International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 4, 2017, pp.-3708-3712.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

RESIDUE AND WEED MANAGEMENT PRACTICES IN ZERO-TILL WHEAT (*Triticum aestivum* L.) UNDER RICE-WHEAT CROPPING SYSTEM

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Received: December 05, 2016; Revised: January 10, 2017; Accepted: January 11, 2017; Published: January 24, 2017

Abstract- A field experiment was conducted during 2005-06 to 2006-07 at Varanasi to find out the effect of three residue management practices *viz*. R_1 (Residue Removal), R_2 (Residue Retention alone), R_3 (Residue Retention with *Trichoderma*) and four weed management treatments *viz*. W_1 (Control), W_2 (Hand weeding at 30 & 45 DAS), W_3 (Isoproturon +2,4-D (1.0+0.5 ha^{-1} at 30 DAS), W_4 (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 & Poal) in rice-wheat cropping system during the winter (*rabi*) season. Weeds in weedy check caused 20.32 and 25.82% reduction in grain yield of wheat, respectively. Wheat grown under rice wheat cropping system with residue retention with *Trichoderma* application produced 6.8 and 8.2 % higher grain and 7.3 and 6.2 % straw yield over residue retention alone.

Keywords- Residue Management, Weed Control, Nutrient Removal, Zero-Till, Wheat

Citation: Kumar Rakesh, et al., (2017) Residue and Weed Management Practices in Zero-Till Wheat (*Triticum aestivum* L.) under Rice-Wheat Cropping System. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 4, pp.-3708-3712.

Academic Editor / Reviewer:

Introduction

Rice (*Oryza sativa* L.) - Wheat (*Triticum aestivum* L. emend Fiori & Poal) cropping sequence is the most predominant production system of Indo-Gangatic plains of South Asia (India, Bangladesh, Nepal, Pakistan) about 13M ha. and on the same areas in the basin of the Yangtze river in China [7, 13]. Now, economical and environmental past of the system got threaten because the factor productivity of the system is getting declined and the yield either got platitude or started declining in spite of using higher and higher inputs. This grin 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) develop 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 save 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 [3,4]. This 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 weed emerging with the crop compete with it for nutrients (especially nitrogen), grow faster and utilize it in larger amount than the crop [10]. 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 [17].

Materials and Methods

Field trials on wheat crop were conducted at Varanasi (latitude 25^{0}18'N, longitude 83^{0}03'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*. R_1 (Residue Removal), R_2 (Residue Retention alone), R_3 (Residue Retention with *Trichoderma*), and sub plot treatments were four weed management techniques *viz*. W_1 (control), W_2 (Hand weeding at 30 &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})). 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/ m^2 area by placing a quadrate of 0.5 ×0.5 m randomly at three places in 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 per square meters. 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 [2].

Result and Discussion

Effect on weeds

Out of the weed species present in the experimental field during the investigation, six species identified as major one. Among these species *Phalaris minor* was grasses, *Cyprus rotundous* was sedges and other four species were *viz. Chenapodium album, Rumex denticulate, Anagalis arvensis* and *Melilotus species*. Other minor species were *Lathyrus aphace* L., *Solenum nigrum* L., *Avena fatua* L. *Setaria gluca* L. the population of weeds was found to be maximum at 45th day stage [Table-2] and there after it decreased at successive stage of crop growth during both the years, irrespective of treatments. This was owing to death of most of the broad leaved weds which had completed their life cycle before of crop. The residue retention with *Trichoderma* application (R_3) and residue retention alone (R_2) had minimum weed population of weeds during both the years as compared to residue removal treatment. This was due to the covering of soil surface with crop residue and it caused mulching effect during crop period as reported by [1,5]. Out of various weed management treatments, hand weeding twice (W_2) was found to be significant over rest of other treatments in controlling weed population. Among the herbicides, Fenoxaprop 120 g ha^{-1} *fb* Metsulfuron 4 g ha^{-1} (W_4) was more effective in reducing population of weeds as compared to Isoproturon +2,4-D(1.0+0.5 kg/ha (W_3) at all stages of growth. [6,7,8] reported that the higher efficacy of Fenoxaprop 120 g ha^{-1} *fb* Metsulfuron 4 g ha^{-1} (W_4) was due to effective control of narrow as well as broad leaf weeds.

