.1)	4.39 (21.1)	3.42 (12.9)	3.44 (11.9)	9.8 (102.3)	9.23 (87.0)	6.59 (46.2)	6.05 (37.6)
Hand weeding	Hand weeding											
	8.33 (77.3)	7.60 (62.7)	8.97 (84.9)	8.65 (77.6)	6.86 (49.3)	6.23 (40.2)	4.24 (19.3)	3.98 (15.9)	11.72 (139.3)	11.08 (123.3)	7.64 (63.5)	7.11 (51.3)
LSD (p=0.05)	2.05	1.98	1.38	1.4	1.53	1.47	0.97	0.74	1.27	0.85	1.44	1.20

DAS, Days after sowing; Data were subjected to a square root transformation. Data are given in parenthesis are original values; ZT – Zero tillage, CT – Conventional tillage

Table 2. Effect of tillage and weed control on weed dry matter production (g/m²) in direct-seeded rice

Treatment	Weed dry matter production											
	Grasses				Sedges				Broad-leaved weeds			
	30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
<i>Tillage</i>												
<i>Rice – Wheat</i>												
ZT - ZT	6.55 (47.9)	5.87 (39.2)	7.90 (73.5)	7.37 (65.5)	3.92 (16.2)	3.52 (12.8)	3.53 (12.7)	3.28 (10.9)	10.50 (113.7)	9.50 (95.3)	4.86 (25.8)	4.45 (22.3)
ZT – CT	5.59 (33.1)	5.42 (30.5)	7.34 (62.3)	7.00 (56.8)	3.43 (12.6)	3.25 (11.2)	3.33 (11.3)	3.07 (9.7)	10.03 (105.1)	9.17 (88.6)	4.41 (23.6)	3.99 (18.7)
CT – ZT	4.27 (20.0)	3.97 (16.6)	5.83 (37.7)	5.57 (34.2)	2.50 (7.1)	2.43 (6.4)	2.59 (6.9)	2.27 (5.4)	6.95 (49.8)	5.48 (32.8)	3.68 (14.7)	3.31 (12.5)
ZT – ZT	3.85 (16.7)	3.31 (11.6)	5.11 (30.6)	4.97 (27.6)	2.40 (6.6)	2.36 (5.9)	2.46 (6.4)	2.20 (4.9)	5.80 (36.0)	5.07 (30.2)	3.47 (13.2)	2.98 (10.6)
LSD (p=0.05)	1.15	0.89	1.23	0.71	0.81	0.31	0.55	0.38	1.26	0.64	0.47	0.60
<i>Weed management</i>												
Rice	Wheat											
Weedy check	Weedy check											
	6.86 (49.2)	6.27 (42.0)	9.83 (102.9)	9.59 (95.8)	4.27 (18.7)	4.01 (16.1)	3.72 (14.1)	3.51 (12.3)	10.33 (112.3)	9.91 (102.9)	6.08 (37.8)	5.74 (33.6)
Butachlor 2,4-D	Isoproturon + 2,4-D											
	3.40 (13.1)	3.28 (11.3)	4.5 (21.2)	4.2 (17.8)	1.92 (4.1)	1.89 (3.6)	2.22 (4.9)	2.06 (4.1)	7.10 (55.1)	5.67 (36.7)	2.61 (7.1)	2.07 (4.2)
Hand weeding	Hand weeding											
	4.93 (26.1)	4.38 (20.0)	5.3 (28.9)	4.89 (24.6)	3.00 (9.0)	2.76 (7.5)	3.00 (8.9)	2.56 (6.7)	7.53 (61.0)	6.34 (45.7)	3.63 (13.2)	3.24 (10.4)
LSD (p=0.05)	0.78	0.55	1.07	0.71	0.51	0.38	0.52	0.43	0.99	1.08	0.62	0.30

DAS, Days after sowing; Data were subjected to a square root transformation. Data are given in parenthesis are original values; ZT – Zero tillage, CT – Conventional tillage

Table 3. Effect of tillage and weed control on weed density (no./m²) and weed dry matter production (g/m²) in wheat

