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Evaluation of tillage system and herbicides on wheat (*Triticum aestivum*) performance under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system

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ABSTRACT

Field experiment was conducted during winter seasons of 2001-02 and 2002-03 to evaluate the effect of tillage system and herbicides in wheat (*Triticum aestivum* L. emend, Fiori & Paol) under rice (*Oryza sativa L.*) - wheat cropping system. Significantly lower weed density was recorded in zero tillage (ZT) when compared with conventional tillage (CT) whereas it remained at par with reduced tillage (RT). ZT reduced the density of *Phalaris minor* by 72.5 % but increased the density of *Rumex maritimus* by 126.4% when compared with CT. However, ZT system recorded 22.5 % higher weed dry weight when compared with CT due to germination of weeds along with wheat crop. Seed yield was not affected due to different tillage systems. Uncontrolled weeds caused 30% reduction in wheat yield. Sole application of fenoxaprop –p-ethyl (100 g/ha) and clodinafop propargyl (60 g/ha) were found effective against the grassy weeds only. The maximum reduction in weed density (90.7%) and weed dry matter (89.8%) was obtained with sequential application of fenoxaprop and clodinafop with metsulfuron due to control of complex weed flora. The seed yield in sequential application of fenoxaprop and clodinafop with metsulfuron remained at par when applied as tank mix with metsulfuron but was significantly higher (18.9 and 19.5%) than the sole application of fenoxaprop and clodinafop.

Key words: Conventional tillage, Economics, Herbicides, Weed density, Wheat, Yield, Zero tillage

The delay in wheat (*Triticum aestivum* L. emend , Fiori & Paol) sowing after basmati rice (*Oryza sativa* L.) harvesting encourages germination of weeds even before the sowing of wheat crop (Dhiman *et al.,* 2003). Tillage and weed management are the high priority areas for wheat cultivation. In wheat cultivation, zero tillage has certain advantages like improved soil conditions due to decomposition of crop residue *in situ*, increase in infiltration rate, less soil compaction and reduced cost of seed bed preparation (Singh *et al.,* 2001). Success of zero tillage is largely dependent on solving the key issue of weed management with economic crop yields (Hari Om *et al.,* 2006). Under Haryana conditions, the wheat fields are infested with complex weed flora constituting grassy and broadleaf weeds. In rice - wheat rotation, the infestation of wild canary grass (*Phalaris minor*) and *jangali palak (Rumex retroflex*) has acquired alarming proportions (Malik *et al.,* 2004). Due to evolution of resistance towards isoproturon, use of alternate herbicides *viz.* clodinafop and fenoxaprop have been recommended. However, these herbicides have been found to be ineffective against broadleaf weeds (Chopra and Chopra, 2005). Tank mix of the alternate herbicides with metsulfuron reduces their efficacy towards *Phalaris minor* (Yadav *et al.,* 2002). Therefore it was realized to evaluate these herbicides under sequential application with metsulfuron to exploit the possibility of their success towards the complex weed flora. Keeping, these points in view, the present investigation was undertaken to evaluate different tillage systems and herbicides on wheat performance.

