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Effect of crop-establishment methods and weed-management options on weed and yield of wheat

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Abstract
A field experiment was conducted during *Rabi* season of 2012-13 and 2013-14 at GBPUAT, Pantnagar to study the effect of tillage and weed management practices on weed control and yield of wheat under rice-wheat cropping system. Zero tillage (ZT) in wheat was more beneficial as it recorded higher yield with lower cost than convention tillage (CT) in wheat. Among the weed management options, post-emergence application of pinoxaden 50g/ha *fb* metsulfuron-methyl (MSM) 4g/ha resulted in lowest density and biomass of total weeds, which was statistically at par with readymix combination of clodinofop 60g + MSM 4g/ha. The post- emergence application of pinoxaden 50g/ha *fb* MSM 4g/ha followed by readymix combination of clodinofop 60g + MSM 4g/ha recorded highest weed control efficiency (WCE) and grain yield.

Keywords: Rice-wheat system, tillage, weed management, wheat, yield

Introduction
The rice-wheat cropping system is one of the most important cropping patterns for food self-security in the region while this system is the most dominating in India with around 40% of the wheat is being grown in rotation with rice. Wheat is the most important cereal crop and an integral component of food security at global level. At present, the soil resources are under stress owing to intensive cropping with raising of more than two crops in a year without replenishing the resources as is desirable. Repeated conventional tillage coupled with other faulty land utilization practices have caused large scale degradation of our soils over the past 50-60 years and most of the soils have lost up to one-half of their native organic matter content and fauna (Malik *et al.* 2006) [10]. Traditional tillage practices also contribute to the energy and labour cost in crop production systems resulting in lower economic returns (Saharawat *et al.* 2010 and Kumar *et al.* 2013) [12, 9]. Furthermore, intensive ploughing results in decrease in soil organic matter due to acceleration of the oxidation and breakdown of organic matter and ultimately led to degradation of soil properties (Gathala *et al.* 2011) [6]. Zero tillage practice in wheat crop is beneficial to farmers because it saves land preparation time which often delays the wheat sowing. Lower productivity of wheat by and large can also be attributed to several other limiting factors and but most important among these has been the poor weed management, which poses a major threat to crop productivity. Wheat crop is badly infested with grasses as well as broad-leaf weeds. Therefore, timely weeding is most important to minimize the losses in crop yields especially during the critical crop-weed competition periods. Management of weeds through the use of herbicides has been found to be very effective and economical compared to that realized with manual or mechanical methods in various crops including wheat. Hence keeping the above facts in forefront there is greater need to evaluate tillage and weed control for wheat in irrigated rice - wheat cropping system

Materials and Methods
The field experiment was conducted at Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, during *Rabi* season of 2012-13 and 2013-14. The soil of experimental field was silty clay loam in texture with slightly alkaline in reaction (pH 7.2), medium in organic carbon (0.68%), low in available nitrogen (250.0 kg/ha), medium in available phosphorus (21.9 kg/ha) and potassium (230.0 kg/ha). The experiment was conducted in split-plot design with three replications.
The main plot comprised of three tillage treatments, *viz.* zero tillage (ZT), reduced tillage (RT) and conventional tillage (CT) in wheat whereas, sub-plot comprised of six weed management practices, *viz.* sulfosulfuron 25 g/ha, clodinofop propargyl 60 g/ha + metsulfuron-methyl (MSM) 4g/ha (readymix), clodinofop 60 g/ha fb MSM4g/ha, pinoxaden 50 g/ha *fb* MSM 4

g/ha, weed free and weedy check. Wheat variety '*UP-2565'* was sown with 100 kg seed/ha at row to row spacing of 20 cm. After the harvest of the rice crop, for conventional tillage, the field was harrowed six times and levelled with tractor driven *patela* four times. In case of zero tillage, no tillage is performed. Under reduced tillage, the field was prepared by three harrowing and planked with tractor driven *patela* three times, general sowing was done with the help of zero till seed drill.

