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Influence of residue and weed management practices on no-till wheat (*Triticum aestvium* L.) under rice-wheat cropping system

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ABSTRACT

A field experiment was conducted during 2005-2006 and 2006-07 at Varanasi to evaluate the effect of rice residue (R_1-residue removal, R_2-residue retention, R_3-residue retention with *Trichoderma* application and weed management practices (W_1- Control, W_2- Hand weeding at 30 and 45 days after sowing (DAS), W_3- Isoproturon +2,4-D (1.0+0.5 kg ha^{-1}) at 30 DAS, W_4- Fenoxaprop 120 g ha^{-1} *fb* Metsulfuron 4 g ha^{-1} on growth, yield attributes and yield of wheat (*Triticum aestvium* L.). The rice residue retention with *Trichoderma* application produced significantly higher crop growth, yield attributes, grain (3321 and 3617 kg ha^{-1}) and straw yield as compared to residue retention alone (3264 and 3681 kg ha^{-1}) and residue removal (3069 and 3386 kg ha^{-1}). Among the weed management options, application of fenoxaprop *fb* metsulfuron (120 + 4 g ha^{-1}) gave significantly higher weed control efficiency (WCE) (74.19 and 75.07 %) and grain (3355 and 3722 kg ha^{-1}) and straw yields compared to isoproturon +2,4-D (1.0+0.5 kg ha^{-1}). Residue retention with *Trichoderma* application also registered the highest nitrogen uptake by wheat.

1. INTRODUCTION

Rice (*Oryza sativa* L.) - Wheat (*Triticum aestivum* L. emend Fiori and Poal) cropping sequence is the most predominant production system occupying about 18 m ha in Asia, of which 13.5 m ha area in Indo-Gangetic Plains (IGP) of India (10 m ha), Pakistan (2.2 m ha), Bangladesh (0.8 m ha) and Nepal (0.5 m ha) and feeds about 1.3 billion people (20% of the world population) (Saharawat *et al.,* 2010). Intensive cropping system coupled with better irrigation and fertilizer application has provided congenial growing condition for weeds particularly in rice-wheat cropping system where weeds causes yield reduction to the level of 30-80% (Walia and Brar, 2001). Dependence on only one herbicide for very long period for the control of weeds in wheat has resulted in problem of resistance to herbicides (Walia *et al*., 1997). New herbicides (Fenoxaprop -P-ethyl, Clodinafop-proparyl and Sulfosulfuron) recommended in 1998 to control Isoproturon resistant weeds, were more effective against grasses and their incessant use shifted the weed flora towards broad leaf weed dominance particularly when Clodinafop and Fenoxaprop were used. Efforts have been made to develop integrated approach to reduce weed population pressure through placement of rice residues or with application of herbicides in order to sustain the productivity of wheat crop. Also the uptake of nutrients by the crop is governed by the nutrient supply system of soil through leaching and removal by weeds. The weeds emerging with the crop compete for nutrients (especially nitrogen), grow faster and utilize resources in large amount than the crop resulting in poor crop yields (Singh and Reddy, 1998). In this regard, placement of rice residue and herbicide could be a better solution in preventing weeds from removing nutrients from soil through restricting their growth and enhancing the time of nutrients availability by increasing it's splitting over one time placement for the better nutrient uptake by the crop. Keeping these points in view, an experiment was conducted to study the effect of rice residue and weed management techniques on growth and development in no-till wheat (*T. aestvium* L.) under rice-wheat cropping system.

