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RESEARCH NOTE

Tillage and weed management effect on wheat in inceptisols grown under soybean-wheat cropping sequence

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ABSTRACT

A field experiment was conducted to study the effect of tillage and herbicidal weed management on soybean-wheat sequence during 2021-22. Four tillage treatments were given in main plot for soybean during *Kharif*; conventional tillage (CT: ploughing 2 harrowing tyne cultivator + harrowing with blade harrow), reduced tillage (RT: harrowing with tyne cultivator + rototill), minimum tillage (MT: rototill), zero tillage and in wheat uniform rototill was given to conventional tillage to minimum tillage (MT: rototill) treatments excluding zero tillage treatment where soybean crop residue was used for soil cover while the sub-plot treatments with five weed management treatments namely; sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS, mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS, clodinafop + metsulfuron 0.064 kg/ha at 30 DAS, weed-free (3 HW at 20, 40 and 60 DAS), weedy check. The results indicated that the total weed density, weed dry matter and wheat grain yield were significantly influenced by various tillage practices at all stages of crop growth. Conventional tillage in the *kharif* and rototill in *rabi* season was found statistically most superior in respect to lowest weed density, weed dry matter, higher yield and economic returns over rest of the tillage treatments. However, the significantly highest value of total weed density and weed dry matter was recorded with zero tillage. Among the different herbicidal treatments, minimum weed density, weed dry weight, maximum yield and economic benefit was achieved with ready mix application of clodinafop + metsulfuron 0.064 kg/ha applied at 30 DAS.

Keywords: Clodinafop + metsulfuron, Mesosulfuron + iodosulfuron, Sulfosulfuron + metsulfuron, Tillage, Wheat

Wheat (*Triticum aestivum* L.) is the first important strategic cereal crop for the majority of the world's population. It is the most important staple food in the world. It exceeds in acreage and the production of every other grain crop (including rice and maize) and is therefore, the most important cereal grain of the world, which is cultivated over a wide range of climatic conditions. Wheat is infested with diverse weed flora, as it is grown in diverse agro-climatic conditions, under different cropping sequences, tillage and irrigation regimes (Rao *et al.* 2014). For the control of broad-leaf weeds in wheat, the major herbicides used in India are metsulfuron, 2,4-D and carfentrazone (Singh *et al.* 2012). As the wheat fields are infested with diverse weed flora and for their effective management, a combination of herbicides either as a ready mixture, if compatible or tank mixture, or as sequential, if not compatible are required. However, the sole dependence on herbicide of a single mode of action is also not advisable as it has contributed to a shift towards difficult-to-control weeds and the rapid evolution of multiple herbicide resistance, which is a threat to wheat production (Malik *et al.* 2013). The tillage system also influences the vertical distribution of weed seeds in the soil layer and weed diversity. No-till cropping system leaves most of the weed seeds in the top 1.0 cm of the soil profile, while in deep tillage, a significant reduction of weed population was observed due to the inversion of soil with mould board plough which resulted in the deeper placement of most of the weed seeds which could not emerge out (Chahal *et al.* 2003). Diversifying herbicide-based weed management by using rotation, tank mixtures, and sequential application in integration with tillage will help in controlling difficult-to-control weed species (Peerzadaa and Ali 2016). Keeping all these facts in view, the present investigation was carried out to find out the effective crop establishment method and herbicides for effective control of broad-spectrum weeds in wheat crops.

The experiment on conservation tillage practices in wheat was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Rabi* 2021-22. Akola is situated in the Sub-tropical zone at the latitude of 22042' North longitude of 770 02' East. The altitude of the place is 307.41 meter above mean sea level. The soil of the experimental plot was medium-deep black with fairly uniform and leveled topography with

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slightly alkaline in reaction with medium status of organic carbon content, available nitrogen and phosphorous and fairly rich status of available potassium. Four tillage treatments were given in main plot for soybean during *Kharif*; T1- conventional tillage (CT: ploughing, 2 harrowing with tyne cultivator + blade harrow), reduced tillage (RT: harrowing with tyne cultivator + rototill), minimum tillage (MT: rototill), zero tillage and in wheat uniform rototill was given to conventional tillage to minimum tillage (MT: rototill) treatments excluding zero tillage treatment where soybean crop residue was used for soil cover while the sub-plot treatments with five weed management treatments to wheat namely; sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS, mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS, clodinafop + metsulfuron 0.064 kg/ha at 30 DAS, weed free (3 HW at 20, 40 and 60 DAS), weedy check. The gross plot size of the subplot was 70 m2, while the gross plot size of the main plot was 350 m2. The wheat variety WSM 109-4 during *Rabi* (November) was sown at row-to-row spacing of 22 cm. The application of herbicide was done as per the treatments with a manually operated knapsack sprayer attached to a flat fan nozzle. The recommended practice of fertilizer application was followed for the crop. The N, P and K were given in the form of urea, single super phosphate and muriate of potash to wheat 120:60:60 NPK kg/ha.

