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Research Communication

Weed and nitrogen management in zero-till wheat (*Triticum aestivum*) grown after rice (*Oryza sativa*)

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ABSTRACT

An experiment was conducted during 2020–21 at the Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh to study the effect of tillage, rice (*Oryza sativa* L.) residue, weed control and N fertilizer levels on weeds, and growth and yield of wheat (*Triticum aestivum* L.). Weed infestation in zero-tillage (ZT) wheat was significantly lower (16.7–27.6%), more so when rice-residue was retained on soil surface compared with conventional tillage (CT). Post-emergence application of sulfosulfuron + 2,4-D (ester) at 30 days after sowing (DAS) provided near weed-free conditions, and integration with hand-weeding at 45 DAS increased the grain yield of wheat marginally (3.7–4.2%). The grain yield increased significantly by 0.91–1.27 t/ha under ZT compared with CT (2.27 t/ha), the greater response was obtained with ZT + rice-residue and additional N fertilizer (150 kg N/ha). Higher net returns (₹ 44,400 per ha) and net energy output (141,300 MJ/ha) under ZT + rice-residue with 150 kg N/ha showed the potential of this technology in the Bundelkhand region.

Key words: Energy use, N fertilizer, Net returns, Rice residue, Sulfosulfuron + 2,4 D, Weed control, Wheat yield, Zero tillage

In Bundelkhand region of central India, rice (*Oryza sativa* L.) cultivation is becoming popular in lowland areas with the development of irrigation facilities. In these areas, wheat (*Triticum aestivum* L.) is the most important crop in winter season as it provides stable yield and assured market. Due to combine harvesting of both these crops, burning of rice-residues to a greater extent and of wheat residue to a relatively smaller extent is an emerging issue in this region as well. Such undesirable practices not only pollute the environment but also cause loss of plant nutrients and deterioration of soil fertility (Singh and Sidhu, 2014; NAAS, 2017). Herbicidal control of weeds is followed in most areas but mostly in an inefficient manner. Zero tillage technology has been advocated for resource saving and improving soil and crop productivity in north-western India (Sharma, 2021). However, no research work has been conducted on this aspect so far in the Bundelkhand region. It is often suggested to use relatively higher seed rate and N fertilizer, so as to compensate for the likely poor crop stand and vigour in zero-till wheat, especially in the initial years (Singh *et al*., 2015). In view of the above, an experiment was planned to study the performance of wheat grown under zero tillage with rice-residue, integrated weed management and additional use of N fertilizer.

The experiment was conducted during 2020–21 at the research farm of the Rani Lakshmi Bai Central Agricultural University, Jhansi, (25°51'N, 78°54'E, 300 m above mean sea-level) Uttar Pradesh on a sandy-loam black soil, having neutral *p*H (6.8), low organic C (0.45%) and available N (232 kg/ha), and medium available P (15.1 kg/ha) and available K (254 kg/ha). Rice was grown uniformly in the field through direct seeding in the rainy season. After rice harvesting, long-narrow strips of 13.0 m × 3.5 m (gross plot size) were demarcated for wheat for different treatments of tillage, residue, weed management and N fertilizer application. Twelve treatment combinations, involving 2 levels each of rice-residue (with and without rice-residue) and weed management (herbicide alone and with hand-weeding) and 3 N fertilizer levels (100, 125 and 150 kg N/ha) for zero-till (ZT) wheat, and 1 treatment of conventional tillage (CT) with recommended herbicide and N fertilizer (125 kg/ha), were laid out in a randomized block design with 3 replications. Conventional tillage involved ploughing with harrow (twice) followed by cultivator after removal of rice-residue, while no ploughing was done under ZT. Rice-residue @ 5 t/ha was retained on soil surface

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in the respective treatments (ZT + R). Tank-mix application of sulfosulfuron (25 g/ha) + 2, 4-D ester (500 g/ha) was done as post-emergence (30 DAS), and hand-weeding was done at 45 DAS. In all the ZT plots, glyphosate was sprayed @ 1 kg/ha before sowing to kill the previously-growing weeds. Seed of wheat variety 'HD 2932' was sown on 13 November 2020 with a calibrated happy seeder in all the treatments. A common dose of 26 kg P and 33 kg K/ha along with 50% N was basally placed close to the seed, and the remaining N was top-dressed after the first irrigation at 30 DAS. Observations were recorded on weeds, crop growth and yield parameters, and yield of wheat. Statistical, economics, and energy analysis (Panesar and Bhatnagar, 1994) were done as per standard techniques.