Table-1 *Effect of residue and weed management on plant height, number of tillers, ear length, grains ear head and test weight in wheat.*

Treatment	Plant Height (cm)		Number of tillers m^{-2}		Ear length (cm)		Grains ear-$head^{-1}$		Grain yield (kg ha^{-1})		Straw yield (kg 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												
R_1 (Residue removal)	84.25	85.31	334	349	8.56	8.71	45.64	46.76	3069	3386	4752	5021
R_2 (Residue retention)	89.10	89.88	356	370	9.09	9.19	45.83	47.57	3264	3581	5019	5296
R_3 (Residue retention with *Trichoderma*)	90.56	90.83	363	373	9.19	9.26	46.09	47.90	3321	3617	5100	5332
SEm±	1.39	1.37	5.78	5.77	0.14	0.14	0.73	0.75	51.90	55.79	60.30	82.66
CD (*P*=0.05)	4.39	4.32	18.23	18.19	0.45	0.45	NS	NS	163.54	175.78	190.00	260.43
Weed management												
W_1 (Control)	83.57	83.84	336	344	8.33	8.47	41.25	43.34	2789	2958	4672	4814
W_2 (Hand weeding at 30 &45 DAS)	90.35	91.24	362	378	9.25	9.29	47.87	49.31	3415	3788	5118	5426
W_3 (Isoproturon +2,4-D(1.0+0.5 kg/ha) at 30 DAS)	88.74	89.58	352	365	9.08	9.19	47.02	48.43	3313	3642	4988	5292
W_4 (Fenoxaprop 120 g/ha *fb*Metsulfuron 4g/ha)	89.24	90.02	356	370	9.14	9.25	47.29	48.56	3355	3722	5050	5333
SEm±	0.59	0.57	2.45	2.43	0.06	0.06	0.31	0.32	21.28	23.86	34.89	34.91
CD (*P*=0.05)	1.67	1.62	7.02	6.94	0.17	0.17	0.88	0.91	60.81	68.18	99.71	99.77
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Interaction Effect

Data revealed that fenoxaprop *fb* metsulfuron under residue retention with *Trichoderma* application recorded minimum total weed population which was at par with residue retention alone and significantly superior in reducing total weed population as compared to residue removal treatments at 45th day stage during both the year of investigation. The interaction effect between residue and weed management was significant at 45th day stage of crop. It is evident from the [Table -2] that under each residue retention treatment less dry weight of total weed was recorded by hand weeding twice followed by fenoxaprop *fb* metsulfuron and isoproturon +2,4-D over weedy check. Among the herbicidal treatments fenoxaprop *fb* metsulfuron was noted less dry weight of total weeds with residue retention with *Trichoderma* application which was at par with residue retention alone and significantly superior in reducing total weed dry weight than residue removal treatment at 45th day of stage during both the years.

Nitrogen removal by weeds (kg ha^{-1})

It is obvious from the data [Table-3] that in residue management, residue retention with *Trichoderma* application appeared more effective in reducing the nitrogen removal by weeds which was on par with residue retention alone as compared to residue removal treatment during both years of study. Among the weed management hand weeding twice was recorded less nitrogen removal by weeds followed by fenxoaprop *fb* metsulfuron and isoproturon +2, 4-D as compared to weedy check which depleted maximum nitrogen by weeds during both the year of study [14-16]. Interaction effect [Table-3.1] between residue management and weed management on nitrogen removal by weeds was found to have significant effect during both the year. Data revealed that fenoxaprop *fb* metsulfuron under residue retention with *Trichoderma* application recorded minimum nitrogen removal by weeds which was at par with residue retention alone and significantly superior to residue removal treatment. Similar results were found with isoproturon +2, 4-D and residue management treatment in respect of nitrogen removal by weeds during both the year of study.