Weed flora: The major weed flora during *rabi* season in wheat in the experimental area composed of *Cyperus rotundus*, *Parthenium hysterophorus*, *Boerhavia diffusa, P ortulaca oleracea*, *Amaranthus viridis*, *Euphorbia hirta, Alternanthera triandra*.

Weed density: At 40 DAS up to harvest, the conventional tillage treatment recorded a minimum total weed count which might be due to good preparatory tillage operation *i.e*. ploughing and harrowing practices were carried out in *Kharif* season (for the previous crop), while maximum total weed count/m2 observed with zero tillage. A minimum number of total weed counts was noticed in treatment weed-free than the rest of the treatments from 40 DAS up to harvest. Among the herbicidal treatments clodinafop + metsulfuron 0.064 kg/ha at 30 DAS recorded the significantly lowest total weed population followed by mesosulfuron + idosulfuron 0.0144 kg/ha at 30 DAS and sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS which have effective control of weed than weedy check. Among these herbicides mesosulfuron + idosulfuron 0.0144 kg/ha although found promising in reducing the weed population in wheat these herbicides expressed phytotoxicity on wheat, however, phytotoxicity with this herbicide was recorded 7 days after application of herbicides was minimal (<3) and recovered after two weeks.

Weed dry matter accumulation: The treatment conventional tillage registered significantly lowest weed dry matter from 40 DAS up to harvest while reduced and minimum tillage were at par with conventional tillage. This might be due to favorable conditions available for plant growth under tilled plots with healthy grown plants having fast metabolic activity leading to fast translocation of herbicides to their site of action inside the plant body (Kumar *et al.* 2014). The weed dry matter at 40 DAS up to harvest was significantly influenced by different weed

Table 1. Weed density, weed dry matter, and weed control efficiency as influenced by various tillage and weed management practices

Treatment	Weed density (no./m^2)		Weed dry matter accumulation (g/m^2)		Weed control efficiency (%)		Weed index (%)
	40 DAS	60 DAS	40 DAS	60 DAS	40 DAS	60 DAS	
Tillage management							
MT1 Rototill	3.04(8.7)	4.64(21.1)	3.93(14.9)	5.14(25.9)	79.57	72.34	8.35
MT1 Rototill	3.62(12.6)	5.56(30.4)	4.35(18.4)	5.65(31.5)	74.84	66.37	17.22
MT 1 Rototill	4.12(16.5)	5.87(34.0)	4.57(20.4)	5.89(34.1)	72.04	63.49	20.25
Zero tillage + R	4.64(21.0)	6.56(42.5)	5.46(29.3)	6.20(37.9)	59.88	59.49	26.33
LSD (p=0.05)	0.21	0.19	0.48	0.40	--	--	
Weed management							
Sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS	2.17(4.2)	5.13(25.8)	2.97(8.3)	4.30(18.0)	88.64	80.79	17.57
Mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS	2.32(4.9)	5.37(28.3)	3.26(10.1)	5.20(26.5)	86.17	71.65	21.02
Clodinafop + metsulfuron 0.064 kg/ha at 30 DAS	1.51(1.8)	4.41(19.0)	2.32(4.9)	4.09(16.2)	93.35	82.66	7.96
Weed free	2.13(4.04)	2.40(5.2)	1.88(3.0)	2.39(5.2)	95.84	94.44	--
Weedy check	7.47(55.2)	8.77(76.4)	8.58(73.1)	9.70(93.5)	0.00	0.00	43.33
LSD (p=0.05)	0.19	0.14	0.30	0.18	--	--	--
Interaction (A ×B)							
LSD (p=0.05)	NS	NS	NS	NS	--	--	--

Data are subjected to square root transformation $\sqrt{x+0.5}$ and original data presented in parentheses

control treatments in which hand weeding thrice (20, 40 and 60 DAS) recorded significantly lowest weed dry matter. The different herbicidal treatments applied, in which clodinafop + metsulfuron 0.064 kg/ha at 30 DAS recorded the lowest weed dry matter accumulation followed by mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS and sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS were recorded lower weed dry matter. However, weedy check treatment recorded significantly higher weed dry weight. This might be due to combination of both herbicides effectively controlling the weeds in a broad-spectrum way (Grassy and Non grassy weeds) and showing a significant reduction in weed dry matter accumulation over the weedy check.

