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Effect of tillage and herbicides on grain yield and nutrient uptake by wheat (*Triticum aestivum*) and weeds

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ABSTRACT

A field experiment was conducted during winter season of 2003-04 and 2004-05 on clayey soil to study the effect of different tillage practices (zero tillage, zero tillage with chemically stale seed-bed, conventional tillage and deep tillage) and herbicides (clodinafop @ 0.06 kg/ha followed by 2,4-D @ 0.5 kg/ha, isoproturon @ 1.0 kg/ha + 2,4-D @ 0.5 kg/ha and weedy check) on nutrient depletion by weeds, and the grain yield and nutrient uptake by wheat (*Triticum aestivum* L. emend. Fiori & Paol.). The depletion of N, P and K by weeds and uptake by crop were more or less the same under zero, conventional and deep tillage systems. Clodinafop 0.06 kg/ha followed by 2,4-D at 0.50 kg/ha gave 45.88-47.05 and 63.20-66.08 per cent higher grain yield than isoproturon + 2,4-D and weedy check respectively. The N, P and K uptake by wheat increased by 44.29-51.24, 12.00-12.87 and 8.37-9.87 kg/ha due to application of clodinafop followed by 2,4-D, whereas isoproturon + 2,4-D increased the uptake by 10.85-15.50, 3.12-4.63 and 2.31-2.89 kg/ha N, P and K respectively compared with weedy check. Maximum benefit: cost ratio was obtained with zero tillage along with application of clodinafop followed by 2,4-D.

Key words: Economics, Grain yield, Herbicide mixture, Nutrient depletion, Tillage, Weeds, Wheat

Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is an important cereal crop of Madhya Pradesh, invaded by both grassy and broad-leaf weeds. The intensive tillage operations after the harvest of transplanted rice (*Oryza sativa* L.) not only require a huge amount of energy and time but also increase the cost of production. To make the system economically viable, it is essential to reduce the cost of input per unit of output. Under such a situation, zero-tillage technology could be a valid option to reduce the turn-around time, cost and establishment of good crop stand of wheat without loss in productivity and sustainability of natural resources. The weeds are the major hurdle in the adoption of zero-tillage technology in wheat. Though zero tillage in wheat fields reduces the infestation of *Phalaris minor*, it aggaravates the problem of *Avena ludoviciana* as well as some broad-leaf weeds (Yaduraju and Mishra, 2002). If these weeds are not controlled in time, they reduce the wheat yield sustainability up to 10 to 50% (Walia *et al.*, 1990). Presently isoproturon is being used in wheat for effective control of weeds like *Phalaris minor* and a few others but it is not much effective against *Avena ludoviciana*. Hence, there is an urgent need to identify an alternative herbicide that could control it as well as other predominant weeds. Effective control of weeds is important not only to check the yield losses due to weeds but also to reduce the nutrient losses. Pandey *et al.* (2001) reported nutrient depletion by weeds up to 24.3-28.6% N, 13.5-16.2% P and 22.3-25.2% K. Johri *et al.* (1992) found that N, P and K uptake by the crop was respectively 56, 45 and 60% less, when the weeds were allowed to grow throughout the growing season compared with the weed-free plots. Combined use of tillage and herbicides may greatly check the loss of nutrients. Therefore the present investigation was carried out to find out the effect of tillage and herbicides on grain yield of wheat and nutrient removal by wheat and weeds.

MATERIALS AND METHODS

A field experiment was conducted at National Research Centre for Weed Science, Jabalpur (23°90' N, 79°58' E, 412 m above mean sea-level) during the winter season of 2003-04 and 2004-05 after the harvest of transplanted rice. The soil was clayey, medium in organic C (0.66%) and available P (17 kg/ha) and K (298 kg/ha), low in available N (239 kg/ha), and neutral in reaction (pH 7.2). After the harvest of rice, 12 treatment combinations involved four tillage packages as main-plot treatments, viz. zero tillage (ZT), ZT with chemically stale seed-bed, conventional till-