Treatment	Weed density								Weed dry matter production							
	Grasses				Broad-leaved weeds				Grasses				Broad-leaved weeds			
	30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
<i>Tillage</i>																
Rice – Wheat																
ZT - ZT	4.11 (17.8)	3.90 (18.8)	3.62 (17.0)	2.39 (7.2)	19.58 (430.0)	16.79 (301.7)	14.9 (274.0)	13.49 (261.3)	2.71 (7.4)	2.54 (6.9)	2.14 (4.8)	1.96 (3.9)	7.92 (65.2)	7.45 (58.5)	6.97 (64.7)	4.92 (29.4)
ZT – CT	5.78 (34.6)	5.37 (33.0)	6.6 (51.5)	4.94 (27.8)	23.28 (588.7)	21.02 (460.7)	19.94 (502.0)	17.1 (354.0)	1.63 (2.6)	1.14 (0.9)	1.44 (1.7)	1.29 (1.3)	5.67 (34.0)	4.76 (26.3)	4.17 (26.7)	3.27 (12.7)
CT – ZT	4.63 (22.5)	4.04 (20.1)	3.97 (21.3)	3.28 (11.3)	20.24 (449.7)	17.79 (344.3)	16.14 (319.7)	14.21 (279.2)	2.30 (5.4)	2.10 (4.5)	1.98 (3.9)	1.85 (3.3)	7.41 (59.3)	6.97 (51.1)	6.11 (51.1)	4.85 (27.0)
ZT – ZT	6.74 (48.7)	6.32 (44.7)	7.88 (83.7)	5.26 (34.1)	25.02 (669.7)	23.84 (594.3)	22.08 (605.7)	18.56 (401.3)	1.45 (1.8)	1.07 (0.7)	1.27 (1.3)	1.18 (1.0)	4.92 (26.3)	4.62 (22.7)	3.62 (20.0)	2.64 (9.4)
LSD (p=0.05)	1.02	0.96	1.77	1.55	2.63	3.07	2.93	1.82	0.64	0.85	0.32	0.28	0.92	0.96	1.34	1.01
<i>Weed management</i>																
Rice																
Weedy check	6.82 (49.1)	7.63 (60.0)	8.14 (83.8)	5.84 (39.1)	30.82 (912.9)	26.4 (655.5)	29.96 (935.3)	26.73 (719.5)	2.91 (7.2)	2.03 (4.6)	2.33 (5.3)	2.15 (4.5)	8.39 (74.0)	7.82 (63.9)	9.30 (97.4)	6.24 (40.5)
Butachlor	4.02 (17.0)	3.08 (10.1)	3.25 (13.0)	2.64 (8.6)	16.50 (264.5)	15.71 (248.0)	9.66 (98.5)	7.48 (67.6)	1.54 (2.4)	1.39 (1.9)	1.32 (1.4)	1.14 (1.0)	5.08 (27.1)	4.61 (23.6)	3.02 (10.0)	2.39 (7.1)
Hand weeding	5.11 (26.6)	4.03 (17.3)	5.15 (33.4)	3.42 (12.6)	20.73 (426.3)	19.36 (372.3)	15.18 (242.3)	13.31 (184.8)	1.76 (3.3)	1.71 (3.3)	1.48 (2.0)	1.42 (1.7)	5.98 (37.4)	5.43 (31.4)	3.34 (14.4)	3.13 (11.2)
LSD (p=0.05)	0.68	0.64	1.74	0.67	2.80	2.15	2.39	1.56	0.32	0.38	0.29	0.29	0.98	1.03	1.51	0.77

DAS, Days after sowing; Data were subjected to a square root transformation. Data are given in parenthesis are original values; ZT – Zero tillage, CT – Conventional tillage

Table 4. Effect of tillage and weed control on yield attributes of rice and wheat and rice equivalent yield (pooled data)

Treatment	Rice								Wheat					Rice equivalent yield (t/ha)	
	Productive tillers (no./m ²)	Panicle length (cm)	Filled grains/panicle	Unfilled grains/panicle	1000 grains weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Productive tillers (no./m ²)	Spike length (cm)	Filled grains/panicle	Unfilled grains/panicle	1000 grains weight (g)	Grain yield (t/ha)		Straw yield (t/ha)
<i>Tillage</i>															
Rice – Wheat															
ZT - ZT	249	17.9	58	14.5	20.0	2.3	3.1	217	10.4	44	10	42.2	3.0	4.1	5.9
ZT – CT	277	18.2	60	14.9	20.4	2.5	3.4	233	10.8	46	10	42.4	3.4	4.8	6.8
CT – ZT	297	18.5	64	15.9	20.9	2.9	4.0	221	10.5	45	10	42.3	3.1	4.3	6.7
ZT – ZT	305	18.7	65	16.2	21.4	3.1	4.3	240	10.8	47	10	42.1	3.6	5.1	7.3
LSD (p=0.05)	28.0	NS	4.1	0.7	NS	2.9	3.5	NS	NS	NS	NS	NS	2	3	4.5
<i>Weed management</i>															
Rice															
Weedy check	210	17.8	50	12	20.0	1.6	2.2	192	10.3	43.2	9.8	42.2	2.7	3.7	4.8
Butachlor + 2,4-D	314	18.4	67	17	20.8	3.3	4.4	239	10.7	46.3	10.2	42.1	3.5	4.9	7.4
Hand weeding	323	18.7	68	17	21.4	3.3	4.7	252	10.9	46.9	10.3	42.4	3.7	5.1	7.8
LSD (p=0.05)	26.1	0.9	4.6	1.0	1.7	2.8	2.1	16	0.5	2.6	0.6	2	2	3	4.4

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