2. MATERIALS AND METHODS

The study was conducted at the Agricultural Research

Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the years 2005-06 and 2006-07. The experimental site is situated in Eastern Uttar Pradesh at an altitude of 128.93 m above msl. It lies on latitude $25^0 18'$N and longitude $83^0 03'$E. The soil was sandy clay loam having pH 7.8, organic carbon 0.44%, available N 200 kg ha^{-1}, available P 16.2 kg $ha^{-1}$and available K 240 kg ha^{-1}. The experiment was laid out in the fixed net plot size (5.2×2 m^2) during both the years in split plot design keeping three residue management techniques, R_1 (Residue removal at 2-5 cm from ground level), R_2 (Residue retention up to 30-40 cm above the ground level), R_3 (Residue retention with *Trichoderma*) in the main plot and four weed management techniques W_1 (control), W_2 (Hand weeding at 30 and 45 DAS), W_3 (Isoproturon +2, 4-D (1.0+0.5 kg ha^{-1}) at 30 DAS, W_4 (Fenoxaprop 120 g ha^{-1} *fb* Metsulfuron 4 g ha^{-1}) in sub plots. The treatments were replicated three times. The crop of wheat was sown under no-till maintaining the rice residue in respective plots as per treatments allocated during both the years. Rice cultivar 'Sarjoo-52' was grown from June to October and wheat cultivar 'HUW-234' was sown at the seed rate 120 kg ha^{-1} with the help of tractor drawn no-till machine maintaining row to row spacing of 20 cm from November to March in each treatment. Isoproturon+2, 4-D (1.0+0.5 kg a.i. ha^{-1}) and fenoxaprop 120 g a.i. ha^{-1} were applied at 30 DAS as per treatments with 500 liters ha^{-1} of water with the help of knap sack sprayer, fitted with flat-fan nozzle while metsulfuron 4 g a.i. ha^{-1} was applied after one week of fenoxaprop herbicide application. Weed control efficiency (WCE) was calculated at 45^{th} day stage which had maximum weed population (m^{-2}) during both the years (AICRPWC, 1994).

$$\text{Weed control Efficiency (\%)} = \frac{\text{DWC - DWT}}{DWC} \times 100$$

Where, DWC = Dry weight of weeds in control plot; DWT = Dry weight of weeds in treated plot.

Weed dry weight was recorded at 45 DAS of wheat from 0.25 m^{-2} areas by placing a quadrate of 0.5×0.5 m randomly at three places in border rows of each plot. A total number of weeds enclosed in each quadrate were identified as well as counted species wise and was expressed as number of weeds sq m^{-1}. The harvested crop after sun drying for 3-4 days was weighed to record biological yield. It was threshed and grains were cleaned and expressed as kg ha^{-1}. Straw yield was recorded by subtracting the grain yield from biological yield $plot^{-1}$ and expressed in kg ha^{-1}. Nitrogen content was determined in grain as well as straw by modified kjeldahl method as described by Jackson (1973). Total nitrogen content of grain and straw was multiplied by the respective dry matter yield to get the total nitrogen present in the grain and straw in kg ha^{-1}. Economics of different treatments were worked out on the basis of cost of inputs and return from the produce of different treatment plots of wheat crop. Net return was calculated by subtracting total cost of production from gross return and expressed in ₹ ha^{-1}. Benefit cost ratio was worked out by dividing the net return with respective treatment wise cost of cultivation. The data relating to each character were analyzed statistically by applying the technique of analysis of variance and the significance was tested by "F" test (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

Growth Attributes of Wheat

Crop growth attributes data (Table 1) revealed that taller plants (90.56 and 90.83) with maximum tillers (73 and 75) and dry matter accumulation (184.65 and 191.16) g m^{-1} row in residue retention with *Trichoderma* application was closely

Table: 1
Effect of residue and weed management practices on growth and yield attributes of no-till wheat