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age (CT) and deep tillage (DT), and three weed-control practices as subplot treatments, viz. weedy check, isoproturon @ 1.0 kg/ha + ethyl ester of 2,4-D @ 0.5 kg/ha and clodinafop @ 0.06 kg/ha followed by ethyl ester of 2,4-D @ 0.5 kg/ha. These were laid out in split-plot design replicated four times. The gross plot size was 8.0 m ×10.0 m. Deep tillage consisted of disc ploughing once + cultivator twice + rotavator. Conventional tillage involved cultivator twice + leveller, whereas zero tillage included planting directly with zero-till seed drill in the presence of rice residue. In ZT with chemical stale seed-bed, emerged weeds were killed using glyphosate (1% solution) before sowing. Wheat variety 'WH 147' was sown at seed rate 120 kg/ha by tractor-mounted zero-till seed-cum-fertilizer drill in rows 20 cm apart in ZT; but in the plots receiving conventional and deep-tillage treatments, the seeds were sown with the normal seed-cum-fertilizer drill at the same row spacing. Fertilizers were applied uniformly in all the plots through urea, diammonium phosphate and muriate of potash @ 120 kg N, 26.2 kg P and 33.3 kg K/ha in both the years. Half the nitrogen and full quantity of phosphorus and potassium were given basal and the remaining nitrogen was given in two splits just a day after the first and second irrigations in both the years. In zero-tillage plots the crop was sown on 16 November whereas; in zero-tillage plots with chemical stale seed-bed, conventional tillage and deep tillage, the crop was sown on 27 November during both the years. Isoproturon and 2,4-D were applied as tank mixed in 500 litres water/ha at 25 days after sowing (DAS), whereas clodinafop and 2,4-D were sprayed separately at 25 and 30 DAS respectively, each in 500 litres water/ha by knapsack sprayer using flat-fan nozzle.

RESULTS AND DISCUSSION

Weed infestation

The major weeds observed in the experimental plots were *Avena ludoviciana* (66.75-79.22%) among monocotyledons and *Medicago hispida* (19.30-26.99%) among dicotyledons. The other weeds present in the field were *Phalaris minor* (0.44-0.80%), *Chenopodium album* (0.42-4.79%). *Vicia sativa* (0.10-0.18%) and *Lathyrus aphaca* (0.32-0.49%).

The tillage practices did not influence the intensity of weeds (Table 1). Higher population of *A. ludoviciana* under zero tillage was due to fact that flooding facilitates the wild oat seeds to float on the surface due to their lighter weight and higher surface area (Yaduraju and Mishra, 2002). Application of clodinafop followed by 2,4-D resulted in significantly lower weed density (9.20/m^2) and proved more effective than of isoproturon + 2,4-D (17.57/m^2) and weedy check (22.98/m^2). The efficacy of clodinafop followed by 2,4-D was more than of isoproturon + 2,4-D in reducing the population of grassy weeds. This was due to better efficacy of clodinafop against *Avena ludoviciana*, which accounted more than 65% of the weed population (Brar *et al.*, 2000).

Minimum dry weight of weeds was recorded under conventional tillage but the differences were non-significant between zero tillage and deep tillage (Table 1). Application of clodinafop followed by 2,4-D recorded significantly lower dry weight of weeds than isoproturon + 2,4-D and weedy check. Brar *et al.* (2000) also reported effective control of grassy weeds by clodinafop. Malik *et al.* 1988) also reported poor efficacy of isorproturon + 2,4-D

Table 1. Effect of tillage packages and herbcides on weed density (number/m^2) and dry weight of weeds (g/m^2) at 50 days after sowing and weed-control efficiency at harvest (pooled data of 2003-04 and 2004-05)