Weed control efficiency and weed index (%): The highest weed control efficiency (79.57%) was recorded in the treatment of conventional tillage at 40 DAS and the next best treatment was reduced tillage (74.84%). However, the lowest weed control efficiency (59.88%) was noticed with the treatment of zero tillage + residues. Similar was the trend of treatment differences in weed control efficiency at 60, 80 DAS and harvest. The weed index was significantly influenced by various tillage practices. Significantly lowest weed index (8.35%) was recorded with treatment conventional tillage which was followed by reduced tillage (17.22%). However, treatment of zero tillage recorded the highest weed index (26.33%). All Weed control treatment significantly influenced the dry matter accumulation of weeds, over the weedy check. The highest weed control efficiency was achieved with thrice hand weeding (20, 40 and 60 DAS) at 40 and 60 DAS. In herbicidal treatment at 40 DAS highest weed control efficiency (93.35%) was recorded with clodinafop + metsulfuron 0.064 kg/ha followed by sulfosulfuron + metsulfuron 0.030 kg/ha and mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS. It might be due application of a ready mixture of two herbicides which effectively control or check the growth of weeds in the abroad-spectrum way at the seedling stage. It was noticed that the lowest weed index (7.96%) was registered with post-emergence spray of clodinafop + metsulfuron 0.064 kg/ha at 30 DAS followed by sulfosulfuron + metsulfuron 0.030 kg/ha (17.57%) and mesosulfuron + iodosulfuron 0.0144 kg/ha (21.02%). This might be due to better control of weeds in this treatment which ultimately increases the yield as compared to all other ready-mix applications of herbicides. A combination of clodinafop + metsulfuron resulted in the highest WCE and WCI was reported by Rana *et al*. (2017). The highest weed index was registered by unweeded plots due to maximum yield reduction as well as heavy infestation of weeds and higher competition between weeds and crop plants.

Growth and yield attributes: Significantly highest plant height and total dry matter per plant were recorded with conventional tillage followed by reduced, minimum and zero tillage. Maximum plant height at harvest was recorded in cultural methods of hand weeding thrice but found at par with all post-emergence herbicide treatments. The next best treatments regarding plant height, dry matter accumulation and number of effective tillers were noticed with ready mix application of clodinafop + metsulfuron 0.064 kg/ha at 30 DAS which was at par with another combination of sulfosulfuron + metsulfuron 0.030 kg/ha and mesosulfuron +

Table 2. Growth and yield attributing characters of wheat as influenced by various tillage and weed management treatment

Treatment	Plant height (cm)	Dry matter/ plant (g)	Number of effective tillers (no./m^2)	Earhead length at harvest (cm)	Grain/ earhead at harvest	Test weight (g)
Tillage management						
MT1 rototill	102.72	17.03	427	9.14	50.69	41.88
MT 1 rototill	97.38	15.72	407	8.89	49.42	41.36
MT1 rototill	93.99	15.14	399	8.59	47.54	41.18
Zero tillage + R	88.15	14.66	363	8.18	46.59	40.98
LSD (p=0.05)	2.44	0.24	23.87	NS	NS	NS
Weed management						
Sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS	95.89	15.33	419	8.78	50.29	41.42
Mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS	91.6	14.93	395	8.61	49.67	41.11
Clodinafop + metsulfuron 0.064 kg/ha at 30 DAS	98.8	17.26	410	8.88	51.28	41.52
Weed free	101.86	19.27	428	8.41	54.35	41.65
Weedy check	88.49	10.9	329	8.11	39.21	40.98
LSD (p=0.05)	6.27	0.28	14.54	NS	7.54	NS
Interaction (A ×B)						
LSD (p=0.05)	NS	NS	NS	NS	NS	NS

idosulfuron 0.0144 kg/ha applied at 30 DAS. The yield attributing characters namely spike length, spikelet per ear head and test weight could not reach up to a significant level with either ready mix application herbicides or thrice hand weeding. An interaction effect due to various tillage and weed management practices on growth and yield attributing characters was found to be non-significant.

