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Long-Term Effect of Tillage and Weed Control on Weed Dynamics, Soil Properties and Yield of Wheat in Rice-Wheat System

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ABSTRACT

A field experiment was conducted at Jabalpur during winter seasons of 2001-02, 2002-03, 2003-04 and 2004-05 to study the influence of tillage and herbicides on weed dynamics, yield and soil properties under rice-wheat system in vertisols. Irrespective of the tillage, population of *Phalaris minor* and *Chenopodium album* decreased and that of *Avena ludoviciana* and *Medicago hispida* increased over time. Zero tillage reduced the population of *P. minor* and *C. album* but increased the population of *A. ludoviciana* as compared to conventional tillage. Application of clodinafop at 0.06 kg/ha *fb* 2, 4-D ethyl ester at 0.50 kg/ha effectively controlled both grassy and broad-leaved weeds and produced 77.8% higher grain yield than that of isoproturon 1.0 kg + 2,4-D 0.50 kg/ha. Under moisture stress, zero tillage retained more soil moisture than conventional tillage. Tillage and weed control did not affect the physico-chemical properties of soil.

Key words : Long-term effect, tillage, herbicide, soil properties, weed dynamics

INTRODUCTION

Zero tillage (ZT) technology in wheat has already proven its worth in the rice-wheat cropping system and is being followed on nearly 2.1 million ha area of Indo-Gangetic Plains of India (Yadav *et al*., 2009). In medium and heavy textured soils (Vertisols) of Madhya Pradesh, the tillage operations are difficult. Moisture stress in these soils results in deep (more than 50 cm) and wide (1-5 cm) cracks and higher moisture content makes the soil sticky and plastic and thus, difficult to manage. With increased combine harvest of rice, residues pose problem in tillage resulting in delayed sowing and lower wheat yield. Under such conditions too, zero tillage in wheat has increased the grain yield as compared to conventional tillage in rice-wheat system (Rautaray, 2002). Altering tillage practices changes weed seed depth in the soil, which plays a major role in weed species shifts and affects the efficacy of control practices. Although, zero tillage has reduced the incidence of *Phalaris minor*, the problem of *Avena ludoviciana* and some broad-leaved weeds has increased (Yaduraju and Mishra, 2002). Hence, there is a need to find out the long-term effect of tillage and weed control on weed dynamics, soil properties and productivity of wheat in rice-wheat system.

MATERIALS AND METHODS

A long-term (2001-02 to 2004-05) field experiment was conducted at National Research Centre for Weed Science, Jabalpur ($23^0 90'$ N, $79^0 58'$ E, 412 m above mean sea level). The soil was clay loam (Typic Chromusterts), low in available nitrogen (238 kg/ha), medium in available phosphorus (18 kg P/ha), and high in available potassium (304 kg/ha), with organic carbon 0.54% and pH 6.8. Treatments consisting of two tillage systems (zero and conventional) in main plots and three weed management practices (isoproturon 1.0 kg/ha+2, 4-D ethyl ester 0.50 kg/ha at 25 days after sowing (DAS), clodinafop 0.06 kg/ha at 30 DAS followed by 2, 4-D ethyl ester 0.50 kg/ha at 35 DAS and a weedy check in sub-plots were replicated four times in a split-plot design with four replications. Conventional tillage consisted of disc ploughing once, tillage twice with a field cultivator (5 cm wide shovels), rototilled once with a vertical tine tiller to prepare a fine seedbed before planting the crops. Zero-till crops were planted by direct seeding into dead residue of the previous crop without field preparation using zero till ferti-seed drill having inverted T-type furrow openers. Glyphosate [N-(phosphonomethyl) glycine] at 1000 g/ha was applied one week before seeding in all the

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zero-till plots to kill the existing vegetation. Field was irrigated through sprinkler immediately after sowing to ensure proper seed germination. The crops were raised under irrigated conditions with recommended package of practices except weed control. Weed density was recorded at 30 DAS from 1 m^2 area by placing a 50 x 50 cm quadrat randomly at four places in each plot. Weed dry matter was collected at 90 DAS (before crop harvesting) from 1 m^2 area by placing a quadrat of 50 x 50 cm randomly at four places in each plot. Soil properties were measured after the completion of 4th year experiment. Soil moisture was measured by gravimetric method.

