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EFFECT OF TILLAGE AND WEED MANAGEMENT PRACTICES ON GRASSY WEEDS IN WHEAT (*Triticum aestivum* L.)

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Abstract: In this study, weed management in wheat influenced by different tillage and weed management systems was investigated. The experiment was carried out during two growing seasons (2014-15 and 2015-16). The two factors (different tillage and weed management systems) were studied, with four levels of tillage systems (conventional tillage no-residue, conventional tillage with residue, zero tillage no residue, zero tillage with residue) in main plot and six levels of post-emergence weed management systems (weedy check, weed free, mesosulfuron 12 g ai. ha^{-1} at 30 DAS *fb* one hand weeding at 45 DAS, metsulfuron 4 g ai. ha^{-1} at 30 DAS *fb* one hand weeding at 45 DAS, clodinafop +metsulfuron 60+4 g ai. ha^{-1} at 30 DAS and mesosulfuron + iodosulfuron 12+2.4 g ai. ha^{-1} at 30 DAS) were allocated to sub plots. The conventional tillage with or without residue retention, performed for seedbed preparation recorded the emergence of a high percentage of weeds, increases the appearance of grassy weeds, especially *Phalaris minor, Avena ludoviciana, and Cynodan dactylon* in wheat crops, when compared to their establishment in zero-till system with or without residue retention. Among post-emergence herbicide treatment, mesosulfuron + iodosulfuron recorded lowest population of grassy weeds followed by clodinafop + metsulfuron. Therefore, zero tillage with residue and the mix application of mesosulfuron + iodosulfuron can be recommended for grassy weed control in wheat in eastern part of Uttar Pradesh.
Keywords: Herbicides, Zero tillage, Conventional tillage, Weed, Wheat.

Introduction

Wheat (*Triticum aestivum L.*) is an important *Rabi* season crop of Uttar Pradesh, contributing towards food security of the country to a large extent. Heavy weed infestation is one of the major factor declining productivity of wheat. In wheat, acute problem of both grassy and broad leaved weeds is becoming very common in north India. The crop is infested with heavy population of *Phalaris minor, Cyperus rotundus, Cynodon dactylon, Chenopodium album, Chenopodium murale, Spergula arvensis, Vicia sp., Desmodium trifoloium, Anagallis arvensis, Avena fatua, Avena ludoviciana, Rumex dentatus, Coronopus didymus, Convolvulus arvensis* and *Lathyrus aphaca etc.* Uncontrolled weeds are reported to cause upto 66%

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reduction in wheat grain yield (Singh *et al*., 2015) or even more depending upon the weed density, type of weed flora and duration of infestation.

It is known that tillage, carried out by plough, was accepted, traditionally, as a principal means for guaranteeing a clean seedbed for crops. On the other hand, it can also be fundamental for controlling weeds (Verma *et al*., 2015). An increase in the weeds in reduced tillage systems, can be attributed to the direct effect of tillage on the weeds, their seed production, the seed bank, survival during certain periods and spreading, as a consequence of the propagating weed parts that are cut by the equipment. For example, tillage for preparation of seedbed can improve the conditions for germination of weeds, which will increase the population density of the weeds in the crop (Bahadur *et al*., 2015).

With regard to zero-till systems, which are characterized by depositing seeds on the top soil, it is necessary to follow an appropriate procedure, to avoid high weed densities and prevent unacceptable problems (Susha *et al*., 2014). Therefore, in zero-till and reduced tillage systems, the application of pre-sowing non selective herbicides is a common practice to control the perennial weeds which are already present. This application substitutes tillage, which cause great soil disturbances, and can have advantages with regard to water storage and increase wheat grain yield (Shakher *et al*., 2014). During the past two decades Indian farmers are searching increasingly for alternatives to the traditional system for the establishment of winter cereals, based predominantly on tillage. In reduced tillage and especially zero-till systems they are looking for options able to provide environmental but mainly economical sustainability in a region where natural conditions strongly limit wheat productivity levels.