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MATERIALS AND METHODS

A field experiment was conducted during winter seasons of 2001-02 and 2002-03 at the Indian Agricultural Research Institute, Regional Station, Karnal, Haryana located at 29.42^{O} N latitude and 79.59^{O} E longitude at an altitude of 250 m above the mean sea level. The experimental soil was clay loam in texture with 7.6 pH. The organic carbon, electrical conductivity and available nitrogen, phosphorus and potash were 0.50%, 0.31 dS/m, 180, 24 and 290 kg/ha, respectively. The experiment was laid out in split plot design with three replications keeping three tillage systems (zero, reduced and conventional) in the main plots and eight weed control treatments [fenoxaprop-p-ethyl (100 g/ha), clodinafop propargyl (60 g/ha) as sole application, as sequential application with metsulfuron (4 g/ha), as tank mix with metsulfuron (4 g/ha), isoproturon (1000 g/ ha) tank mixed with metsulfuron (4 g/ha) and weedy check] in the sub-plots. Zero tillage (ZT) wheat was sown without any tillage operation with the help of Pant zero till fertilizer cum seed drill. Reduced tillage (RT) plots were prepared by giving two harrowings followed by one planking whereas conventional tillage (CT) plots were prepared by giving 3 harrowings and two cultivations followed by planking. 'HD 2687' wheat was sown in rows 22.5 cm apart on 6 December in 2001 and 8 December in 2002. Fertilizer dose of 125-26.4-33.3 kg N-P-K/ha was applied to crop. Full dose of P and K along with $^1/_3$ dose of nitrogen were applied at sowing and remaining $^2/_3$ dose of nitrogen was top dressed in 2 equal splits after Ist and IInd irrigation. All herbicides except metsulfuron were applied 30 days after sowing (DAS). Metsulfuron was applied five days after the spraying of fenoxaprop and clodinafop under sequential application treatment. Herbicides were sprayed using a spray volume of 600 liter/ha with a knapsack sprayer fitted with flat-fan nozzle. Data on weed count and weed biomass from an area enclosed in a quadrate of 1 m^2 under different tillage systems and herbicides plots were recorded at 90 DAS. Data on total weed density was subjected to square root transformation $\sqrt{x+1}$. Weed persistence index (WPI) was calculated as described by Singh and Singh (2006).

$$\text{WPI} = \frac{\text{Dry weight of weeds in treated plots}}{\text{Dry weight of weeds in control plot}} \times \frac{\text{Weed count in treated plot}}{\text{Weed count in control plot}}$$

RESULTS AND DISCUSSION

Density and weed dry weight

Weed density was significantly affected due to different tillage systems. There was 36.7% reduction in total weed density in ZT (Table 1) when compared with CT. Higher weed density in CT may be due to better tilth, and exposure of weed seeds to the upper soil layers (Singh *et al.*, 2001). Density of *Phalaris minor* and *Coronopus dydimus* was maximum in the CT system whereas *Rumex maritimus* and *Medicago denticulata* showed their dominance in ZT system (Table 1). Maximum weed dry weight was recorded in ZT which was 40.3 and 29.1% higher when compared with RT and CT because weeds germinated along with the crop due to preceding irrigation and accumulated maximum dry matter. All the herbicides reduced weed density and weed dry weight over weedy check in all the tillage systems. Sole application of fenoxaprop (100 g/ha) and clodinafop (60 g/ha) were

Table 1. Effect of tillage and herbicides on weed density species wise in wheat

Tillage	*Phalaris minor*		*Cornopus dydimus*		*Rumex maritimus*		*Medicago denticulata*	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Zero	(17.4) 4.1	(10.7) 3.2	(11.1) 3.1	(9.2) 3.0	(29.0) 4.7	(25.8) 4.5	(17.3) 3.8	(16.2) 3.7
Reduced	(28.2) 4.8	(21.0) 4.1	(14.0) 3.5	(11.5) 3.2	(23.8) 4.1	(19.4) 3.9	(13.5) 3.5	(12.2) 3.3
Conventional	(63.6) 6.7	(38.9) 5.2	(24.5) 4.3	(19.2) 4.0	(10.3) 3.4	(13.9) 3.6	(9.4) 3.0	(10.2) 3.1
SEm±	(1.1) 0.2	(1.0) 0.1	(0.2) 0.1	(0.7) 0.2	(2.2) 0.2	(0.9) 0.1	(1.2) 0.2	(0.9) 0.1
CD (P=0.05)	(4.4) 0.6	(3.9) 0.3	(0.8) 0.2	(2.9) 0.6	(8.5) 0.7	(3.8) 0.5	(4.7)NS	(3.5) NS
Herbicide								
Fenoxaprop- p-ethyl (100g/ha)	(10.4) 3.3	(6.3) 2.7	(33.8) 5.7	(25.3) 4.9	(46.4) 6.6	(39.6) 6.4	(26.8) 5.2	(23.2) 4.9
Clodinafop (60g/ha) – propargyl (60g/ha)	(9.0) 3.1	(5.4) 2.5	(35.2) 5.9	(24.6) 4.9	(40.2) 6.4	(37.3) 6.3	(25.5) 5.1	(24.4) 4.9
Fenoxaprop fb Metsulfuron (4g/ha)	(14.2) 3.7	(4.8) 2.4	(4.6) 2.4	(4.0) 2.1	(5.6) 2.5	(5.2) 2.5	(4.0) 2.1	(4.7) 2.4
Clodinafop fb Metsulfuron	(8.8) 3.1	(5.6) 2.5	(4.1) 2.2	(4.0) 2.1	(5.0) 2.4	(4.7) 2.2	(4.1) 2.2	(4.4) 2.2
Fenoxaprop + Metsulfuron	(23.3) 4.9	(13.6) 3.8	(3.1) 2.2	(4.8) 2.4	(5.1) 2.4	(5.3) 2.5	(4.1) 2.2	(4.1) 2.2
Clodinafop + Metsulfuron	(23.7) 4.9	(14.1) 3.9	(4.0) 2.1	(4.2) 2.2	(5.3) 2.2	(5.3) 2.2	(5.1) 2.4	(3.7) 2.1
Isoproturon 1000g/ha + Metsulfuron	(69.7) 8.0	(48.2) 6.6	(4.1) 2.7	(6.0) 2.6	(6.5) 2.4	(7.2) 2.7	(4.8) 2.4	(6.3) 2.7
Weedy check	(132.0)10.8	(90.3) 9.1	(43.3) 5.6	(33.5) 5.8	(55.5) 7.4	(52.8) 7.0	(34.3) 5.8	(32.2) 5.6
SEm±	(2.9) 0.2	(2.1) 0.2	(1.3) 0.2	(1.5) 0.2	(3.2) 0.2	(2.1) 0.2	(1.2) 0.2	(1.0) 0.2
CD (P=0.05)	(8.3) 0.5	(5.9) 0.5	(3.6) 0.5	(3.1) 0.5	(9.4) 0.6	(6.0) 0.4	(3.5) 0.5	(3.0) 0.4