The experimental field was dominated by the presence of toothed bud clover (*Medicago polymorpha* L.: syn. *M. denticulata* Willd.), white sweet clover (*Melilotus albus* Medik.), scarlet pimpernel (*Anagallis arvensis* L.), corn spurry (*Spergula arvensis* L.), representing 54.7, 12.6, 5.2, 3.2%, respectively, besides a few species of nut grass (*Cyperus rotundus* L.) and Bermuda grass [*Cynodon dactylon* (L.) Pers.]. Total weed density at 30 DAS (before weeding) was significantly higher but decreased drastically after application of sulfosulfuron + 2, 4-D (Table 1). Rice-residue application under ZT (ZT + R) also showed a depressing effect on the weed density (10.5–31.4%) as well as dry weight (13.0–37.7%) compared with ZT alone. Integrated weed management (IWM) involving herbicide application at 30 DAS followed by hand-weeding at 45 DAS lowered the weed dry weight at 60 DAS by 62.2%. Nitrogen levels did not make a significant difference on weed growth at 30 DAS, but at 60 DAS, application of 150 kg N/ha recorded greater weed density than at lower N levels. Contrast analysis revealed that, ZT was significantly superior to CT in reducing weed density at 30 DAS and dry weight at 60 DAS. This is against the conventional belief that weed infestations are greater under ZT. In our study, the previously-growing weeds at sowing in ZT plots were killed with the application of glyphosate. In the CT plot, the weeds emerged in greater numbers due to the disturbance of soil, and grew vigorously. On the other hand, there was no greater emergence of weeds from the lower soil layers, and those coming from the surface layer (0–5 cm) were killed with herbicide application. It has been proved based on long-term studies that, weed infestations gradually decreased under ZT + R conditions (Fonteyne *et al*., 2020; Cordeau, 2022).

Crop growth and yield attributes of wheat were apparently better under ZT+R and higher rate of N application compared with CT (Table 1). Plant height at maturity was significantly higher under ZT + R than ZT alone, but reduced when HW was done at 45 DAS along with herbicide

Table 1. Mean effect of tillage, rice-residue, weed management and N fertilizer levels on weeds, crop growth and yield parameters of wheat

Treatment	Weed density (no./m^2)		Weed dry weight (g/m^2)		Plant height at maturity (cm)	Spikes/ m^2	Grains/ spike	1,000-grain weight (g)
	30 DAS	60 DAS	30 DAS	60 DAS				
ZT-residue								
ZT	62.1	12.1	7.61	1.75	94.3	231	37.2	38.3
ZT + R	55.6	8.3	6.62	1.09	101.3	249	40.9	38.7
SEm±	2.4	0.9	0.16	0.08	1.4	1.4	1.1	0.2
CD (P=0.05)	4.9	3.8	0.46	0.23	2.9	3.9	3.2	NS
Weed management								
Herbicide	59.1	12.5	7.14	2.04	99.5	239	39.1	38.7
Herbicide + HW (IWM)	59.3	7.9	7.08	0.77	96.0	241	39.1	38.3
SEm±	2.4	0.9	0.16	0.08	1.4	1.4	1.1	0.2
CD (P=0.05)	NS	3.8	NS	0.23	2.9	NS	NS	NS
N (kg/ha)								
100	58.2	8.4	6.72	0.96	93.6	226	39.2	38.6
125	59.1	8.9	7.19	1.52	96.8	242	38.6	38.1
150	60.2	13.4	7.43	1.78	102.9	252	39.4	38.8
SEm±	3.6	1.3	0.24	0.34	1.7	2.1	1.7	0.3
CD (P=0.05)	NS	3.8	NS	NS	4.9	5.9	NS	NS
CT vs ZT								
CT	71.2	14.1	7.74	6.89	87.4	218	37.3	37.1
ZT	59.3	10.2	7.13	4.26	97.8	240	39.6	38.6
SEm±	3.9	2.3	0.43	0.52	3.4	3.5	0.6	0.5
CD (P=0.05)	8.0	NS	NS	1.07	7.0	7.2	1.2	1.0