For the adoption of modern agriculture systems and their widespread uptake, weed flora and its dynamics must be understood. The knowledge and study of these dynamics is essential to define best management practices for weed control under given environmental conditions. There are differences in the infestation dynamics between traditional tillage based and zero-till systems, because soil disturbance can both promote germination of the seeds of the existing seed bank in the soil as well as destroy the weeds that are already established.

Chemical weed control is a preferred practice due to scarce and costly labour as well as lesser feasibility of mechanical or manual weeding especially in broadcast wheat (Singh *et al*., 2015). Few herbicides such as sulfosulfuron, metsulfuron, fenoxaprop, iodosulfuron, mesosulfuron, pinoxadim and clodinafop have sown their high efficacy against weeds in wheat. At present, some herbicides molecules (ready mixed combination) having its very high potency at lower doses to kill grassy along with other weeds have been developed. These molecules may be more effective to control various weed species as well as relatively safer for environmental pollution point of view. Hence, there is a need to find out some suitable tillage and weed management system to tackle this problem of weed flora in wheat. Keeping above facts in mind the present investigation was carried out to evaluate the effect of tillage and weed management practices on grassy weeds in wheat.

Materials and methods

A field experiment was carried out during the winter (*rabi*) season of 2014-15 and 2015-16 at Institute of Agricultural Sciences, BHU, Varanasi. The soil of the experimental field was sandy clay loam in texture, with slightly alkaline in reaction (pH 7.8). It was moderately fertile, being low in available organic carbon (0.43 %), available nitrogen (206.2 kg ha^{-1}), and available phosphorus (19.2 kg ha^{-1}) and potassium (238.2 kg ha^{-1}). Average values for bulk density 1.42 g cm^{-1}, particle density 2.62 g cm^{-1}, filed capacity 19.57%, permanent wilting point 4.31% and EC were 0.181 dSm^{-1}. The experiment was conducted in split plot design with three replication. Treatments consisted of four crop establishment methods *viz*. conventional tillage no-residue, conventional tillage with residue, zero tillage no-residue and zero tillage with residue were assigned to main plots and weed management practices *viz*. weeded check, weed free (Weeds were removed with the help of hand hoe during entire crop period), mesosulfuron (12 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS, metsulfuron (4 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS, clodinafop +metsulfuron (60+4 g ai. ha^{-1}at 30 DAS) and mesosulfuron + iodosulfuron (12+2.4 g ai. ha^{-1} at 30 DAS) were allocated to sub plots. Conventional tillage plots were ploughed by tractor- drawn disc plough followed by planking and zero tillage plots was left undisturbed. Wheat variety ‘HUW 234’ was sown under different crop establishment methods at row distance of 22.5 cm by opening slits with zero-till-drill machine. Previous season rice straw was applied @ 6 t ha^{-1}as mulch in the respective treatments. All the herbicides were applied as post emergence (30 DAS) with the help of foot sprayer fitted with flat fan nozzle. The spray volume was 500 litres water/ha. Half amount of nitrogen and full dose of phosphorus and potash were applied as basal at the time of sowing, ¼ part of nitrogen was top dressed after first irrigation and remaining ¼ part of nitrogen was top dress at spike initiation stage. The nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and murate of potash, respectively. Three irrigations were given to crop at critical stages of growth (CRI- 21DAS, before spike initiation-75 DAS and grain filling 90 DAS) stages. An area of 0.25 m^2 was selected randomly at 3 spots by throughing a quadrate of 0.5x0.5m, weed species were counted from that area, and density was expressed in numbers m-^{2} at 40 and 80 days after sowing. The collected weeds ere first sun-dried and then kept in an electric oven at 70^{o} C till the weight become constant, and dry weight was expressed as g m^{-2}. As wide variation existed in data, number and dry weight of weeds were transformed through squire-root $\sqrt{(x+0.5)}$ methods before analysis of variance. Wheat was harvested manually, but was threshed by power operated thresher. Grain yield were recorded at harvest of crop. Recorded data analyzed statistically to draw a valid conclusion.