Phosphorus removal by weeds (kg ha^{-1})

It is evident from the data that residue management differed significantly in phosphorus removal by weeds during both the years. Data revealed that residue retention with *Trichoderma* application and residue retention alone both were significantly superior to cause reduced phosphorus depletion by weeds as compared to residue removal which recorded more phosphorus removal by weeds during both the year of study. An analysis of data revealed that significant effect of weed management on phosphorus removal by weeds during both the years. The minimum phosphorus removal was recorded under hand weeding twice followed by fenoxaprop *fb* metsulfuron and isoproturon +2, 4-D. These were significantly superior in reducing phosphorus removal by weeds and over weedy check during both the year of study [14,15].

Potassium removal by weeds (kg ha^{-1})

Significant variation in potassium removal by weeds was recorded due to residue management. The minimum potassium removal by weeds was recorded under residue retention with *Trichoderma* application which was at par with residue retention alone and significantly lowers than residue removal treatment during both the year of investigation. Weed management differed significantly in potassium removal by weeds during both the years. Amongst weed management, hand weeding twice had significantly minimum potassium removal by weeds as compared to herbicidal treatment and weedy check during both the years. Data also indicated that fenoxaprop fb metsulfuron observed significantly lower potassium removal by weeds as compared to weedy check during both the years. Interaction effect [Table-3.2] of residue and weed management treatments potassium removal by weeds found to be significant at 45th day stage during both

the years. Data showed that hand weeding twice under residue management recorded minimum potassium removal by weeds followed by fenoxaprop fb metsulfuron and isoproturon +2, 4-D as compared to weedy check [14,15].

Table-2 *Effect of residue and weed management on total weed densityat 45 & 90 DASand total weed dry weightat 45 & 90 DAS in wheat.*

Treatment	Total weed density (m^{-2}) at 45 DAS		Total weed density(m^{-2}) at Harvest		Total weed dry weight (g m^{-2}) at 45 DAS		Total weed dry weight (g m^{-2}) at Harvest	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue management								
R_1 (Residue removal)	5.61 *(40.99)	5.21 (35.07)	5.42 (32.81)	5.17 (29.76)	4.21 *(23.72)	3.92 (20.50)	4.26 (22.15)	3.87 (18.63)
R_2 (Residue retention)	5.38 (37.73)	4.99 (32.41)	5.21 (30.32)	4.98 (27.86)	3.97 (21.02)	3.72 (18.24)	4.00 (19.68)	3.79 (17.79)
R_3 (Residue retention with *Trichoderma*)	5.29 (36.66)	4.96 (32.00)	5.15 (29.72)	4.96 (27.68)	3.90 (20.34)	3.71 (18.11)	3.96 (19.36)	3.74 (17.46)
SEm±	0.03	0.04	0.03	0.04	0.02	0.03	0.03	0.03
CD (*P*=0.05)	0.10	0.12	0.09	0.12	0.17	0.09	0.08	0.09
Weed management								
W_1 (Control)	9.91 (97.29)	9.28 (85.24)	8.71 (74.97)	8.39 (69.48)	8.03 (63.59)	7.56 (56.20)	7.67 (57.93)	7.37 (53.34)
W_2 (Hand weeding at 30 &45 DAS)	1.00 (0.00)	1.00 (0.00)	3.26 (9.64)	3.08 (8.49)	1.00 (0.00)	1.00 (0.00)	1.78 (2.18)	1.80 (2.26)
W_3 (Isoproturon +2,4-D(1.0+0.5 kg/ha) at 30 DAS)	5.69 (31.43)	5.20 (26.13)	4.79(21.92)	4.61 (20.29)	3.69 (12.63)	3.44 (10.83)	3.56 (11.68)	3.19 (9.16)
W_4 (Fenoxaprop 120 g/ha *fb*Metsulfuron 4g/ha)	5.11 (25.12)	4.71 (21.25)	4.27 (17.25)	4.06 (15.48)	3.40 (10.55)	3.13 (8.78)	3.28 (9.81)	2.84 (7.08)
SEm±	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02
CD (*P*=0.05)	0.06	0.08	0.04	0.06	0.06	0.05	0.05	0.02
Interaction	**	**	NS	NS	**	**	NS	NS

