

Original Research Article

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Performance of Zero-till Wheat (*Triticum aestivum* L.) and Weed Species as Influenced by Residue and Weed Management Techniques in Rice based Cropping System

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ABSTRACT

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A field experiment was conducted during 2005-06 to 2006-07 at Varanasi to find out the effect of three residue management practices viz. R₁ (Residue Removal), R₂ (Residue Retention alone), R₃ (Residue Retention with *Trichoderma*) and four weed management treatments viz. W₁ (Control), W₂ (Hand weeding at 30 & 45 DAS), W₃ (Isoproturon + 2,4-D (1.0+0.5 ha⁻¹ at 30 DAS), W₄ (Fenoxaprop 120 g a.i. ha⁻¹ fb Metsulfuron 4g a.i. ha⁻¹) on weeds and productivity of zero-till wheat (*Triticum aestivum* L. emend Fiori & Paol) in rice-wheat cropping system during the winter (*rabi*) season. Wheat grown under rice wheat cropping system with residue retention with *Trichoderma* application produced 8.2 and 6.8 % higher grain and 7.3 and 6.2 % straw yield over residue removal treatment during both the year of experimentations. Out of all residue management approaches under test, residue management alone along with isoproturon + 2, 4-D application for weed control gave higher net returns during the course of above study.

Introduction

Rice (*Oryza sativa* L.) - Wheat (*Triticum aestivum* L. emend Fiori & Paol) cropping sequence is the most predominant production system occupying about 18 Mha in Asia, of which 13.5 Mha area in Indo-Gangetic Plains (IGP) of India (10 Mha), Pakistan (2.2 Mha), Bangladesh (0.8 Mha) and Nepal (0.5 Mha) and feeds about 1.3 billion people (20% of the world population) (Farooq *et al.*, 2007, Saharawat *et al.*, 2010). This grain scenario is

stemmed from the exhaustive nature of both the crops because belonging to the same family and their extreme tillage requirement. The new Resource Conservation Technologies (RCTs) developed over the past ten years provide an opportunity to reduce the cost of production. Among these, new RCTs, the zero tillage technologies of wheat cultivation have been adopted over large areas. This technology saves more than 90% energy, time, labour and helps to produce wheat at a much lower cost. Uncontrolled

weed growth may reduce wheat yield ranging from 15-40 % depending upon magnitude, nature and duration of weed infestation (Jat *et al.*, 2003). These call for the use of other broad spectrum herbicides either independently or in combination for the management of complex weed flora of wheat to avoid perceptible change in weed flora. The weeds were reduced under zero till sowing in standing stubbles as rice straw acted as mulch, in partial burning treatment due loss of viability of weed seeds due to high temperature generated during burning and in bed planting due to drying of bed tops which reduced the germination of weeds and hence dry weight was also less under these treatment (Brar and Walia, 2007). Less effort has been made to manage weed population by imposing diverse designed tillage techniques with residue retention. Hence, the present study was, therefore, undertaken to assess the efficacy of herbicides against weeds along with residue retention which have direct effect on weed infestation in wheat crop under the rice- wheat cropping system.

Materials and Methods

Field trials on wheat crop were conducted at Varanasi (latitude 25⁰18'N, longitude 83⁰03'E and altitude 128.93 m above mean sea level) during 2005-06 to 2006-07. The soil was sandy clay loam, low in available N (200 kg/ha) medium in organic carbon (0.44%), available P (16.2 kg/ha) and available K (240 kg/ha) with pH 7.8 and EC (0.19 ds/m). The experimental design was split plot design with thrice replications. Main plot treatments were three residue management techniques viz. R₁ (Residue Removal), R₂ (Residue Retention alone), R₃ (Residue Retention with *Trichoderma*), and sub plot treatments were four weed management techniques viz. W₁ (control), W₂ (Hand weeding at 30 & 45 DAS), W₃ [Isoproturon +2, 4-D (1.0+0.5 kg ha⁻¹) at 30 Days after sowing], W₄