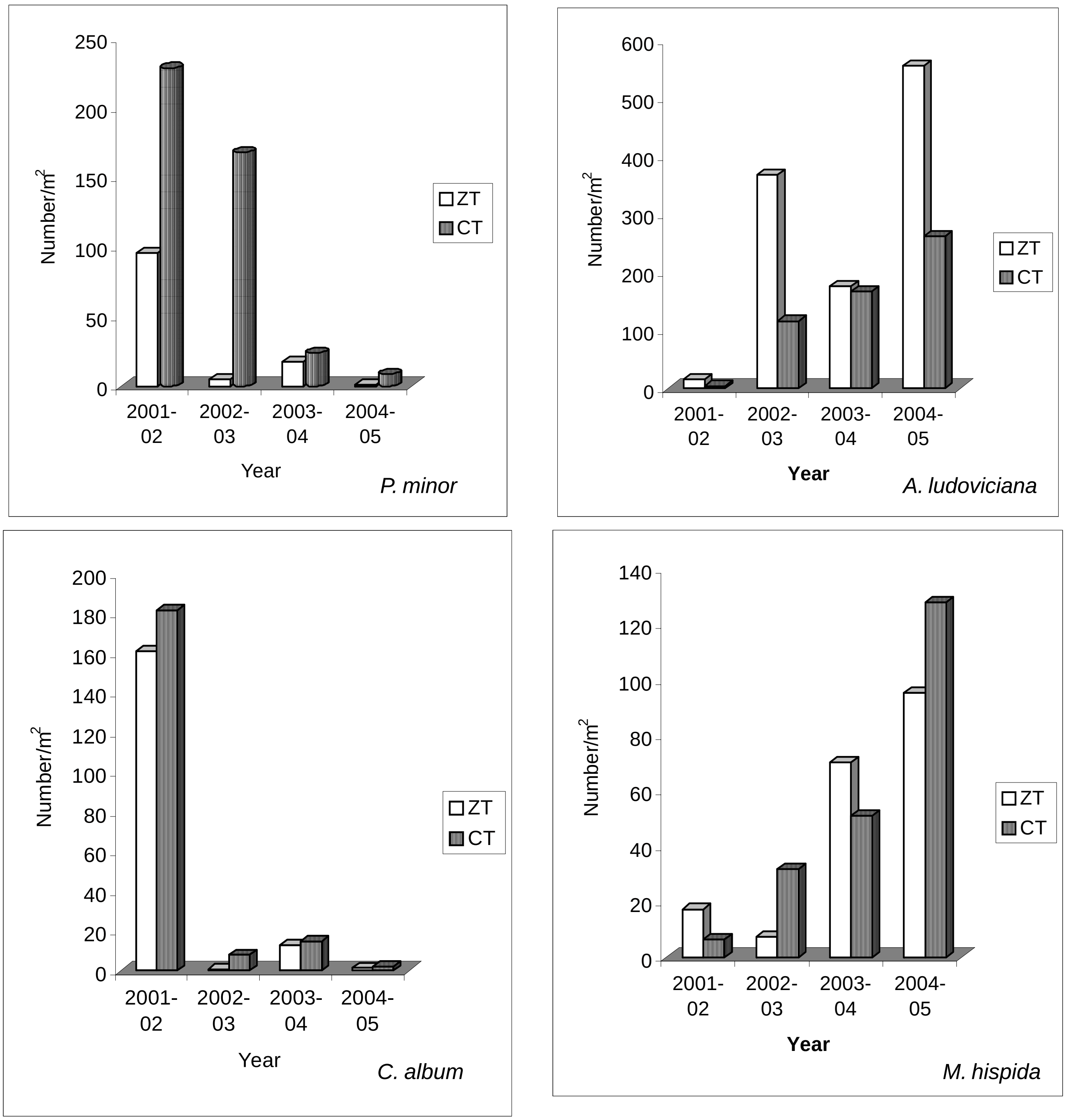

Fig. 1. Influence of tillage practices on weed dynamics in wheat.

$$\text{Soil moisture (\%)} = \frac{\text{Weight of wet soil} - \text{Weight of oven-dry soil}}{\text{Weight of oven-dry soil}} \times 100$$