Results and discussion

Weed population

The conventional soil tillage system increased the number of grassy weeds (*Phalaris minor, Avena ludoviciana* and *Cynodon dactylon*) at the beginning of the tillering stage of the wheat (at 40 DAS). During this period, the zero till system is characterized by the occurrence of less grassy weeds. The counting of the weeds carried out at the heading stage of the wheat (at 80 DAS), showed that the average number of grassy weeds continues to be less under no-till (Table 1). Therefore, conservation agriculture, especially zero-till system, can contribute to decrease grassy weeds in wheat.

Significantly the maximum population of *Phalaris minor, Avena ludoviciana* and *Cynodon dactylon* was recorded under conventional tillage no-residue, which facilitates an adequate growing environment to the weeds. Zero tillage with residue recorded minimum population of these grassy weeds followed by conventional tillage with residue, conventional tillage no-residue and zero tillage no-residue, respectively. This was owing to more suppression ability of zero tillage with residue as mulch resulting in lowest population of these weeds or perhaps mulch provided a competitive advantage to crop over weeds for resource utilization than without residue treatments. In the entire situation, residue treatments had lowest population of these grassy weeds than without residue under zero and conventional tillage system. This indicated possible smothering effect of residues on weeds. Results are corroborated with the research results of Chhokar *et al*. (2007) and Nath *et al*. (2016).

Soil tillage enhanced the emergence of grassy weeds, mainly *Phalaris minor, Avena ludoviciana* and *Cynodon dactylon*, the dominant species in the region of the study. Therefore, despite the elimination of weeds through tillage performed for seedbed preparation, an increase in weed emergence can be expected after crop establishment (Calado *et al*., 2013), due to more favourable conditions for weed germination created by the tillage operations (Mirsky *et al*., 2010).

Weed management practices significantly reduced the population of *Phalaris minor, Avena ludoviciana* and *Cynodon dactylon* as compared to weedy check. Mix application of mesosulfuron + iodosulfuron (12+2.4 g ai. ha^{-1} at 30 DAS) were significantly at par with clodinafop +metsulfuron (60+4 g ai. ha^{-1}at 30 DAS) at 40 and 80 days after sowing of wheat which recorded the lowest weed density of *Phalaris minor, Avena ludoviciana* and *Cynodon dactylon* as compared to rest of the herbicidal treatments. Application of mesosulfuron (12 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS, metsulfuron (4 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS were however significantly superior over untreated control but found to be least effective against these grassy weeds as compared to mix application of the herbicide treatments when observed at 40 and 80 days after treatment. None of the herbicidal treatments as effective as weed free condition with respect to reduction of grassy weed population. Excellent control of complex weed flora in wheat was observed with the tank mix application of clodinafop + metsulfuron at 60 g ha^{-1} (Tiwari *et al*., 2015) and mesosulfuron-methyl 3% + idosulfuron-methyl sodium 0.6% WG at 400 g ha^{-1} (Singh *et al*., 2015).

Weed dry matter accumulation

Zero tillage with residue recorded significantly lowest dry matter accumulation by *Phalaris minor, Avena ludoviciana* and *Cynodon dactylon* as compared to conventional tillage with residue, conventional tillage no-residue and zero tillage no-residue, respectively (Table 2). This was owing to more suppression ability of zero tillage with residue as mulch resulting in lowest weed population and dry matter accumulation.