Treatment	Plant height (cm)		Number of tillers row running m^{-1}		Dry matter accumulation (g row running m^{-1})		Ear head (m^{-2})		Test weight (g)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue management										
R_1 (Residue removal)	84.25	85.31	67	70	173.36	180.33	290	302	39.87	40.05
R_2 (Residue retention)	89.10	89.88	71	74	181.15	191.02	308	322	40.50	41.22
R_3 (Residue retention with *Trichoderma*)	90.56	90.83	73	75	184.65	191.16	312	324	40.62	41.37
Sem±	1.39	1.37	1.16	1.15	2.85	2.98	4.81	5.00	0.64	0.65
CD (P=0.05)	4.39	4.32	3.65	3.64	8.97	9.38	15.16	15.77	NS	NS
Weed management										
W_1 (Control)	83.57	83.84	67	69	174.25	177.10	276	291	38.23	39.33
W_2 (Hand weeding at 30 & 45 DAS)	90.35	91.24	72	76	184.65	192.74	314	327	41.33	41.66
W_3 (Isoproturon+2,4-D(1.0+0.5 kg ha^{-1}) at 30 DAS)	88.74	89.58	70	73	179.62	189.52	311	322	40.76	41.15
W_4 (Fenoxaprop 120 g ha^{-1} *fb* Metsulfuron 4g ha^{-1})	89.24	90.02	71	74	180.36	190.66	313	323	41.00	41.39
Sem±	0.59	0.57	0.49	0.49	1.20	1.25	2.03	2.12	0.27	0.27
CD (P=0.05)	1.67	1.62	1.40	1.39	3.42	3.57	5.80	6.05	0.77	0.78

followed by residue retention alone and significantly higher to residue removal treatment during both the years. However, residue retention alone treatment also received higher crop growth attributes as compared to residue removal treatment during both years except dry matter accumulation (181.15 g m^{-1} row) during 2005-06, which was observed non-significant variation (Table 1). It might be due to better soil moisture conducive for good germination brought good crop establishment and supported growth parameters in residue retention treatment. Among the weed management practices, hand weeding twice and weedy recorded the highest and lowest plant height, number of tillers and dry matter accumulation, respectively, in comparison to herbicides treatment application of fenoxaprop 120 g ha^{-1} *fb* metsulfuron 4 g ha^{-1} showed the highest plant height, number of tillers and dry matter accumulation followed by isoproturon 1.0 + 2, 4-D 0.5 kg ha^{-1} at 30 (DAS) and significantly higher to weedy treatment during both the years. Similar findings were also reported by Singh and Yadav (2006), Brar and Walia (2009).

Yield Attributes and Yield

Grain yield is considered to be a function of various yield attributing characters *viz.,* ear head (m^{-2}) and 1000-grain weight. Ear head (m^{-2}) and 1000-grain weight were significantly influenced by residue management (Table 1). The highest ear head (m^{-2}) was recorded by residue retention with *Trichoderma* application (312 and 324) followed by residue retention alone (308 and 322) and residue removal treatment (290 and 302). However, residue retention with *Trichoderma* application and residue retention alone were statistically at par to each other but they registered significantly higher ear head (m^{-2}) than residue removal treatment during both the years of investigation (Table 1). It might be higher solubility and availability of nutrients to plant through cellulolytic fungous in residue retention with *Trichoderma* application and thus resulted in better development of yield attributes over other treatments. Similar observations were observed by Singh and Yadav (2006). In weed management treatments hand weeding twice had the highest ear head m^{-2} (314 and 327) and 1000-grain weight (41.33 and 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 head m^{-2} (276 and 291) and 1000-grain weight (38.23 and 39.33) during both the years of investigation. However, Application of fenoxaprop 120 g ha^{-1} *fb* metsulfuron 4 g ha^{-1} accounted more ear head m^{-2} (313 and 323) and 1000-grain weight (41.00 and 41.29) which was at par to isoproturon + 2, 4-D (1.0+0.5 kg ha^{-1}) ear head m^{-2} (311 and 322) and 1000-grain weight (40.76 and 41.15) and these were found significantly superior to weedy check (Table 1) which might be due to higher yield attributing characters as a result of low weed population under this treatment. It might be minimum crop weed competition enables the crop to make maximum use of inputs for the formation and development of yield attributes. Similar results were drawn by Thomas *et al*. (2000); Singh *et al.* (2005) and Meena *et al.* (2011).