The crop was fertilized with 150 kg N, 60 kg P and 40 kg/ha K through urea, NPK mixture and muriate of potash. Full dose of P and K along with 1/3rd of N were applied as basal dose at the time of sowing and remaining N was applied in two equal splits at tillering stage and booting stage. Post-emergence application of herbicide was sprayed by knapsack sprayer fitted with flat fan nozzle using a spray volume of 500 l/ha. sulfosulfuron, readymix combination of clodinofop+ MSM, clodinofop, and pinoxaden were applied at 30 days after sowing (DAS) while follow up application of MSM alone was done at 37 DAS. In case of weed free treatment weeds were removed frequently as and when required. Weedy plot sremained infested with native population of weeds till harvest. The data on density and biomass of weeds were subjected to square root transformation $\sqrt{(x+1)}$to normalize their distribution.WCE was calculated by using the formulae suggested by Gomez and Gomez (1984) [7].

Results and Discussion

During both the years, population of broad leaf weeds dominated over grassy weeds. Among grasses, *Phalaris minor was* the most dominated weed, whereas, among broad leaf weeds *Chenopodium album, Melilotus indica., Medicago denticulata, Rumex acetosella,*and *Vicia sativa* contributed maximum per cent to total weed density during both the years(data not given). The relative density of non-grassy weeds to the total weed population was higher at all stages of crop growth as compared to grasses. Higher relative density of non-grassy weed at all stages of crop growth was due to the more aggregate population of *Chenopodium album, Melilotus indica, Medicago denticulate, Rumex acetosella.*and *Vicia sativa* to the total weed population at all stages of crop growth during both the years.

Weed density

The total number of weeds influenced significantly due to various tillage practices at all the stages of crop growth during both years. The overview of the data in the Table 1 showed that the maximum density of total weeds in tillage methods was recorded at 30 days stage of crop during both the years and reduced thereafter at later stages of crop. At all the stages of crop growth, the minimum population of total weed was registered when crop raised through zero tillage except at 120 days stage during 2012-13, where the total density of weeds under this treatment was found at par to that of crop raised through reduced tillage. Similar findings have been reported by Singh *et al.* 2001 [14].

Density of total weed recorded the highest at 60 days stage in weedy check and thereafter it decreased with increasing crop stage. All the herbicidal treatments reduced the weed population significantly over weedy check at all the stages of crop growth. The total weed density at 60, 90 and 120 DAS in treatments clodinofop 60 g + metsulfuron-methyl (MSM) 4 g/ha (readymix), clodinofop 60 g/ha followed by MSM 4 g/ha and pinoxaden 50 g/ha *fb* MSM 4 g/ha were at par with each other but significantly lower than sulfosulfuron 25 g/ha. Chhokar and Malik (2002) [2] reported the similar findings.

Weed dry matter

Significant differences in total dry matter of weeds were recorded due to different tillage practices at all the growth stages. Crop raised through zero tillage was found very effective with respect to reduction in dry matter of total weeds than other tillage practices during both the years. The lowest dry weight of total weeds was noted in zero tilled wheat at all the stages of crop growth during both the years except it was at par with reduce tillage at 60 and 90 days stage during 2012-13. This was due to lower total weed density in zero tillage plots which is evident from Table 2. These findings are in conformity with Chopra and Chopra (2010) [4] who also noted lower weed density and dry weight in zero tillage when compared with reduced tillage.

Total weed dry matter per square meter influenced significantly due to weed control measures during both the years at all the stages of crop growth. The readymix combination of clodinofop 60 g + MSM 4 g/ha, clodinofop 60 g/ha *fb* MSM 4g/ha and pinoxaden 50 g/ha *fb* MSM 4g/ha recorded significantly lower weed dry weight over sulfosulfuron 25 g and weedy check. All the herbicidal combinations were at par with each other at all the crop growth stages during both the years. Application of sulfosulfuron also recorded significantly lower weed dry weight than weedy check but its efficacy was poor for the control of grasses and broad leaf weeds than herbicides combinations. These results are in close conformity with the findings of Dev *et al.* (2013) [5].

Weed control efficiency

At 60 DAS during 2013-14, significantly higher weed control efficiency was found when crop raised with conventional tillage though it was at par with reduced tillage. Crop raised with zero tillage recorded lowest weed control efficiency being at par with reduced tillage (Table 3).