ZT, zero tillage; CT, conventional tillage; R, rice-residue; H, herbicide; IWM, integrated weed management; DAS, days after sowing application. Increasing levels of N up to 150 kg/ha improved height of plants significantly. Wheat plants under CT were dwarfer than under ZT due to relatively poor growth and greater weed infestation. Number of spikes/m^2 improved significantly under ZT + R compared with ZT alone, and with increasing levels of N up to 150 kg/ha. However, grains/spike increased under ZT + R but not with N application. Test weight (1,000-grain weight) remained unaffected with rice-residue, weed management and N rates. Non-significant effect of IWM over herbicide alone was due to fact that herbicide application provided complete control of all the weed species present, and HW at 45 DAS was not beneficial as there were few weeds left uncontrolled. All the yield attributes showed significant improvement under ZT over CT. Better growth and yield attributes of the ZT crop were owing to fewer weeds, good crop stand, and possibly higher N and soil-moisture availability to the wheat plants (Yadav *et al*., 2005; Kumar *et al*., 2013).

Grain yield of wheat was significantly higher under all treatments of ZT compared with CT (Table 2). The mean increase in yield ranged from 0.91 t/ha under ZT to 1.27 t/ha under ZT + R over CT (2.27 t/ha). The beneficial effect of ZT was attributed to lack of crop-weed competition at the early stage and very good crop stand. Further, optimum soil moisture and N availability, and temperature moderation under ZT might have also improved the crop performance (Singh *et al*., 2015; Rani *et al*., 2019). Integrated weed management (IWM) was superior to herbicide alone, which might be owing to the additional advantage of HW providing some aeration in the rhizosphere besides weed control. Interaction showed that the highest grain yield was under ZT + R with IWM and 150 kg N/ha. This indicated that for maximum benefit of ZT, rice-residue application and additional N fertilization was essential. Straw yield followed a similar trend, with ZT + R (4.96 t/ha) showing a significant improvement over ZT (4.32 t/ha) and CT (4.05 t/ha). The improvement in straw yield with IWM over herbicide alone was not discernible. Retention of residue on the soil surface as mulch modifies the hydrothermal regime, helps in weed suppression and adds to soil fertility in the long-run (Garg *et al*., 2006). In the initial years of conversion from CT to ZT, additional N application is often recommended to overcome the likely shortfall in crop stand and vigour due to the possible management deficiencies (Singh *et al*., 2015). Net returns and net benefit : cost (B:C) ratio showed improvement under ZT than CT, with the highest values at 150 kg N/ha. Net energy output and energy ratio (output: input energy) also indicated that, rice-residue application with additional N was essential under ZT. These findings indicated that, ZT + R was not only more productive but also economically superior and energy-use efficient practice than CT.

It was concluded that zero-tilled wheat with application of rice-residue, additional N fertilizer and integrated weed management resulted in higher productivity, profitability and energy-use efficiency. Adoption of ZT has tremendous potential for improving wheat productivity grown after rice in the Bundelkhand region.

Table 2. Effect of tillage, rice-residue, weed management and nitrogen fertilizer levels on yield, economics and energy-use efficiency of wheat

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Net returns ($\times 10^3$ ₹/ha)	Net benefit: cost	Net energy output ($\times 10^3$ MJ/ha)	Energy ratio
ZT						
H + 100 kg N/ha	2.91	4.36	29.52	1.12	108.9	7.7
H + 125 kg N/ha	2.94	4.38	29.60	1.11	105.7	6.2
H + 150 kg N/ha	3.48	4.99	40.27	1.49	127.3	8.0
IWM + 100 kg N/ha	3.05	3.63	30.97	1.12	97.2	7.0
IWM + 125 kg N/ha	3.33	4.26	35.41	1.26	110.8	7.1
IWM + 150 kg N/ha	3.34	4.30	35.87	1.26	110.2	6.5
ZT + R						
H + 100 kg N/ha	3.42	4.72	40.00	1.46	122.7	8.4
H + 125 kg N/ha	3.50	5.01	40.33	1.51	146.5	8.9
H + 150 kg N/ha	3.50	5.49	40.02	1.46	134.8	7.7
IWM + 100 kg N/ha	3.32	4.21	35.69	1.30	111.8	7.7
IWM + 125 kg N/ha	3.59	4.77	40.64	1.43	105.5	6.7
IWM + 150 kg N/ha	3.90	5.53	44.44	1.55	141.3	7.9
CT						
H + 100 kg N/ha	2.27	4.05	25.00	0.84	91.9	6.1
SEm±	0.09	0.14	-	-	-	-
CD (P=0.05)	0.27	0.40	-	-	-	-

ZT, zero tillage; CT, conventional tillage; R, rice-residue; H, herbicide; IWM, integrated weed management

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