(Fenoxaprop 120 g ha⁻¹ fb Metsulfuron 4 g ha⁻¹). During both the years' wheat crop was sown with zero tillage maintaining the rice residue in respective plots as per treatments allocated. Isoproturon + 2, 4-D (1.0+0.5 kg ha⁻¹) at 30 DAS) and Fenoxaprop (120 g ha⁻¹) fb Metsulfuron (4 g ha⁻¹) were applied as post emergence with 500 liters of water with the help of knap sack sprayer, fitted with flat-fan nozzle at 30 DAS. Rice 'Sarjoo-52' was grown from June to October for residue purpose only as a commercial crop and no observations were made and wheat 'HUW-234' was grown from November to March in each treatment with recommended package of practices. The experiment was conducted under irrigated conditions. Weed density was recorded (at 45 and at harvest stage) from 0.25 m² area by placing a quadrat of 0.5 × 0.5 m randomly at three places in each plot. A total ten species of weeds enclosed in each quadrat were identified as well as counted species wise and was expressed as number of weeds per square meters.

Results and Discussion

Effect on weeds

Weed flora of wheat differ from field to field, depending on environmental conditions, irrigation, fertilizer use, soil type, weed control practices and cropping sequences. The predominant weeds associated with conventional and zero-till wheat are *Poa annua*, *Polypogon monspeliensis*, *Avena ludoviciana*, *Rumex dentatus*, *R. spinosus*, *Anagallis arvensis*, *Convolvulus arvensis*, *Malva parviflora*, *Medicago denticulata*, *Chenopodium album*, *Vicia sativa*, *Lathyrus aphaca*, *Cirsium arvense*, *Melilotus alba*, *Coronopus didymus*, *Polygonum plebejum* and *Spergula arvensis*. Among grassy weeds, *P. minor* and among broad-leaved weeds, *Rumex dentatus* and *Medicago denticulata* are of major concern in irrigated wheat under

rice-wheat system in India (Balyan and Malik 2000, Chhokar *et al.*, 2006). Dominant weed species present in the experimental site were *Phalaris minor*, grasses, *Cyprus rotundous* was sedge and other four broad leaf weed species viz. *Chenopodium album*, *Rumex denticulate*, *Anagalis arvensis* and *Melilotus species* were identified as major one during both the year of investigation. The population of weeds was found to be maximum at 45th day stage (Table 1) and thereafter it decreased at successive stage of crop growth (Table 2) during both the years, irrespective of treatments.

This was owing to death of most of the broad leaved weeds which had completed their life cycle before of crop. Residue management resulted in significant reduction in all the weed species as compared to residue removal. Among weed species *Phalaris minor* showed lower population at 45 DAS in residue retention with *Trichoderma* application (6.05 & 5.28) which was at par with residue retention alone (2.41 & 2.24) and significantly lower to residue removal (2.56 & 2.44) during both years of investigation. Similarly density of *Cyprus rotundous*, *Chenopodium album*, *Rumex denticulate*, *Anagalis arvensis* and *Melilotus species* were found significantly lower population in residue retention with *Trichoderma* application treatment from residue removal and closely related to residue retention alone. This was due to the covering of soil surface with crop residue and it caused mulching effect during crop period as reported by Kumar *et al.*, (2004), Chhokar *et al.*, (2009) and Kumar *et al.*, (2013). All the weed control methods caused significant reduction in weed density over weedy check. Minimum weed densities were observed under hand weeding twice at 30 & 45 DAS. Among the herbicides, application of fenoxaprop 120 g ha⁻¹ fb metsulfuron 4 g ha⁻¹ was showed significant reducing population of all weeds as compared

to isoproturon +2,4-D (1.0+0.5 kg ha⁻¹) at all stages of growth during both the years except *Cyprus rotundous* which was resulted at par in 2006-07. It was might be due to higher efficacy of herbicide. Singh and Singh (2002) and Singh *et al.*, (2015) reported that the higher efficacy of Fenoxaprop 120 g ha⁻¹ fb Metsulfuron 4 g ha⁻¹ was due to effective control of narrow as well as broad leaf weeds.

Effect on yield attributes and yield

Grain yield is considered to be a function of various yield attributing characters like ear length, grains ear head⁻¹ and 1000-grain weight. Ear length was significantly influenced by residue management (Table 3). Highest ear length was recorded by residue retention with *Trichoderma* application (9.19 & 9.26) followed by residue retention alone (9.09 & 9.19) and residue removal treatment (8.56 & 8.71). However, residue retention with *Trichoderma* application (9.19 & 9.26) and residue retention alone (9.09 & 9.19) were statistically at par to each other but they registered significantly higher ear length than residue removal (8.56 & 8.71) during both the year of investigation.