Weed management measures had significant effect on weed control efficiency at 60, 90 and 12 DAS stage during both the years. At all the stages, the highest weed control efficiency was noted with the application of pinoxaden 50 g/ha *fb* MSM 4g/ha which was closely followed by readymix combination of clodinofop 60g + MSM 4 g/ha and clodinofop 60 g/ha *fb* MSM 4g/ha during both the years over alone application of sulfosulfuron 25 g/ha. Paighan *et al.* (2013) [11] also found highest weed control efficiency in case of metsulfuron-methyl at 4 g/ha applied after weed free treatment which was further confirmed by Chhokar and Malik (2002) [2] who also concluded that metsulfuron and clodinofop were effective against broad-leaved and grassy weeds, respectively.

Grain yield

Grain yield of wheat was affected significantly owing to various tillage practices during both the years (Table 3). The maximum grain yield was obtained under zero tillage, which was followed by reduced tillage during both the years. The conventional tillage resulted into minimum grain yield during 2013-14 although it was at par with reduced tillage during 2012-13. All the weed control measures produced significantly higher grain yield than weedy check during both the years. The highest grain yield of wheat was obtained with weed free treatments. Among herbicidal treatments, maximum grain yield was obtained in the plots treated with pinoxaden 50 g/ha *fb* MSM 4 g/ha which was closely followed by clodinofop 60 g + MSM 4 g/ha (readymix) and clodinofop 60 g/ha *fb* MSM 4 g/ha during both the years. Sulfosulfuron was found to be statistically superior over the weedy check but its efficacy was not as good as other herbicidal treatments. These results are in conformity with Bharat and Karchroo (2007) [1] who also noted that tank mixing of clodinofop + metsulfuron- methyl was found superior over isoproturon alone in broadening the spectrum of weed control and increasing yield. These findings were supported by Chopra *et al.* (1999) [3] and Singh *et al*. (1997) [13] who stated that uncontrolled weeds caused 30-60% reduction in grain yield of wheat.

On the basis of two years study, it was concluded that ZT in wheat was more beneficial as it reduced cost of cultivation and also recorded higher grain yield than CT in wheat. Among herbicidal treatments, post emergence application of pinoxaden 50 g/ha *fb* MSM 4 g/ha in wheat was found to be most effective for weed management.

Table 1: Density of total Weeds (number/m^2) at various stages of crop growthduring 2012-13 and 2013-14

Treatment	30 DAS		60 DAS		90 DAS		120 DAS	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Tillage								
Zero tillage	10.8 (136)	10.5 (128)	4.9 (44.0)	4.9 (40.4)	4.2 (28.7)	3.9 (27.3)	3.3 (19.8)	3.1 (18.7)
Reduced tillage	13.7 (219)	13.7 (219)	6.2 (69.1)	5.9 (66.8)	5.1 (48.4)	5.1 (50.6)	4.3 (34.4)	4.2 (31.8)
Conventional tillage	15.0 (265)	15.1 (270)	6.7 (82.0)	6.7 (90.7)	5.7 (60.0)	5.6 (63.1)	4.7 (42.0)	4.6 (45.1)
LSD (p=0.05)	0.56	0.83	0.76	0.51	0.59	0.95	1.08	0.48
Weed management								
Sulfosulfuron 25g/ha	15.4 (239)	15.3 (238)	7.6 (57.8)	7.2 (52.0)	6.2 (38.7)	6.2 (38.5)	4.6 (22.2)	4.97 (24.9)
Clodinofop 60 g/ha + MSM 4 g/ha (ready mix)	15.3 (239)	14.9 (227)	3.1 (10.2)	2.8 (7.1)	2.7 (6.7)	2.3 (4.9)	2.3 (4.9)	1.90 (3.1)
Clodinofop 60 g/ha *fb* MSM 4 g/ha	15.6 (248)	15.3 (239)	3.6 (13.8)	3.6 (12.4)	3.1 (8.9)	2.7 (7.1)	2.1 (4.0)	1.99 (3.5)
Pinoxaden 50 g/ha *fb* MSM 4 g/ha	15.8 (254)	15.0 (230	3.2 (10.7)	2.7 (7.1)	2.5 (5.8)	2.1 (4.4)	2.1(4.0)	1.49 (1.8)
Weed free	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Weedy	16.0 (259)	17.1 (300)	17.1 (298)	17.5 (317)	14.6 (214)	14.8 (227)	12.4 (157)	12.4 (158)
LSD (p=0.05)	0.95	0.80	0.98	0.64	0.76	0.83	0.80	0.64