Weed management treatments significantly reduced the dry matter of grassy weeds as compared to weedy check. At 40 and 80 DAS, lowest dry weed weight of grassy was recorded with mesosulfuron + iodosulfuron (12+2.4 g ai. ha^{-1} at 30 DAS) which was at par with clodinafop +metsulfuron (60+4 g ai. ha^{-1}at 30 DAS) and significantly superior over mesosulfuron (12 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS, metsulfuron (4 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS. Reduction in the dry matter accumulation by weeds in wheat with tank-mix application of herbicides was also reported by Singh *et al.* (2015) and Choudhary *et al.* (2016). However, weed free was found more effective than the herbicidal treatments, for reduction of dry matter accumulation. Faisal *et al.* (2012) reported that the lowest weed biomass under hand weeded plots followed by herbicidal treatments.

Weed control efficiency

Among tillage systems, zero tillage with residue recorded highest weed control efficiency (WCE) followed by WCE with conventional tillage with residue, zero tillage with no-residue and conventional tillage no-residue, respectively. Among the weed management practices, hundred per cent weed control efficiency of grassy weeds were recorded with weed free as compared to herbicidal treatments (Table 2). Among herbicidal treatments, tank mix application of mesosulfuron + iodosulfuron (12+2.4 g ai. ha^{-1} at 30 DAS) recorded highest WCE followed by clodinafop +metsulfuron (60+4 g ai. ha^{-1}at 30 DAS), mesosulfuron (12 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS and metsulfuron (4 g ai. ha^{-1}at 30 DAS) *fb* one hand weeding at 45 DAS, respectively.

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Table 1. Effect of tillage and weed management practices on weed density (pooled data of two years)

	Phalaris minor (m^2)		*Avena ludoviciana* (m^2)		*Cynodoan dactylon* (m^2)		Total weed population (m^{-2})	
Treatments	**40 DAS**	**80 DAS**	**40 DAS**	**80 DAS**	**40 DAS**	**80 DAS**	**40 DAS**	**80 DAS**
Crop establishment method								
Conventional tillage-no residue	6.18(37.8)	5.96(35.1)	2.90(7.93)	2.87(7.71)	5.62(31.1)	5.46(29.3)	8.79(76.8)	8.52(72.1)
Conventional tillage-with residue	5.35(28.1)	5.14(25.9)	2.53(5.90)	2.49(5.70)	5.04(25.0)	4.77(22.3)	7.71(59.0)	7.37(53.8)
Zero tillage-no residue	5.98(35.3)	5.77(32.8)	2.81(7.40)	2.78(7.21)	5.45(29.2)	5.25(27.1)	8.51(71.9)	8.22(67.1)
Zero tillage-with residue	4.95(24.1)	4.77(22.3)	2.36(5.05)	2.33(4.91)	4.65(21.2)	4.53(20.0)	7.12(50.3)	6.91(47.2)
CD (P=0.05)	0.39	0.36	0.17	0.15	0.38	0.22	0.57	0.44
Weed management practices								
Weedy check	7.67(58.4)	7.41(54.4)	3.57(12.25)	3.53(11.96)	6.52(42.0)	6.28(38.9)	10.6(112.6)	10.3(105.2)
Weed free	0.71(0.0)	0.71(0.0)	0.71(0.00)	0.71(0.00)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)
Mesosulfuron @ 12 g ai ha^{-1} at 30 DAS *fb* one HW at 45 DAS	6.12(36.9)	5.89(34.3)	2.87(7.75)	2.84(7.54)	5.91(34.4)	5.69(31.9)	8.92(79.0)	8.62(73.7)
Metsulfuron @ 4 g ai ha^{-1} at 30 DAS *fb* one HW at 45 DAS	5.98(35.3)	5.73(32.3)	2.81(7.40)	2.83(7.11)	5.74(32.4)	5.53(30.1)	8.69(75.1)	8.37(69.5)
Clodinafop+metsulfuron @ 60+4 g ai ha^{-1} at 30 DAS	5.57(30.6)	5.32(27.9)	2.63(6.42)	2.57(6.13)	5.19(26.5)	4.97(24.3)	7.99(63.4)	7.66(58.2)
Mesosulfuron+iodosulfuron @ 12+2.4 g ai ha^{-1} at 30 DAS	5.21(26.7)	5.09(25.4)	2.47(5.60)	2.49(5.59)	4.98(24.4)	4.84(22.8)	7.58(56.6)	7.38(53.8)
CD (P=0.05)	0.36	0.25	0.16	0.09	0.23	0.14	0.42	0.29

Figures in parentheses are the original values which were transformed to $\sqrt{(x+0.5)}$ for analysis.