It might be higher solubility and availability of nutrients to plant through cellulolytic fungus in residue retention with *Trichoderma* application and thus resulted in better development of yield attributes over other treatments (Singh and Yadav, 2006). In weed management hand weeding twice had the highest ear length (9.25 & 9.29), grains ear head⁻¹ (47.87 & 49.31) and 1000-grain weight (41.33 & 41.66) which was at par to fenoxaprop fb metsulfuron and isoproturon + 2, 4-D and these were found significantly superior to weedy check which had the lowest ear length (8.33 & 8.47), grains ear head⁻¹ (41.25 & 43.34) and 1000-grain weight (38.23 & 39.33) during both the year of investigations.

Table.1 Effect of residue and weed management on weed species in zero-till wheat at 45 days after sowing

Treatment	<i>P. minor</i>		<i>C. rotundas</i>		<i>C. album</i>		<i>A. arvensis</i>		<i>R. denticulate</i>		<i>Mellilotus spp</i>	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue Management												
R₁	2.56 (7.29)	2.44 (6.31)	2.35 (5.56)	2.22 (4.76)	2.56 (6.87)	2.41 (5.98)	2.28 (5.08)	2.21 (4.59)	2.40 (5.74)	2.16 (4.53)	2.18 (4.69)	2.07 (4.00)
R₂	2.41 (6.52)	2.24 (5.34)	2.28 (5.12)	2.17 (4.53)	2.49 (6.43)	2.34 (5.62)	2.25 (4.90)	2.16 (4.32)	2.30 (5.26)	2.12 (4.35)	2.13 (4.38)	2.01 (3.62)
R₃	2.33 (6.05)	2.22 (5.28)	2.24 (4.90)	2.16 (4.49)	2.47 (6.30)	2.33 (5.56)	2.23 (4.81)	2.15 (4.29)	2.29 (5.19)	2.11 (4.29)	2.12 (4.33)	1.99 (3.54)
SEm±	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.11	0.05	0.04	0.04	0.04	0.05	0.03	0.04	0.04	0.04	0.04	0.04
Weed Management												
W₁	4.51 (19.38)	4.15 (16.21)	4.15 (16.23)	3.55 (11.59)	4.15 (16.23)	3.98 (14.84)	3.60 (12.00)	3.33 (10.08)	3.75 (13.05)	3.56 (11.71)	3.58 (11.82)	3.22 (9.35)
W₂	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.02 (0.03)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
W₃	2.31 (4.38)	2.22 (3.96)	2.55 (5.51)	2.11 (3.44)	2.55 (5.51)	2.39 (4.72)	2.23 (3.98)	2.19 (3.80)	2.45 (4.98)	2.06 (3.24)	2.11 (3.45)	2.02 (3.07)
W₄	1.92 (2.71)	1.84 (2.39)	2.32 (4.39)	2.08 (3.35)	2.32 (4.39)	2.08 (3.32)	2.18 (3.75)	2.16 (3.68)	2.13 (3.56)	1.90 (2.61)	1.90 (2.59)	1.86 (2.44)
SEm±	0.03	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD(P=0.05)	0.08	0.04	0.06	0.03	0.06	0.04	0.03	0.02	0.02	0.02	0.02	0.02

Data transformed to $\sqrt{x+1}$. Figure in parentheses indicate original values.

R₁ (Residue Removal), R₂ (Residue Retention), R₃ (Residue Retention with *Trichoderma*), W₁ (Control), W₂ (Hand weeding at 30 &45 DAS), W₃ (Isoproturon +2,4-D (1.0+0.5 Kg/ha) at 30 DAS), W₄ (Fenoxaprop 120 g/ha *fb* Metsulfuron 4g/ha).