Table 2: Dry matter of total weeds (g/m^2) at various stages of crop growth during 2012-13 and 2013-14

Treatment	30 DAS		60 DAS		90 DAS		120 DAS	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Tillage								
Zero tillage	3.21 (10)	3.03 (9.1)	3.08 (15)	3.31 (16)	3.67 (22)	3.53 (22)	2.96 (16)	2.86 (15)
Reduced tillage	4.33 (20)	4.29 (20)	3.76 (24)	3.95 (26)	4.49 (37)	4.60 (41)	3.72 (25)	3.71 (24)
Conventional tillage	4.89 (26)	4.96 (27)	4.31 (32)	4.56 (39)	5.02 (46)	5.14 (52)	4.21 (32)	4.18 (37)
LSD (p=0.05)	0.8	0.19	0.44	0.28	NS	0.83	0.92	0.41
Weed management								
Sulfosulfuron 25 g/ha	4.66 (21)	4.63 (22)	4.59 (20)	4.72 (21)	5.38 (29)	5.65 (32)	4.08 (17)	4.51 (20)
Clodinofop 60 g/ha + MSM 4 g/ha (ready mix)	4.72 (22)	4.57 (21)	2.06 (3.7)	2.23 (4.1)	2.44 (5.1)	2.16 (4.0)	2.11 (3.7)	1.73 (2.3)
Clodinofop 60 g/ha *fb* MSM 4 g/ha	4.73 (22)	4.64 (21)	2.16 (4.1)	2.51 (5.5)	2.66 (6.5)	2.42 (5.3)	1.89 (3.1)	1.80 (2.7)
Pinoxaden 50 g/ha *fb* MSM 4 g/ha	4.89 (24)	4.60 (21)	2.01 (3.2)	2.15 (3.8)	2.23 (4.5)	1.94 (3.5)	1.94 (3.1)	1.40 (1.3)
Weed free	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Weedy	4.87 (23.6)	5.10 (26)	10.48 (112)	11.0 (126)	12.7 (164)	13.38 (185)	10.77 (118)	11.0 (125)
LSD (p=0.05)	0.34	0.27	0.53	0.38	0.73	0.76	0.70	0.55

Table 3: Weed control efficiency of different treatments at 60, 90 and 120 DAS and grain yield of wheat during 2012-13 and 2013-14

Treatment	Weed control efficiency (%)							
	60 DAS		90 DAS		120 DAS		Grain yield t/ha	
Tillage	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Zero tillage	77.83	76.01	77.95	78.16	80.30	80.25	4.85	4.93
Reduced tillage	78.72	78.25	78.96	79.39	79.14	78.65	4.62	4.68
Conventional tillage	78.69	79.82	78.79	79.58	79.35	80.14	4.40	4.37
LSD (p=0.05)	NS	2.74	NS	NS	NS	NS	0.33	0.33
Weed management								
Sulfosulfuron 25g/ha	80.62	80.64	81.54	81.28	85.94	83.54	4.33	4.27
Clodinofop 60 g/ha + MSM 4 g/ha (ready mix)	96.84	96.15	96.77	97.93	96.95	98.03	5.10	5.21
Clodinofop 60 g/ha *fb* MSM 4 g/ha	96.14	94.99	95.72	96.93	97.26	97.68	5.05	5.10
Pinoxaden 50g/ha *fb* MSM 4 g/ha	96.90	96.58	97.38	98.14	97.46	98.89	5.15	5.22
Weed free	100.0	100.0	100.0	100.0	100.0	100.0	5.33	5.42
Weedy	00.0	00.0	00.0	00.0	00.0	00.0	2.80	2.74
LSD (p=0.05)	3.11	1.91	3.18	2.97	3.08	2.73	0.33	0.32

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