*Data transformed to √x+1. Figure in parentheses indicate original values

Table-2.1 *Interaction effect of residue and weed management on total weed population (m^{-2}) at 45 days after sowing.*

Treatment	Residue management					
	2005-06			2006-07		
Weed management	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)
W_1 (Control)	10.14 *(101.9)	9.84 (95.78)	9.76 (94.20)	9.46 (88.44)	9.21 (83.92)	9.18 (83.37)
W_2 (Hand weeding at 30 &45 DAS)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.05 (0.10)	1.00 (0.00)	1.00 (0.00)
W_3 (Isoproturon +2,4-D(1.0+0.5 kg/ha) at 30 DAS)	5.95 (34.42)	5.63 (30.70)	5.49 (29.17)	5.44 (28.64)	5.11 (25.15)	5.06 (24.58)
W_4 (Fenoxaprop 120 g/ha *fb*Metsulfuron 4g/ha)	5.35 (27.64)	5.05 (24.46)	4.93 (23.28)	4.91 (23.12)	4.64 (20.58)	4.59 (20.07)
SEm± for weed management at the same level of residue management.		0.04			0.05	
CD (*P*=0.05)		0.11			0.13	
SEm± for residue management at the same or different levels of weed management.		0.04			0.05	
CD (*P*=0.05)		0.11			0.14	

*Data transformed to √x+1. Figure in parentheses indicate original values

Table-2.2 *Interaction effect of residue and weed management on total weed dry weight (g m^{-2}) at 45 days after sowing.*

Treatment	Residue management					
	2005-06			2006-07		
Weed management	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)
W_1 (Control)	8.35 *(68.71)	7.92 (61.69)	7.83 (60.38)	7.86 (60.78)	7.42 (54.13)	7.39 (53.68)
W_2 (Hand weeding at 30 &45 DAS)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
W_3 (Isoproturon +2,4-D(1.0+0.5 kg/ha) at 30 DAS)	3.94 (14.53)	3.62 (12.09)	3.50 (11.27)	3.59 (11.90)	3.36 (10.30)	3.36 (10.30)
W_4 (Fenoxaprop 120 g/ha *fb*Metsulfuron 4g/ha)	3.55 (11.64)	3.36 (10.31)	3.27 (9.71)	3.21 (9.33)	3.08 (8.52)	3.08 (8.48)
SEm± for weed management at the same level of residue management.		0.03			0.03	
CD (*P*=0.05)		0.10			0.09	
SEm± for residue management at the same or different levels of weed management.		0.03			0.03	
CD (*P*=0.05)		0.09			0.10	

*Data transformed to √x+1. Figure in parentheses indicate original values

Effect on yield attributes and yield

Ear length (cm) and grain ear-head^{-1} were significantly influenced by residue management [Table-1]. The longest 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 and residue retention alone were statistically at par to each other but they registered significantly higher ear length than residue removal treatment during both the year 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 [9]. In weed management treatments hand weeding twice had the longest ear length (9.25&9.29) and grain ear-head^{-1} (47.87&49.31) which was at par to fenoxaprop *fb* metsulfuron and isoproturon + 2, 4-D and these were found significantly superior to weedy check which registered lowest ear length (8.33&8.47) and grains ear-head^{-1}(41.25&43.34) respectively, during both the year of investigations. However, Application of fenoxaprop 120 g ha^{-1} *fb* metsulfuron 4 g ha^{-1} accounted more ear length (9.14&9.25) and grain ear-head^{-1} (47.29&48.56) which was at par to isoproturon + 2, 4-D (1.0+0.5 kg ha^{-1}) 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 [6,12,17].