RESULTS AND DISCUSSION

Weed Dynamics

The experimental field was infested with wild oats (*Avena sterillis* ssp. *ludoviciana*), burclover (*Medicago hispida* Gaertn.), littleseed canarygrass (*Phalaris minor* Retz.), common lambsquarters (*Chenopodium album* L.), common vetch (*Vicia sativa* L.) and lathyrus (*Lathyrus aphaca* L.). Initially (2001-02), the population (No./m^2) of *P. minor* (162.5) and *C. album* (171.5) was higher (46.8 and 48.5%, respectively of the total population) as compared to *M. hispida* (6.78) and *A. ludoviciana* (9.75) (1.9 and 2.8%), but after four years (2004-05), the trend was completely reverse (Fig. 1). Irrespective of the tillage, population of *P. minor* (4.77) and *C. album* (1.75) decreased drastically (1.0 and 0.33%, respectively, of the total population) and that of *A. ludoviciana* (409) and *M. hispida* (111.75) increased (77.6 and 21.2%). Because of increased density and vigorous growth of *A. ludoviciana*, it suppressed other weeds in general and *P. minor* and *C. album* in particular over time. Zero tillage reduced the population of *P. minor* and *C. album* but increased the population of *A. ludoviciana* as compared to conventional tillage. The population of *M. hispida;* however, did not show any definite trend in response to tillage. Tank mix application of isoproturon+2,4-D failed to control wild oats and resulted in increased population similar to that of weedy check. Application of clodinafop at 0.06 kg/ha *fb* 2,4-D at 0.50 kg/ha effectively controlled both grassy and broad-leaved weeds (Fig. 2).

Grain Yield

In general, tillage did not influence the grain yield of wheat over the years except in 2003-04, where zero tillage yielded significantly higher than conventional tillage. Weeds caused 59.8% reduction in grain yield of wheat as compared to clodinafop *fb* 2, 4-D. The highest mean grain yield (3230 kg) was recorded with application of clodinafop *fb* 2,4-D due to effective control of wild oats and other weeds,