Treatment	*Avena ludoviciana*	*Medicago hispida*	Total weeds	Dry weight of weeds	Weed-control efficiency (%)
Tillage					
Zero tillage	16.02 (325.29)	5.04 (30.42)	17.54 (366.74)	11.67 (135.71)	59.46
Zero tillage with chemical stale seed-bed	14/30 (250.50)	4.89 (33.29)	16.01 (290.93)	11.57 (133.44)	56.78
Conventional tillage	14.54 (259.00)	4.86 (32.67)	16.17 (299.81)	11.05 (121.57)	62.70
Deep tillage	14.69 (262.75)	5.49 (38.17)	16.75 (317.92)	11.40 (129.36)	63.74
SEm±	0.98	0.76	0.88	0.74	
CD (P=0.05)	NS	NS	NS	NS	
Weed control					
Weedy check	16.46 (274.75)	7.33 (59.15)	22.98 (545.31)	14.70 (215.54)	
Isoproturon + 2,4-D	12.71 (162.50)	1.80 (3.35)	17.57 (324.42)	10.56 (110.91)	49.68
Clodinafop fb 2,4-D	7.04 (50.44)	6.08 (38.41)	9.20 (86.83)	8.01 (63.60)	71.52
SEm±	0.56	0.43	0.59	0.39	
CD (P=0.05)	1.63	1.26	1.71	0.95	

*Data subjected to square-root transformation; original values are in parentheses in controlling *A. ludoviciana*. Saini and Singh (2001) reported significantly lower dry weight of weeds due to application of clodinafop. Isoproturon + 2,4-D was however found significantly better in reducing the dry weight of weeds than weedy check.

Weed-control efficiency varied from 68.18 to 72.42% under the different tillage packages during the first year but it was higher under tilled condition during the second year. Clodinafop followed by 2,4-D resulted in higher weed-control efficiency than isoproturon + 2,4-D.

Grain yield of wheat

Variation in tillage packages also did not affect grain yield of wheat significantly. Herbicidal treatments, however, recorded significantly higher grain yield than weedy check (Table 2). The grain yield was significantly higher in the plots receiving clodinafop followed by 2,4-D after different tillage packages than isopoturon + 2,4-D and weedy check. Clodinafop followed by 2,4-D gave 45.88-47.05% and 63.20-66.08% higher grain yield over isoproturon + 2,4-D and weedy check respectively. Dhaliwal *et al.* (1998) also registered significant increase in grain yield of wheat with clodinafop than with isoproturon.

Nutrient uptake by crop and weeds

Tillage packages were at par in NPK uptake by wheat (Table 3). Application of clodinafop followed by 2,4-D increased the uptake of N, P and K by wheat by 44.29-51.24, 12.00-12.87 and 8.37-9.87 kg/ha, whereas isoproturon + 2,4-D increased the uptake by 10.85-15.50, 3.12-4.63 and 2.31-2.89 kg/ha N, P and K respectively over the weedy check. The higher increase in nutrient uptake by grain and straw under clodinafop followed by 2,4-D was due to effective control of weeds, which provided congenial environment for crop growth.

Conventional tillage reduced the NPK depletion by weeds than zero tillage and deep tillage, but the differences were non-significant (Table 3). Significantly lower nutrient removal was registered in clodinafop followed by the plots treated with 2,4-D than isoproturon + 2,4-D and weedy check. The higher reduction in depletion under clodinafop followed by 2,4-D was due to effective control of weeds under it. Application of isoproturon + 2,4-D reduced the nutrient losses due to weeds owing to control of both grassy as well as broad-leaf weeds compared with the weedy check. Pandey *et al.* (2001) reported reduction in NPK depletion by adopting suitable weed-control practices.

Economics

Monetary returns were higher under zero tillage in the first year due to higher yields and lower cost of cultivation, but were higher under conventional tillage in the second year due to higher grain yield (Table 4). Postemergence application of clodinafop followed by 2,4-D was more economical than isoproturon + 2,4-D. The higher net monetary return under the former was due to higher grain yield.