Table-3 *Effect of residue and weed management on nitrogen,phosphorus and potassiumremoval by weedat 45 DAS in wheat.*

Treatment	Nitrogen removal by weed (kg ha^{-1})		Phosphorus removal by weed (kg ha^{-1})		Potassium removal by weed (kg ha^{-1})	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue management						
R_1 (Residue removal)	1.86 *(3.10)	1.77(2.69)	1.27(0.68)	1.24(0.61)	1.79(2.75)	1.71(2.39)
R_2 (Residue retention)	1.80 (2.83)	1.72(2.46)	1.25(0.62)	1.23(0.57)	1.73(2.47)	1.66(2.18)
R_3 (Residue retention with *Trichoderma*)	1.78 (2.75)	1.72(2.43)	1.25(0.62)	1.23(0.57)	1.71(2.39)	1.65(2.15)
SEm±	0.01	0.01	0.00	0.00	0.01	0.01
CD (*P*=0.05)	0.03	0.03	0.02	0.01	0.03	0.03
Weed management						
W_1 (Control)	3.08 (8.47)	2.91(7.49)	1.70(1.88)	1.65(1.72)	2.90(7.43)	2.76(6.63)
W_2 (Hand weeding at 30 &45 DAS)	1.00 (0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)	1.00(0.00)
W_3 (Isoproturon +2,4-D(1.0+0.5 kg/ha) at 30 DAS)	1.64 (1.69)	1.56(1.45)	1.17(0.38)	1.16(0.34)	1.57(1.48)	1.51(1.28)
W_4 (Fenoxaprop 120 g/ha *fb*Metsulfuron 4g/ha)	1.55 (1.41)	1.47(1.17)	1.15(0.32)	1.13(0.28)	1.50(1.24)	1.43(1.04)
SEm±	0.01	0.01	0.00	0.00	0.01	0.01
CD (*P*=0.05)	0.03	0.02	0.01	0.01	0.03	0.02
Interaction	**	**	NS	NS	**	**

*Data transformed to √x+1. Figure in parentheses indicate original values

Table-3.1 *Interaction effect of residue and weed management on nitrogen removal by weed (kg ha^{-1}) at 45 days after sowing.*

Treatment	Residue management					
	2005-06			2006-07		
Weed management	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)
W_1 (Control)	3.15 *(8.96)	3.05 (8.30)	3.03 (8.16)	2.99 (7.95)	2.88 (7.30)	2.87 (7.23)
W_2 (Hand weeding at 30 &45 DAS)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
W_3 (Isoproturon +2,4-D(1.0+0.5 kg/ha) at 30 DAS)	1.70 (1.90)	1.62 (1.63)	1.59 (1.53)	1.60 (1.57)	1.55 (1.40)	1.54 (1.38)
W_4 (Fenoxaprop 120 g/ha *fb*Metsulfuron 4g/ha)	1.59 (1.52)	1.55 (1.39)	1.52 (1.32)	1.49 (1.23)	1.47 (1.16)	1.46 (1.13)
SEm± for weed management at the same level of residue management.	0.02			0.01		
CD (*P*=0.05)	0.06			0.03		
SEm± for residue management at the same or different levels of weed management.	0.02			0.01		
CD (*P*=0.05)	0.05			0.03		

*Data transformed to √x+1. Figure in parentheses indicate original values

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-2]. The maximum grain and straw yield was recorded under residue retention with *Trichoderma* application (3321 & 3617) and (5100 & 5332) followed by residue retention alone (3264 & 3581) and (5019& 5296) and residue removal treatment (3069 & 3386) and (4752 & 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 yield attributes owing to higher weed competition. These findings were supported by [17]. Amongst weed management, hand weeding twice recorded maximum grain (3415 & 3788) and straw (5118 & 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 & 3722.27) and straw (5050 & 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 [6, 12, 13,17].

Conclusion

In over all, it is recommended that wheat should be sown under residue retention with *Trichoderma* application along with fenoxaprop 120 g ha^{-1} *fb* metsulfuron 4 g ha^{-1} post emergence at 30DAS to minimise weed population and obtain higher grain yield under rice-wheat cropping system.