found effective against *Phalaris minor* but failed to control the broad leaf weeds like *Rumex maritimus* and *Medicago denticulata.* The results are in agreement to Chopra and Chopra (2005). Application of both these grassy herbicides when followed by (fb) metsulfuron as sequential application resulted in lowest weed density and weed dry weight and highest weed control efficiency (WCE) in both the years due to control of complex weed flora (Table 1). Metsulfuron was found to be very effective against the broadleaf weeds (Hari Om *et al.,* 2006). Isoproturon + metsulfuron was less effective towards *Phalaris minor* and recorded significantly higher density in all the tillage system when compared with clodinafop and fenoxaprop which may be due to the presence of resistant biotypes of *Phalaris minor* to isoproturon but showed better control of broadleaf weeds. Tank mix application of fenoxaprop and clodinafop with metsulfuron recorded reduced efficacy towards *Phalaris minor* control confirming the results of Yadav *et al.* (2002). Clodinafop fb by metsulfuron recorded 89-93% WCE when compared with 66-67% with isoproturon + metsulfuron. Among the herbicides and their combinations, lowest weed persistance index (WPI) was observed with clodinafop fb by metsulfuron followed by fenoxaprop fb metsulfuron which may be due to control of complex weed flora when compared with sole application of fenoxaprop or clodinafop (Table 2). Singh and Singh (2006) also recorded lower WPI and higher WCE in sunflower.

Grain yield

The grain yield of wheat under all the 3 systems of tillage did not show any significant difference. Singh *et al.* (2001) also reported at par seed yield under ZT with RT and CT. Uncontrolled weeds resulted in 30% reduction in seed yield of wheat (Table 2). Grain yield under clodinafop fb metsulfuron and fenoxaprop fb metsulfuron was 18.5 and 19.0% higher than their sole application due to the wide spectrum weed control. Isoproturon + metsulfuron though produced the seed yield significantly higher than weedy check but recorded 21.7% lower yield compared to sequential application of clodinafop and fenoxaprop with metsulfuron due to reduced control of *P. minor* (Table 1). The tank mix application of fenoxaprop and clodinafop with metsulfuron though resulted in reduced efficacy towards control of *P. minor* but recorded seed yield at par with the sequential application (Table 3).

