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Research Communication

Effect of tillage and weed management on performance of wheat (*Triticum aestivum*) in sequence with greengram (*Vigna radiata*)

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ABSTRACT

A field experiment was conducted at the research farm of the Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh during 2019–20, to study the effect of tillage and weed-management practices on the performance of wheat, (*Triticum aestivum* L.) grown after greengram [*Vigna radiata* (L.) R. Wilczek). Zero-till sowing of wheat significantly improved grain yield compared with conventional tillage (CT) but retention of greengram residue along with ZT did not prove beneficial over ZT alone. Pendimethalin applied as pre-emergence was not beneficial as the field was mostly infested with broad-leaf weeds. However, sulfosulfuron applied as post-emergence provided complete control of all weeds, which led to 21.5% higher yield than the unweeded control. Lower cost of cultivation and energy input under ZT led to higher net benefit: cost (B : C) and energy ratio compared with CT.

Key words: Economics, Energy ratio, Grain yield, Sulfosulfuron, Weed dry weight, Wheat, Zero tillage

Bundelkhand region in central India is characterized by water scarcity, undulating topography, poor soils and harsh weather conditions. This is leading to lower crop productivity compared with other parts of the country. In the rainy season, the crops like greengram, blackgram, sesame and groundnut are followed by chickpea, lentil, peas, Indian mustard and wheat in the winter (*rabi*) season. With the development of irrigation facilities, the conventional low-water requiring crops of pulses and oilseeds are getting replaced by wheat. However, the productivity of wheat is one of the lowest in the country (~2.0 t/ha) due to late sowing, broadcast seeding, weed infestation, inadequate fertilization and low varietal replacement rate (Sharma *et al.,* 2020). Repeated ploughing of the land for seedbed preparation during the rainy season (*kharif*) not only leads to erosion hazards but also delays the sowing of *rabi* season crops like wheat beyond mid-November. Zero tillage sowing has been reported to advance the sowing time of wheat and improve productivity in most other regions including north-western India (Tripathi and Chauhan, 2000; Sharma, 2021). Further, contrary to the general perception, weed infestations are comparatively lower and easy to manage under zero tillage (ZT) conditions (Chhokar *et al*., 2007; Sangwan *et al*., 2008). However, conservation agriculture involving zero tillage with residue recycling has not been experimented in the Bundelkhand region. Hence, the objective of the present study was to explore the possibility of zero tillage and weed management on the performance of wheat grown after greengram.

An experiment involving tillage and weed-management practices was conducted at the research farm of the Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh during 2019–20 on a loamy soil having poor fertility. After a uniform crop of greengram during the rainy (*kharif*) season, wheat was taken up in the winter (*rabi*) season with 12 treatment combinations of 3 tillage, viz. zero tillage (ZT), zero tillage + residue (ZT + R) and conventional tillage (CT) in main plots, and 4 weed-management practices, viz. pendi-methalin, pendimethalin followed by (*fb*) sulfosulfuron, pendimathalin *fb* hand-weeding (HW), and unweeded control in sub-plots. The layout of the experiment was in split plot design with 3 replications, and plot size of 45 m^2. The CT involved 3 ploughings with harrow and cultivator, while no ploughing was done under ZT. Residue of greengram was retained @ 3 t/ha under ZT + R. In all the ZT plots, glyphosate @ 1.0 kg/ha was sprayed before sowing to kill the existing weeds. Pendimethalin @ 1.0 kg/ha was applied within 24 hours of

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sowing, while sulfosulfuron @ 25 g/ha was sprayed and HW was done at 30 days after sowing (DAS) in the respective treatments.

Sowing of wheat var. 'HI 1544' was done uniformly on 19 November 2019 with Happy Seeder using 100 kg seed/ha at 20 cm row spacing. Fertilizers @ 50 kg N, 25.8 kg P and 32.2 kg K/ha were basally placed close to the seed, and top-dressing of 50 kg N/ha was done after the first irrigation. Irrigations were given before sowing, and at 21, 54 and 86 DAS. Harvesting was done on 3 April 2020 (134 DAS). Observations were recorded on weed dry matter, and performance of wheat. Economic and energy analysis, besides the statistical analysis were done as per the standard procedures.