Residue retention with *Trichoderma* application registered significantly higher grain (8.2 and 6.8%) and straw (7.3 and 6.2 %) yield as compared to residue removal treatment (Table 2). The maximum grain and straw yield was recorded under residue retention with *Trichoderma* application (3321 and 3617) and (5100 and 5332) followed by residue retention alone (3264 and 3581) and (5019 and 5296) and residue removal treatment (3069 and 3386) and (4752 and 5021). However, residue retention with *Trichoderma* application and residue retention alone were statistically at par to each other and significantly higher to residue removal treatment in respect of grain and straw yield (Table 2) during both the year of investigations. This reduction in grain yield in residue removal was due to poor crop growth and lower value of

Table: 2
Effect of residue and weed management practices on yield, nitrogen uptake and weed control efficiency in no-till wheat

Treatment	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Nitrogen uptake by wheat (kg ha^{-1})		Weed control efficiency (%)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue Management								
R_1 (Residue removal)	3069	3386	4752	5021	72.49	82.36	59.77	60.32
R_2 (Residue retention)	3264	3581	5019	5296	73.59	86.60	60.60	61.37
R_3 (Residue retention with *Trichoderma*)	3321	3617	5100	5332	73.78	88.34	61.08	61.61
Sem±	51.90	55.79	60.30	82.66	0.29	1.33	0.18	0.30
CD (P=0.05)	163.54	175.78	190.00	260.43	0.90	4.18	0.56	0.94
Weed Management								
W_1 (Control)	2789	2958	4672	4814	71.77	78.35	0.00	0.00
W_2 (Hand weeding at 30 & 45 DAS)	3415	3788	5118	5426	74.19	89.59	100.00	100.00
W_3 (Isoproturon +2,4-D (1.0+0.5 kg ha^{-1}) at 30 DAS)	3313	3642	4988	5292	73.54	87.02	67.72	69.36
W_4 (Fenoxaprop 120 g ha^{-1} *fb* Metsulfuron 4g ha^{-1})	3355	3722	5050	5333	73.65	88.10	74.19	75.07
SEm±	21.28	23.86	34.89	34.91	0.20	0.56	0.15	0.20
CD (P=0.05)	60.81	68.18	99.71	99.77	0.57	1.20	0.42	0.58

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 (3415 and 3788) and straw (5118 and 5426) 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 and 3722.27) and straw (5050 and 5333) 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 (Table 2). 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 Walia *et al.* (2000); Singh *et al.* (2005); Jain *et al.* (2007); Singh *et al.* (2010) and Meena *et al.* (2011).

Nitrogen Uptake by Wheat

Nitrogen uptake by wheat as influenced by residue and weed management was significantly influenced in both the years (Table 2). Residue retention with *Trichoderma* application recorded higher nitrogen (73.78 and 88.34 kg ha^{-1}) uptake, which was comparable to residue retention alone (73.59 and 86.60 kg ha^{-1}) but significantly superior to residue removal (72.49 and 82.36 kg ha^{-1}) during both the years. Data further revealed that residue removal treatment recorded minimum nitrogen uptake and found lower to residue retention treatment during both the years. Among weed management hand weeding twice recorded significantly higher nitrogen uptake by wheat which was at par to fenoxaprop *fb* metsulfuron and significantly superior to weedy check (Table 2). Among herbicide fenoxaprop *fb* metsulfuron recorded higher nitrogen uptake (73.65 and 88.10 kg ha^{-1}) by wheat which was at par to isoproturon +2, 4-D (73.54 and 87.02 kg ha^{-1}) and both were significantly superior to weedy check (71.77 and 78.35 kg ha^{-1}) during both the years of study. This might be attributed to poor weed competition during early crop growth period that enabled the crop to make maximum use of inputs for the growth and development (Walia *et al.*, 2000; Thomas *et al.*, 2000; Yadav *et al.*, 2005; Singh and Yadav, 2006 and Meena *et al.*, 2011).