The benefit : cost (B:C) ratio under zero tillage was relatively higher than under conventional tillage, whereas it was lower under zero tillage with chemical stale seed-bed and deep tillage due to higher cost of cultivation. Rautaray (2002) also reported higher B:C ratio under zero tillage than conventional tillage. Clodinafop followed by 2,4-D attained the highest B:C ratio due to considerable increase in yield than isoproturon + 2,4-D. The profitability was minimum under weedy check, due to the lower

Table 2. Effect of tillage packages and weed-control practices on grain yield of wheat (t/ha)

Weed control	Tillage: Zero tillage	Zero tillage with chemical stale seed-bed	Conventional tillage	Deep tillage	Mean
		2003-04			
Weedy check	1.32	1.74	1.79	1.25	1.53
Isoproturon + 2,4-D	2.68	2.42	2.38	2.37	2.46
Clodinafop fb 2,4-D	4.84	4.46	4.71	4.20	4.55
Mean	2.95	2.87	2.96	2.61	
		2004-05			
Weedy check	1.34	1.54	1.73	1.56	1.54
Isoproturon + 2,4-D	1.85	2.01	2.39	2.37	2.16
Clodinafop fb 2,4-D	4.03	4.56	4.22	4.06	4.22
Mean	2.41	2.70	2.78	2.66	

	Tillage (T)		*Weed-control (W)*		*T × W at same T*		*T × W at same W*	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
SEm ±	0.19	0.19	0.15	0.15	0.29	0.30	0.31	0.31
CD (P=0.05)	NS	NS	0.44	0.48	0.87	0.88	NS	NS

Table 3. Effect of tillage packages and herbicides on nutrient uptake by wheat and weeds

Treatment	Nutrient depletion by weeds (kg/ha)						Total uptake by wheat (kg/ha)					
	N		P		K		N		P		K	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Tillage												
Zero tillage	18.24	35.92	3.48	8.12	12.03	28.03	49.17	39.06	12.79	10.56	9.56	7.20
Zero tillage with chemical stale seed-bed	18.80	29.64	3.29	6.38	11.69	22.98	47.92	43.95	12.65	11.87	9.00	8.38
Covnentional tillage	17.71	28.03	3.28	6.09	11.71	21.87	49.34	45.20	13.49	12.04	8.93	8.54
Deep tillage	20.17	30.64	3.94	6.85	13.64	23.77	43.20	43.39	10.97	11.58	8.28	7.83
SEm±	2.31	6.12	0.59	0.92	1.77	3.14	3.09	2.53	0.79	0.64	0.59	0.50
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed control												
Weedy check	37.06	55.93	7.06	12.58	24.38	43.27	25.16	24.52	6.64	6.47	4.69	4.43
Isoproturon + 2,4-D	13.36	33.02	2.41	7.06	8.81	25.91	40.66	35.37	11.27	9.59	7.58	6.74
Clodinafop fb 2,4-D	5.79	4.23	1.03	0.95	3.59	3.30	76.40	68.81	19.51	18.47	14.56	12.80
SEm±	1.39	4.63	0.37	0.66	1.24	3.56	2.45	2.24	0.69	0.58	0.47	0.43
CD (P=0.05)	4.05	13.92	1.06	1.93	3.63	10.39	7.18	6.54	2.02	1.70	1.36	1.25

Table 4. Effect of tillage packages and herbicides on economics of wheat

Treatment	Cost of cultivation (Rs/ha)	Net monetary return (Rs/ha)		Benefit:cost ratio	
		2003-04	2004-05	2003-04	2004-05
Tillage					
ZT immediately after rice	9,204	11,706	8,065	1.81	2.18
ZT with chemical stale seed-bed	11,029	9,585	8,146	1.68	1.82
Conventional tillage	10,104	11,079	9,768	1.92	2.04
Deep tillage	10,974	7,739	8,033	1.69	1.65
Weed control					
Weedy check	9,168	2,386	2,245	1.25	1.27
Isoproturon + 2,4-D	10,130	7,764	5,552	1.55	1.78
Clodinafop fb 2,4-D	11,685	19,932	17,713	2.52	2.73

yield on account of higher crop-weed competition.

It may be concluded that zero-till sowing of wheat and controlling weeds with post-emergence application of clodinafop followed by 2,4-D gives higher crop yield with higher monetary returns in rice-wheat system.

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