Table-3.2 *Interaction effect of residue and weed management on potassium removal by weed (kg ha^{-1}) at 45 days after sowing.*

Treatment	Residue management					
	2005-06			2006-07		
Weed management	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)	R_1 (Residue removal)	R_2 (Residue retention)	R_3 (Residue retention with *Trichoderma*)
W_1 (Control)	2.99 *(7.96)	2.87 (7.23)	2.84 (7.10)	2.84 (7.07)	2.73 (6.45)	2.72 (6.38)
W_2 (Hand weeding at 30 &45 DAS)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
W_3 (Isoproturon +2,4-D(1.0+0.5 kg/ha) at 30 DAS)	1.64 (1.69)	1.56 (1.43)	1.53 (1.33)	1.55 (1.39)	1.49 (1.23)	1.49 (1.22)
W_4 (Fenoxaprop 120 g/ha *fb*Metsulfuron 4g/ha)	1.54 (1.36)	1.49 (1.22)	1.47 (1.15)	1.45 (1.10)	1.42 (1.02)	1.41 (1.00)
SEm± for weed management at the same level of residue management.	0.02			0.01		
CD (*P*=0.05)	0.06			0.03		
SEm± for residue management at the same or different levels of weed management.	0.02			0.01		
CD (*P*=0.05)	0.05			0.03		

*Data transformed to √x+1. Figure in parentheses indicate original values

Acknowledgement

Authors are thankful to the Banaras Hindu University, Varanasi. Authors are also thankful to the Head of Department, Agronomy, Institute of Agricultural; Sciences, Banaras Hindu University Varanasi, (India) for providing necessary facilities and encouragement.

Abbreviations: fb – followed by one week, DAS- Days after sowing.

Author Contributions:

1. Rakesh Kumar, Planning and execution of research experiment, observations and analysis of experimental data and writing of manuscript.
2. U.P. Singh, Hypothesis of this experiment, given valuable suggestion for writing of review and literature.
3. Gaurav Mahajan, Assist in manuscript preparation and editing.

Conflict of Interest: None declared

References

[1] Brar S.S., Kumar S., Brar L.S., Walia S.S. and Kumar S. (1998) *Indian Journal of Weed Science,* 30, 39-43.
[2] Gomez K.A. and Gomez A.A. (1984) Statistical procedures for agricultural research (Second Eds.). *An International Rice Research Institute Book*. John Wiley and Sons.
[3] Jain N., Jain V., Mishra J.S. and Kewat M.L. (2007) *Indian Journal of Agricultural Science,* 77(3), 174-176.
[4] Jat R.S., Nepalia V. and Chaudhary P.D. (2003) *Indian Journal of Weed Science,* 35, 18-20.
[5] Kumar S., Pandey D.S. and Rana N.S. (2004) *Indian Journal of Agronomy,* 49 (4), 223-225.
[6] Meena S.R. and Singh M.K. (2011) *Indian J. Agron.,* 56(2), 127-132.
[7] Singh G., Singh O.P., Singh S. and Prasad K. (2010) *Indian J. Agron.,* 51(4), 247-250.
[8] Singh G., Singh V.P. and Singh M. (2002) *Indian Journal of Weed Science,* 34, 9-12.
[9] Singh R and Yadav D.S. (2006) *Indian J. Agron.,* 51(4), 247-250.
[10] Singh R.P. and Reddy B.G. (1998) *Indian Journal of Weed Science,* 29(4),1-6.
[11] Singh Y., Singh B. and Timsina J. (2005) *Advances in Agronomy,* 85, 269-407.
[12] Thomas C.G., Yaduraju N.T. and Kumar J.S. (2000) *Indian J. Weed Sci.,* 32, 44-50.
[13] Timsina J. and Conner D.J. (2001) *Field crop Research,* 69, 93-132.
[14] Walia S.S., Brar S.S and Kler D.S. (1997) *Environment and Ecology,* 15, 617-620
[15] Walia U.S. and Brar L.S. (2001) *Indian J. Weed Sci.,* 33, 120-123.
[16] Walia U.S., Kaur R. and Kumar N. (2000) *Environment and Ecology* 18,134-137.
[17] Yadav D.S., Shukla R.P., Sushant and Kumar B. (2005) *Indian Journal of Agronomy,* 50(1), 52-53.