Yield: The grain and straw yield was noticed significantly higher under conventional tillage (3.76 t/ha and 7.95 t/ha) over minimum and zero tillage excluding reduced tillage. Tillage affects the weeds by uprooting, dismembering and burying them deep enough to prevent emergence by changing the soil environment and by inhibiting weeds' germination and establishment, thereby creating favourable soil environment for plant growth, which would result in better yield attributes and yield (Jadhav 2014). The lowest yield was recorded in zero tillage system in soybean and wheat crops. Different weed control treatments significantly affected wheat grain yield. Maximum grain yield was achieved under weed-free situation i.e. thrice hand weeding (4.33 t/ha) followed by the ready mix application of clodinafop + metsulfuron (0.064 kg/ha) applied at 30 DAS (4.40 t/ha). The lowest yield (2.22 t/ha) was registered in weedy check treatment which might be due to severe weed competition with a crop that drastically reduced the grain yield. In respect of straw yield similar trend was also observed in wheat crops. An interaction effect of various tillage methods in soybean and weed management practices in wheat was found to be significant concerning the grain yield of wheat. Significantly higher grain yield was obtained with treatment combination of CT in previous season crop soybean with rototill in subsequent *Rabi* season wheat along with ready mix application of clodinafop + metsulfuron as PoE which in turn was found at par with reduced tillage given in previous season with single rototill to wheat with application of similar herbicide treatment. The ready-mix doses of clodinafop + metsulfuron at 35 DAS in wheat at 60 + 4 g/ha attained grain yields similar to weed-free check Yadav *et al.* (2009), Kumar *et al.* (2012) and Rana *et al.* (2017).

Economics: The net monetary return (NMR) values represent pure profit received by cultivating a specific crop with applied treatments. The statistical analysis revealed that various tillage practices significantly influenced the NMR values. Among tillage treatments minimum tillage with single rototill recorded significantly highest NMR which in turn was found at par with each other. The minimum NMR was recorded with zero tillage of ₹ 32232/ha. Among various weed management treatments, the

Table 4. Interaction between tillage and weed management treatment with respect to grain yield of wheat (t/ha)

	Weed management					
Tillage management	W_1	W_2	W_3	W_4	W_5	Mean
MT1 Rototil	3.93	3.36	4.82	4.33	2.81	3.85
MT1 Rototil	3.67	3.00	4.68	4.23	2.73	3.66
MT1 Rototil	3.62	2.79	4.03	4.26	1.85	3.31
ZT+R	2.75	2.70	3.75	4.18	1.00	2.88
Mean	3.49	2.96	4.32	4.25	2.10	
LSD (p=0.05)			0.30			

W_1: Sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS; W_2: Mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS; W_3: Clodinafop + metsulfuron 0.064 kg/ha at 30 DAS; W_4: Weed free; W_5: Weedy check

Table 3. Yield and economics of wheat as influenced by different tillage and weed management treatment

Treatment	Yield (t/ha)		GMR ($x10^3$ `/ha)	Cost of cultivation ($x10^3$ `/ha)	NMR ($x10^3$ `/ha)	BCR
	Grain	Straw				
Tillage management						
MT1 Rototill	3.76	7.95	74.31	30.95	43.35	2.41
MT 1 Rototill	3.65	7.92	72.11	28.31	43.80	2.56
MT1 Rototill	3.60	7.52	71.06	26.94	44.13	2.63
Zero tillage + R	2.88	6.08	56.83	24.60	32.23	2.25
LSD (p=0.05)	0.15	0.29	2.87	--	2.87	--
Weed management						
Sulfosulfuron + metsulfuron 0.030 kg/ha at 30 DAS	3.47	7.13	68.51	24.91	43.60	2.75
Mesosulfuron + iodosulfuron 0.0144 kg/ha at 30 DAS	2.95	6.50	58.31	25.88	32.43	2.26
Clodinafop + metsulfuron 0.064 kg/ha at 30 DAS	4.33	9.26	85.43	28.44	58.39	3.05
Weed free	4.40	9.20	86.83	37.09	48.34	2.31
Weedy check	2.22	4.71	43.80	22.17	21.63	1.94
LSD (p=0.05)	0.15	0.03	3.00	--	3.00	--
Interaction (A×B)						
LSD (p=0.05)	0.31	NS	NS	--	NS	--

Wheat MSP ₹ 19750/t

significantly highest net monetary return was noticed with clodinafop + metsulfuron (₹ 58389/ha) as a result of more productivity and best weed management, and the lowest return was recorded with treatment mesosulfuron + idosulfuron (₹ 33432/ ha) due to phytotoxicity on wheat.

The greater BCR value was delivered by treatment rototill and proved superior over ZT (2.25). Among various weed management treatments, treatment clodinafop + metsulfuron recorded the numerically maximum B: C of 3.05, which was followed by treatment sulfosulfuron + metsulfuron (2.75). This was due to higher grain and straw yield of wheat obtained from the above treatments and less cost of cultivation. Similar monetary benefit was also reported by Singh *et al.* (2004) and Singh (2014).

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