DAS (Days after sowing).

fb (Followed by one week)

Table.2 Effect of residue and weed management on weed species in zero-till wheat at harvest

Treatment	<i>P. minor</i>		<i>C. rotundas</i>		<i>C. album</i>		<i>A. arvensis</i>		<i>R. denticulate</i>		<i>Mellilotus spp</i>	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue Management												
R₁	2.38 (5.73)	2.28 (5.15)	2.24 (4.48)	2.19 (4.17)	2.43 (5.70)	2.44 (5.64)	2.17 (4.07)	2.02 (3.41)	2.25 (4.48)	2.08 (3.71)	2.03 (3.54)	2.04 (3.51)
R₂	2.23 (4.95)	2.19 (4.79)	2.16 (4.05)	2.10 (3.85)	2.37 (5.38)	2.37 (5.33)	2.10 (3.79)	1.98 (3.21)	2.22 (4.34)	2.03 (3.48)	2.00 (3.38)	1.97 (3.25)
R₃	2.21 (4.87)	2.18 (4.77)	2.15 (4.00)	2.09 (3.80)	2.35 (5.29)	2.37 (5.29)	2.07 (3.67)	1.96 (3.15)	2.20 (4.24)	2.03 (3.47)	1.97 (3.31)	1.97 (3.23)
SEm±	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.03	0.04
Weed Management												
W₁	3.99 (14.93)	3.90 (14.24)	3.26 (9.62)	3.19 (9.17)	3.84 (13.73)	3.74 (13.02)	3.09 (8.55)	2.90 (7.44)	3.29 (9.80)	3.08 (8.47)	3.09 (8.52)	3.00 (7.99)
W₂	1.49 (1.22)	1.46 (1.13)	1.63 (1.66)	1.49 (1.22)	1.46 (1.13)	1.53 (1.34)	1.47 (1.16)	1.45 (1.10)	1.63 (1.65)	1.47 (1.16)	1.47 (1.16)	1.44 (1.08)
W₃	1.89 (2.58)	1.96 (2.85)	2.07 (3.29)	2.04 (3.18)	2.17 (3.72)	2.31 (4.35)	2.06 (3.23)	1.81 (2.30)	12.05 (3.20)	1.83 (2.36)	1.79 (2.22)	1.82 (2.32)
W₄	1.73 (1.99)	1.55 (1.40)	1.77 (2.13)	1.79 (2.20)	2.06 (3.24)	1.99 (2.98)	1.85 (2.42)	1.79 (2.19)	1.94 (2.26)	1.79 (2.22)	1.65 (1.73)	1.71 (1.93)
SEm±	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.05	0.02	0.03	0.02	0.03	0.02	0.04	0.02	0.02	0.03	0.02	0.02

Data transformed to $\sqrt{x+1}$. Figure in parentheses indicate original values

R₁ (Residue Removal), R₂ (Residue Retention), R₃ (Residue Retention with *Trichoderma*), W₁ (Control), W₂ (Hand weeding at 30 &45 DAS), W₃ (Isoproturon +2,4-D (1.0+0.5 Kg/ha) at 30 DAS), W₄ (Fenoxaprop 120 g/ha *fb* Metsulfuron 4g/ha)

DAS (Days after sowing)

fb (Followed by one week)

Table.3 Effect of residue and weed management on Ear length, grains ear head⁻¹, test weight, grain and straw yield (kg/ha) in zero-till wheat

Treatment	Ear length (cm)		Grains ear head ⁻¹		Test weight (g)		Grain Yield (Kg/ha)		Straw Yield (Kg/ha)		Net return (₹ ha ⁻¹)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue Management												
R₁	8.56	8.71	45.64	46.76	39.87	40.05	3068.82	3385.66	4752.40	5020.93	18794.86	28562.07
R₂	9.09	9.19	45.83	47.57	40.50	41.22	3264.00	3580.62	5018.88	5295.76	20619.00	30854.00
R₃	9.19	9.26	46.09	47.90	40.62	41.37	3320.73	3616.48	5100.34	5332.27	20273.78	30286.78
SEm±	0.14	0.14	0.73	0.75	0.64	0.65	51.90	55.79	60.30	82.66	470.75	723.16
CD (P=0.05)	0.45	0.45	NS	NS	NS	NS	163.54	175.78	190.00	260.43	1483.26	NS
Weed Management												
W₁	8.33	8.47	41.25	43.34	38.23	39.33	2788.56	2958.35	4672.10	4813.83	17807.96	25541.66
W₂	9.25	9.29	47.87	49.31	41.33	41.66	3414.67	3788.12	5118.39	5426.33	19659.43	30017.44
W₃	9.08	9.19	47.02	48.43	40.76	41.15	3313.11	3641.60	4988.11	5292.34	21911.4	32679.78
W₄	9.14	9.25	47.29	48.56	41.00	41.39	3355.06	3722.27	5050.23	5332.77	20204.72	31364.92
SEm±	0.06	0.06	0.31	0.32	0.27	0.27	21.28	23.86	34.89	34.91	140.03	187.77
CD (P=0.05)	0.17	0.17	0.88	0.91	0.77	0.78	60.81	68.18	99.71	99.77	400.23	536.67