Weed Control Efficiency (WCE)

WCE denotes the relative efficiency of weed control treatments compared to weedy check. Amongst herbicidal treatments fenoxaprop *fb* metsulfuron recorded highest (74.19 and 75.07 %) WCE which was closely followed by isoproturon + 2, 4-D (Table 2) during both the years. However, 2-hand weedings proved superior to herbicidal treatments. The highest WCE was associated with fenoxaprop *fb* metsulfuron which may be attributed to its effective control of complex weed flora grassy as well as broad leaved weeds and to some extent to sedges. Isoproturon + 2, 4-D recorded lower (67.72 and 69.36 %) WCE as compared to fenoxaprop *fb* metsulfuron due to poor efficacy on weed flora these finding established support from Meena *et al.* (2011); Kumar *et al.* (2013) and Singh *et al.* (2015).

Economics

The practical utility of any weed control measure can be best judged on the basis of net return and output-input ratio. The data on economics of various treatments (Table 3) revealed that the maximum net return (₹ ha^{-1} 20619 and 30854) were recorded under residue retention alone as compared to residue retention with *Trichoderma* application (₹ ha^{-1} 20273.78 and 30286.78) and residue removal (₹ ha^{-1} 18794.86 and 28562.07) during 2005-06 and 2006-07, respectively. This is due to fact that under residue retention alone treatment low field preparation operation was involved, whereas in residue retention with *Trichoderma* application increased the cost of cultivation and in residue removal treatment lower grain yield resulted in lower net profit as compared to residue retention alone (Table 3). Weed management treatments showed significant advantage over weedy check in maximizing net return as well as output input ratio. All the herbicidal treatments gave more net

Table: 3
Effect of residue and weed management practices on economics of no-till wheat

Treatment	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
	2005-06			2006-07		
Residue Management						
R_1 (Residue removal)	34055	18795	2.24	45154	28562	2.74
R_2 (Residue retention)	36150	20619	2.34	47722	30854	2.85
R_3 (Residue retention with *Trichoderma*)	36767	20274	2.23	48162	30287	2.71
Weed Management						
W_1 (Control)	31653	17808	2.28	40415	25542	2.72
W_2 (Hand weeding at 30 & 45 DAS)	37554	19659	2.09	50090	30017	2.50
W_3 (Isoproturon+2,4-D (1.0+0.5 kg ha^{-1}) at 30 DAS)	36481	21911	2.50	48324	32680	3.09
W_4 (Fenoxaprop 120 g ha^{-1} *fb* Metsulfuron 4g ha^{-1})	36941	20205	2.20	49221	31365	2.76

return as well as input output ratio than that of weedy check. Out of herbicides isoproturon + 2, 4-D gave the highest net return of ₹ ha^{-1} 21911 and 32680 as compared to fenoxaprop *fb* metsulfuron (₹ ha^{-1} 20205 and 31365) followed by hand weeding twice (₹ ha^{-1} 19659 and 30017) during first and second year, respectively. The lowest net return was recorded under weedy check (₹ ha^{-1} 17808 and 25542) during 2005-06 and 2006-07, respectively due to higher weed density which reduced the grain and straw yield. Average over two years the higher output: input ratio was obtained with application of isoproturon + 2, 4-D which was higher to rest of other weed management treatments during both the years (Table 3). The higher output input ratio under this treatment owed to more grain yield and comparatively low cost of the herbicides used in these treatments. Though, hand weeding twice failed to produce higher net return and output:input ratio during both the years. The lower net return and output-input ratio in this treatment was mainly due to more labour cost. These findings were in conformity with Jain *et al.* (2007).

4. CONCLUSIONS

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 (30DAS) for obtaining higher yield and net return in rice-wheat cropping system.

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