Table 2. Effect of tillage and weed management practices on dry matter accumulation and weed control efficiency (pooled data of two years)

	Phalaris minor (g m-^{2})		*Avena ludoviciana* (g m-^{2})		*Cynodoan dactylon* (g m-^{2})		Total weed dry weight (g m-^{2})		Weed control efficiency (%)	
Treatments	**40 DAS**	**80 DAS**	**40 DAS**	**80 DAS**	**40 DAS**	**80 DAS**	**40 DAS**	**80 DAS**	**40 DAS**	**80 DAS**
Crop establishment method										
Conventional tillage-no residue	2.16(4.15)	2.61(6.31)	1.20(0.95)	1.40(1.47)	1.91(3.20)	2.33(4.92)	2.97(8.30)	3.63(12.69)	35.3	35.5
Conventional tillage-with residue	1.89(3.09)	2.27(4.66)	1.10(0.71)	1.26(1.08)	1.72(2.38)	2.03(3.63)	2.59(6.18)	3.14(9.38)	51.8	52.3
Zero tillage-no residue	2.09(3.88)	2.53(5.90)	1.18(0.89)	1.37(1.37)	1.86(2.99)	2.26(4.59)	2.87(7.75)	3.53(11.86)	39.6	39.7
Zero tillage-with residue	1.77(2.65)	2.12(4.01)	1.05(0.61)	1.20(0.93)	1.59(2.04)	1.90(3.13)	2.40(5.29)	2.93(8.07)	58.8	59.0
CD (P=0.05)	0.11	0.14	0.04	0.05	0.11	0.12	0.18	0.20	-	-
Weed management practices										
Weedy check	2.63(6.42)	3.21(9.78)	1.40(1.47)	1.66(2.27)	2.33(4.94)	2.85(7.63)	3.65(12.83)	4.49(19.68)	-	-
Weed free	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	100.0	100.0
Mesosulfuron @ 12 g ai ha^{-1} at 30 DAS *fb* one HW at 45 DAS	2.14(4.06)	2.58(6.17)	1.20(0.93)	1.39(1.43)	1.90(3.13)	2.30(4.81)	2.95(8.11)	3.59(12.40)	36.8	37.0
Metsulfuron @ 4 g ai ha^{-1} at 30 DAS *fb* one HW at 45 DAS	2.09(3.88)	2.52(5.81)	1.18(0.89)	1.36(1.35)	1.88(2.99)	2.25(4.53)	2.87(7.75)	3.49(11.70)	39.6	40.6
Clodinafop+metsulfuron @ 60+4 g ai ha^{-1} at 30 DAS	1.98(3.36)	2.35(5.01)	1.12(0.77)	1.29(1.16)	1.76(2.59)	2.21(3.91)	2.69(6.72)	3.25(10.08)	47.6	48.8
Mesosulfuron+iodosulfuron @ 12+2.4 g ai ha^{-1} at 30 DAS	1.86(2.93)	2.26(4.57)	1.09(0.67)	1.25(1.06)	1.66(2.26)	2.03(3.56)	2.52(5.86)	3.11(9.20)	54.3	53.3
CD (P=0.05)	0.12	0.10	0.03	0.04	0.10	0.18	0.17	0.15	-	-

Figures in parentheses are the original values which were transformed to $\sqrt{(x+0.5)}$ for analysis.