Economics

Among the different tillage systems, ZT recorded maximum net returns and benefit cost ratio followed by RT owing to reduced cost of production. The highest net returns over the control and benefit: cost ratio was observed

Table 2. Effect of tillage and herbicides on weed parameters in wheat

Tillage	Weed density (No.m^2)		Weed dry weight (g/m^2)		Weed control efficiency (%)		Weed persistence index	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Zero	(75.3) 8.0*	(62.0) 7.3*	34.26	20.66				
Reduced	(78.5) 8.3	(63.4) 7.4	22.97	16.20				
Conventional	(109.6) 9.5	(83.2) 8.3	24.45	18.11				
SEm±	(3.1) 0.2	(1.3) 0.1	0.73	0.50				
CD (P=0.05)	(12.0) 0.7	(5.0) 0.4	2.85	1.93				
Herbicide								
Fenoxaprop- p-ethyl (100 g/ha)	(116.1) 10.8	(96.3) 9.8	27.97	23.15	67.14	59.65	0.140	0.188
Clodinafop (60 g/ha)– propargyl (60 g/ha)	(111.1) 10.6	(94.2) 9.7	26.48	21.77	68.89	62.05	0.130	0.172
Fenoxaprop fb Metsulfuron (4 g/ha)	(28.3) 5.3	(19.0) 4.4	10.52	5.09	87.64	91.12	0.013	0.008
Clodinafop fb Metsulfuron	(22.3) 4.8	(18.1) 4.3	9.42	4.09	88.93	92.87	0.009	0.006
Fenoxaprop+ Metsulfuron	(35.5) 6.0	(28.3) 5.4	12.68	7.97	85.10	86.11	0.019	0.030
Clodinafop + Metsulfuron	(37.2) 6.2	(26.2) 5.2	13.10	7.84	84.61	86.33	0.021	0.028
Isoproturon 1000 g/ha + Metsulfuron	(83.7) 8.9	(67.3) 7.9	32.55	19.29	67.6	66.38	0.120	0.184
Weedy check	(266.3) 16.2	(206.6) 14.3	85.13	57.38				
SEm±	(4.3) 0.2	(2.8) 0.2	1.70	0.85				
CD (P=0.05)	(12.3) 0.6	(8.1) 0.5	4.87	2.43				

*Transformed values, Figures in parentheses indicates original values

Table 3. Effect of tillage and herbicides on grain yield and economics in wheat

Treatment	Seed yield (t/ha)		Total Variable cost (10^3 Rs/ha)		Net Returns (10^3 Rs/ha)		Benefit : Cost ratio	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Tillage								
Zero	3.58	4.03	9.06	9.98	9.56	15.00	1.05	1.50
Reduced	3.64	4.17	10.08	11.10	8.85	14.79	0.87	1.33
Conventional	3.62	4.16	11.06	12.22	7.77	13.56	0.70	1.10
SEm±	0.02	0.04						
CD (P=0.05)	NS	NS						
Herbicide								
Fenoxaprop- p-ethyl (100 g/ha)	3.37	3.93	11.44	12.48	6.08	11.88	0.53	0.95
Clodinafop (60 g/ha) – propagyl (60 g/ha)	3.35	3.97	11.56	12.60	5.85	12.01	0.50	0.95
Fenoxaprop fb Metsulfuron (4 g/ha)	4.14	4.55	11.75	12.79	9.77	15.41	0.83	1.20
Clodinafop fb Metsulfuron	4.15	4.54	11.87	12.91	9.71	15.23	0.81	1.18
Fenoxaprop + Metsulfuron	4.05	4.48	11.75	12.79	9.30	14.98	0.79	1.17
Clodinafop + Metsulfuron	4.07	4.47	11.87	12.91	9.28	14.79	0.78	1.14
Isoproturon 1000 g/ha + Metsulfuron	3.14	3.66	10.81	11.85	5.51	10.83	0.60	0.91
Weedy check	2.65	3.35	10.06	11.10	3.71	9.66	0.36	0.87
SEm±	0.03	0.04						
CD (P=0.05)	0.09	0.12						

with sequential application of fenoxaprop, clodinafop with metsulfuron (Table 3). Lowest net returns were received with application of isoproturon +metsulfuron.

The study suggests that crop of wheat can be taken up at low cost by adopting zero and reduced tillage with sequential application of fenoxaprop (100 g/ha) or clodinafop (60 g /ha) with metsulfuron (4 g/ha) for control of complex weed flora.

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