Major weed species infesting the experimental field were: toothed bud clover (*Medicago polymorpha* L.; *M. denticulata* willd.) (52.0%), honey clover (*Melilotus albus* Medik.) (16.0%), Corn (*Spergula arvensis* L.) (13.1%), *(Anagallis arvensis* L.) (7.8%) and lesser swine-cress [Lepidium didymium L.; syn.) [*Coronopus didymus* (L.) Sm.] (6.1%) among broad-leaf species, and limited infestation of Bermuda grass [*Cynodon dactylon* (L.) Pers.] and nut grass (*Cyperus rotundus* L.) (2.1–2.3%). among grassy species. Weed dry weight increased with time from 30 DAS and varied significantly with tillage and weed-management practices (Table 1). At 30 DAS, ZT with or without residue resulted in significantly lower dry weight than CT. However, the effect of pendimethalin applied as pre-emergence was not discernible. This was because of the fact that, pendimethalin, a grassy weed killer, was not effective against the broad-leaf weeds. At 60 and 90 DAS, ZT gave significantly lower weed dry-matter than CT, and ZT + R was also significantly superior to ZT. Application of sulfosulfuron or hand-weeding (HW) at 30 DAS caused drastic reduction in weed dry weight compared with the unweeded control and pendimethalin alone, both of which were at par with each other. Sulfosulfuron resulted in near weed-free conditions, as it effectively controlled the predominantly broad-leaf and the few grassy weeds (Khokhar and Nepalia, 2010; Kaur *et al*., 2017).

Dry-matter production (DMP) of wheat was not influenced by the tillage and weed-management practices at 30 DAS (Table 1). However, at 60 and 90 DAS, ZT resulted in significantly higher DMP than CT. There was no significant difference between ZT and ZT + R in terms of DMP, which may be because the beneficial effects of residue are normally not observed in the immediate crop but may Became avoided over a period of time. On the other hand, pendimethalin *fb* sulfosulfuron resulted in significantly higher DMP at 60 and 90 DAS, which was significantly higher than pendimethalin *fb* HW. The DMP with pendimethalin alone was on a par with unweeded control. This was because of the fact that, the field was dominated by the broad-leaf weeds, which were not controlled by pendimethalin, and thus the DMP of wheat was not improved under this treatment. Regression analysis between DMP of wheat (Y) and weeds (X) showed negative correlation at 90 DAS ($Y= -2.73 X + 1066.6$; $R^2=0.76$). The DMP of wheat decreased by 2.73 g/m^2 with unit increase (1.0 g/m^2) in weed dry matter.

Number of spikes/m^2 was higher under ZT than CT but the effect of ZT + R was not significant over ZT alone (Table 2). Grains/spike and 1,000-grain weight did not show any change with tillage. Pendimethalin *fb* sulfosulfuron resulted in the highest number of spikes/m^2, followed by pendimetahlin *fb* HW, which was significantly superior to pendimethalin alone and the unweeded control, the latter 2 treatments being at par with each other. Grains/

Table 1. Effect of tillage and weed control on weeds and crop growth of wheat at different stages

Treatment	Weed dry weight (g/m^2)			Crop dry-matter (g/m^2)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Tillage						
ZT	7.64	11.0	32.5	33.8	318.5	1,019.0
ZT + R	6.72	9.7	24.7	33.3	305.8	977.0
CT	9.90	17.3	39.5	34.1	293.9	940.1
SEm±	0.21	0.4	0.8	0.7	4.5	14.3
CD (P=0.05)	0.84	1.3	2.9	NS	17.5	56.2
Weed management						
Pendimethalin	8.00	20.3	54.7	34.0	284.5	919.6
Pendimethalin *fb* sulfosulfuron	7.93	2.3	3.2	34.0	340.8	1,075.0
Pendimethalin *fb* HW	7.81	7.1	15.8	33.5	319.6	1,010.0
Unweeded control	8.60	21.0	55.2	33.5	279.5	911.0
SEm±	0.21	0.3	0.5	0.7	1.9	7.0
CD (P=0.05)	NS	0.8	1.4	NS	5.9	20.9