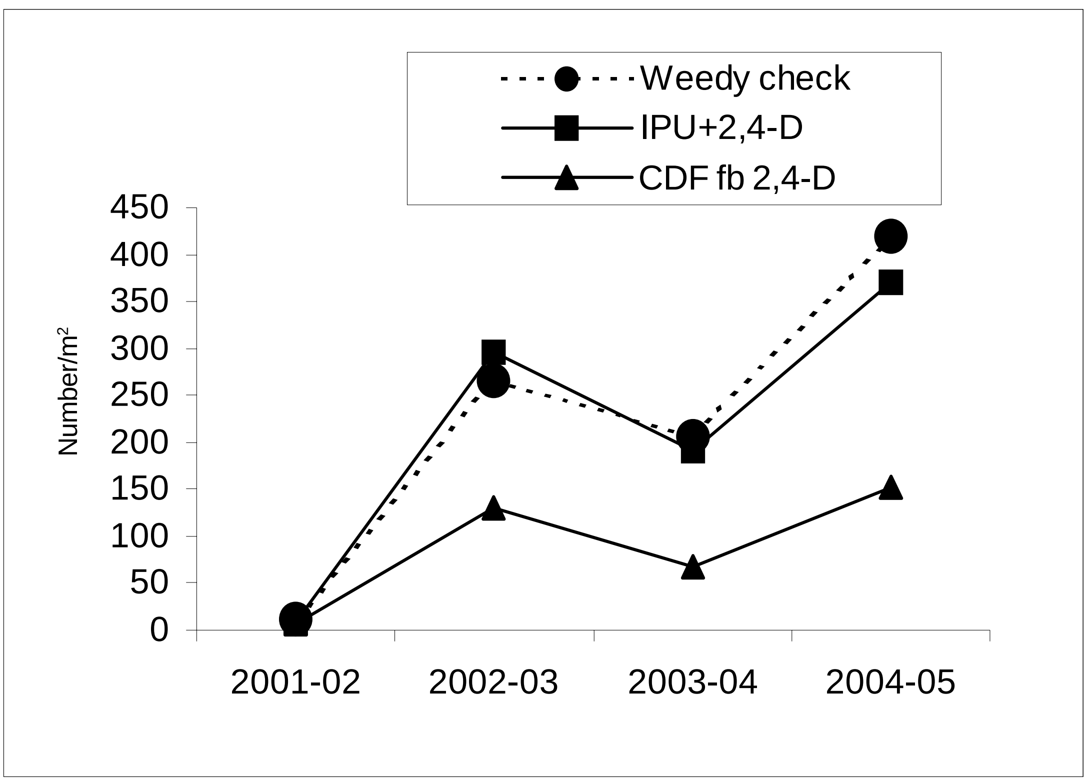

Fig. 2. Effect of long term use of herbicides on infestation of wild oat in wheat.

which was 77.8% higher than that of isoproturon+2,4-D (1817 kg) (Table 1). Lower grain yield in isoproturon+2, 4-D treated plots was due to poor control of wild oats.

Effect of Tillage on Soil Moisture and Physico-chemical Properties

Irrespective of the depth, conventional tillage stored more soil moisture upto five days after first irrigation as compared to zero tillage (Table 2). This might be due to more pore spaces available in soil due to tillage, which allowed more water storage in the soil. However, after 25 days of first irrigation, zero tillage retained more soil moisture (17.88%) as compared to conventional tillage (14.41%) indicating moisture conservation in zero tillage. Preceding crop residue cover in zero tillage provides shade that typically reduces the amount of solar radiation reaching the soil (Sauer *et al.*, 1998), and reduces evaporation rates causing the soil to warm more slowly (Shinners *et al.*, 1994). Variation in tillage did not influence the physico-chemical properties of soils, except organic carbon content, which was slightly improved in zero tillage as compared to conventional tillage. Weed control treatments did not affect the soil properties (Table 3).

Table 1. Effect of tillage and herbicides on grain yield of wheat

Treatments	Grain yield (kg/ha)				
	2001-02	2002-03	2003-04	2004-05	Mean
Tillage					
Zero tillage	1847	1965	2950	1758	2130
Conventional tillage	1981	2033	2674	1694	2096
LSD (P=0.05)	NS	NS	NS	NS	
Weed control					
Weedy check	1707	1133	1455	892	1297
Isoproturon at 0.75 kg+2, 4-D at 0.50 kg/ha	1844	1466	2490	1467	1817
Clodinafop at 0.06 kg fb 2, 4-D at 0.50 kg/ha	2192	3419	4492	2818	3230
LSD (P=0.05)	262	311	428	348	-

NS–Not Significant.

Table 2. Effect of tillage on soil moisture content at different soil depths

Soil depth (cm)	Soil moisture (%) at different time intervals				
	Three days after first irrigation	Four days after first irrigation	Five days after first irrigation	Seven days after first irrigation	25 days after first irrigation (just before second irrigation)
Zero tillage					
0-5	27.10	23.31	22.10	22.79	15.60
5-10	25.46	24.71	20.50	20.59	19.35
10-20	23.26	19.84	16.94	17.05	18.69
Mean	25.27	22.62	19.85	20.14	17.88
Conventional tillage					
0-5	28.73	24.93	23.13	17.40	11.73
5-10	26.47	27.67	23.67	21.95	15.53
10-20	24.82	21.41	17.96	21.67	15.98
Mean	26.67	24.68	21.59	20.34	14.41

Table 3. Effect of tillage and herbicides on soil properties

Treatments	Bulk density (Mg/m^3)	Infiltration rate (cm/h)	EC (dS/m)	pH	Organic carbon (%)
Tillage					
Zero	1.33	1.46	0.34	7.16	0.72
Conventional	1.34	1.44	0.35	7.14	0.67
LSD (P=0.05)	NS	NS	NS	NS	0.04
Weed control					
Weedy check	1.33	1.45	0.35	7.14	0.68
Isoproturon at 0.75 kg+2, 4-D at 0.50 kg/ha	1.34	1.46	0.36	7.15	0.69
Clodinafop at 0.06 kg *fb* 2, 4-D at 0.50 kg/ha	1.34	1.45	0.34	7.15	0.71
LSD (P=0.05)	NS	NS	NS	NS	NS

NS–Not Significant.

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