R₁ (Residue Removal), R₂ (Residue Retention), R₃ (Residue Retention with *Trichoderma*), W₁ (Control), W₂ (Hand weeding at 30 & 45 DAS), W₃ (Isoproturon +2,4-D (1.0+0.5 Kg/ha) at 30 DAS), W₄ (Fenoxaprop 120 g/ha fb Metsulfuron 4g/ha)

DAS (Days after sowing)
fb (Followed by one week)

However, Application of fenoxaprop 120 g ha⁻¹ fb metsulfuron 4 g ha⁻¹ accounted more ear length (9.14 & 9.25), grains ear head⁻¹ (47.29 & 48.56) and 1000-grain weight (41.00 & 41.29) which was at par to isoproturon + 2, 4-D (1.0+0.5 kg ha⁻¹) ear length (9.08 & 9.19), grains ear head⁻¹ (47.02 & 48.43) and 1000-grain weight (40.73 & 41.15) and these were found significantly superior to weedy check (Table 3) which might be due to higher yield attributing characters as a result of low weed population under this treatment. Thomas *et al.*; (2000) were of the opinion that minimum crop weed competition enables the crop to make maximum use of inputs for the formation and development of yield attributes. Residue retention with *Trichoderma* application registered significantly higher grain (8.2 & 6.8 %) and straw (7.3 & 6.2 %) yield as compared to residue removal treatment (Table 3).

The maximum grain and straw yield was recorded under residue retention with *Trichoderma* application (3320.73 & 3616.48) and (5100.34 & 5332.27) followed by residue retention alone (3264.00 & 3580.62) and (5018.88 & 5295.76) and residue removal treatment (3068.82 & 3385.66) and (4752.40 & 5020.93). However, residue retention with *Trichoderma* application (3320.73 & 3616.48) and (5100.34 & 5332.27) and residue retention alone (3264.00 & 3580.62) and (5018.88 & 5295.76) were statistically at par to each other and significantly higher to residue removal (3068.82 & 3385.66) and (4752.40 & 5020.93) in respect of grain and straw yield during both the year of investigations. This reduction in grain yield in residue removal was due to poor crop growth and lower value of yield attributes owing to higher weed competition. These findings were supported by Singh and Yadav (2006). Amongst weed management, hand weeding twice recorded maximum grain (3414.67 & 3788.12) and straw (5118.39 & 5426.33) yield of wheat which was on par with fenoxaprop fb metsulfuron and significantly superior to weedy check during both the years. Study of data further revealed that grain (3355.06 & 3722.27) and straw (5050.23 &

5332.77) yield of fenoxaprop fb metsulfuron was on par with isoproturon + 2, 4-D and significantly superior over weedy check during both the years of experimentation. This could be attributed to efficient control of weeds by fenoxaprop fb metsulfuron as evidenced by lowest density of weeds and higher weed suppression efficiency. Similar results have been reported by Jain *et al.*, (2007) and Singh *et al.*, (2010).

Economics

The practical utility of any weed control measure can be best judged on the basis of net return. The net income was higher with residue retention with *Trichoderma* application (₹ 20273.78 & 30286.78) owing to higher yield, and less cost of cultivation. Irrespective of weed management practices, net income were highest (₹ 21911.4 & 32679.78) with isoproturon + 2, 4-D (1.0+0.5 kg ha⁻¹) followed by fenoxaprop fb metsulfuron mainly due to lower cost of cultivation. Similar results have been reported by Jain *et al.*, (2007) and Singh *et al.*, (2010).

On the basis of experimental findings, it is concluded that wheat should be sown under residue retention (30-40 cm) along with application of isoproturon+2, 4-D (1.0+0.5 kg ha⁻¹) post emergence (30 DAS) for obtaining higher yield and net return under rice-wheat cropping system of India.

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