ZT, Zero tillage; R, residue; CT, conventional tillage; DAS, days after sowing; NS, non-significant

Table 2. Effect of tillage and weed control on yield, economics and energetics of wheat

Treatment	Spikes/ m^2	Grains/ spike	1,000-grain weight (g)	Grain yield (t/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio	Energy ratio
Tillage							
ZT	317.5	42.4	40.4	4.64	71.2	2.18	10.20
ZT + R	309.4	42.0	40.1	4.46	64.9	1.81	9.96
CT	296.2	40.3	40.2	4.22	59.3	1.61	7.35
SEm±	3.8	0.6	0.2	0.08	–	–	–
CD (P=0.05)	14.7	NS	NS	0.29	–	–	–
Weed management							
Pendimethalin	292.4	40.9	40.2	4.12	59.2	1.72	8.63
Pendimethalin *fb* sulfosulfuron	331.4	43.0	40.5	4.92	74.5	2.07	9.97
Pendimethalin *fb* HW	321.0	42.1	40.2	4.66	67.0	1.78	9.44
Unweeded control	286.0	40.3	40.0	4.05	60.2	1.88	8.68
SEm±	2.9	0.4	0.2	0.04	–	–	–
CD (P=0.05)	8.7	1.3	NS	0.12	–	–	–

ZT, Zero tillage; R, residue; CT, conventional tillage; DAS, days after sowing; NS, non-significant

spike were also more and equal under pendimethalin *fb* sulfosulfuron and pendimethalin *fb* HW, and significantly higher than pendimethalin alone and the unweeded control. There was no effect of weed-management practices on 1,000-grain weight.

Mean grain yield of wheat was the highest under ZT and at par with ZT + R, but significantly higher than CT (Table 2). Similarly, pendimethalin *fb* sulfusulfuron was significantly superior to pendimethalin *fb* HW, both of which were vastly superior to pendimethalin alone and the unweeded control. The mean loss in grain yield due to weeds was worked out to be 17.7%. Interaction revealed that, the highest grain yield was obtained with pendimethalin *fb* sulfosulfuron under ZT. All tillage treatments were equal under pendimethalin alone and the unweeded control, but when pendimethalin was accompanied with sulfosulfuron or HW, the yield was significantly better under ZT than CT. This indicates that, ZT should be accompanied with efficient weed control for achieving higher productivity of wheat. As such, pendimethalin alone did not prove beneficial, and it was sulfosulfuron or HW at 30 DAS which controlled the broad-leaf weeds effectively (Arora *et al*., 2013; Jat *et al*., 2014). Also residue effects were not observed in the first year of experimentation.

Regression analysis between grain yield of wheat (Y) and yield attributes (X), viz. spikes/m^2 and grains/spike, showed a positive correlation. The rate of increase in yield was 0.019 t/ha with unit increase in spikes/m^2 ($Y= 0.019 X – 1.46$; R^2=0.98), and 0.25 t/ha with unit increase in grains/spike ($Y=0.25 X – 5.94$; R^2= 0.82). On the other hand, negative correlation between grain yield (Y) and weed dry weight (X) revealed that, the yield decreased by 0.0144 t/ha with unit increase in weed dry weight ($Y= –0.0144 X + 4.90$; R^2=0.73). These results indicate that grain yield of wheat can be increased by reducing weed dry weight and increasing spikes/m^2 and grains/spike.

Net returns and net B : C were the highest with ZT and decreased slightly when residue was also added along with ZT, but still these values were higher than CT (Table 2). This was because greengram residue involved cost but did not prove beneficial in enhancing the yield. Similarly, pendimethalin *fb* sulfosulfuron resulted in the highest net returns and net B : C, while pendimethalin alone was almost equal to that with the unweeded control. A similar trend was observed in energy ratio (energy output/energy input). Hand-weeding involved greater cost and input energy than the output generated, due to which economic efficiency and energy ratio were lower under this treatment.

It was concluded that wheat after greengram can be grown under ZT by controlling emerged weeds before sowing with glyphosate and with sulfosulfuron as post-emergence for higher productivity, profitability and energy-use efficiency in Bundelkhand region.

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