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Effect of crop establishment and weed management practices on soil properties in wheat (*Triticum aestivum* L.)

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Abstract
Research work entitled "Effect of crop establishment and weed management practices on weeds, yield and economics of wheat (*Triticum aestivum* L.)" was carried out during two successive Rabi season of 2019-20 and 2020-21 at the Agricultural research farm of Institute of Agricultural sciences, Banaras Hindu University, Varanasi (UP). The experiment was conducted in split plot design replicated thrice with six crop establishment method as main plot treatment *i.e.* Zero till wheat + rice residue mulching (6 t ha^{-1}), Conventional till wheat + residue as mulch (6 t ha^{-1}), Zero till wheat - residue retention (30 cm height), Conventional till wheat - residue incorporation at 20 days before sowing (30 cm height rice residue), Zero till wheat – residue removed and Conventional till wheat-residue removed whereas weed management practices *i.e.* Weed free, Pendimethalin *fb* carfentrazone + iodosulfuron, Pendimethalin *fb* Sulfosulfuron + Metsulfuron and Weedy check. The data on various soil properties were recorded after harvest of wheat. Available NPK recorded significant differences; whereas no significant variation were observed in soil pH, EC and organic carbon but there were slightly increase due to various crop establishment methods and weed management practices.

Keywords: Zero tillage, residue, wheat, mulching

Introduction
The most frequently farmed cereal crop worldwide is wheat (*Triticum aestivum* L.). It produces 734 million tonnes of goods over an area of 220.41 million hectares. With the current rate of increase, there will be 2.4 million people on Earth overall by the year 2050. In order to lessen the hunger difficulty, this causes a worrying circumstance. One-fifth of daily caloric intakes and 21% of the world's protein needs are met by wheat, which is the primary source of nutrition for 20% of the world's population. Due to its popularity, adaptability, and widespread use among the crops, wheat production has a direct impact on world food security. In terms of acreage (45 million hectares) and production (107 million tonnes), rice is ahead of wheat in India. The Indo-Gangetic Plains, a significant area of the Green Revolution, account for 15% of the world's land area and are the primary cause of the output boom. This region alone contributes 50% of the nation's overall production and 40% of the population's need for food grains. These expansive country plains are among the largest in the world and have rich, fertile alluvium soil that is suited for double and triple cropping (Gangwar *et al*., 2006; Pal *et al*., 2009) [6, 8]. Farmers traditionally use a cultivator and rotavator to prepare the seed bed 4 to 5 times as part of repetitive tillage practises for crop establishment. Unknowingly, farmer practises lead to increased soil bulk density (Fabrizzi *et al*., 2005) [5], decreased soil porosity and aggregates (Chen *et al*., 2007) [3], less availability of water and nutrients (He *et al*., 2009) [7], lower microbial activity with declining soil organic matter (Baker *et al*., 2007) [1], and higher weed flora infestation, which are not sustainable and result in variable and lower crop yields (Chan and Heenan, 2005) [2]. For improved results, the rice-wheat cropping method shortens the time available for rabi season planting; under these circumstances, the traditional activity of crop sowing becomes tiresome. Zero tillage sowing techniques perform cleaning of the row zone, opening of soil, putting of fertilisers and seed; and covering the seed in a single pass to solve such issue. It can be used to perform in residue-filled environments and stop residue from burning. With the least amount of soil disturbance and residue, soil organic carbon sequestration is enhanced, fuel consumption for ploughs is reduced by US $ 52 per ha, and crop yields are increased by 5 to 7 percent (Erenstein and Laxmi, 2008) [4].
Weeds are currently one of the biggest risks to the productivity of rice-wheat agricultural systems.

For natural resources like air, light, moisture, and nutrients, weeds compete with the crop. In the early stages of crop development, delayed crop growth is known as an enabler of dominating weed flora and resource competition. Various studies have shown that uncontrolled weed flora can lead to a 10–60% drop in yield or, in extreme cases, crop failure. Farmers used to manually remove weeds, but this practise has become unprofitable due to wage increases and is also impractical since it takes too long.

The movement of agricultural workforce from rural to urban areas is another issue for effective weed management. Farmers were compelled to use alternative weed control methods in order to produce crops sustainably due to the current condition of manual weed management. In these circumstances, using herbicides to control weeds is the simplest and most practical alternative and has a considerable impact on weed control in contemporary agriculture. Totally relying on one herbicide without rotating it and using greater dosages makes weeds more resistant to it. Herbicide resistance was identified in 512 weed biotypes worldwide.

Materials and Methods

The experiment was carried out during two successive Rabi season of 2019-20 and 2020-21 at the Agricultural research farm of Institute of Agricultural sciences, Banaras Hindu University, Varanasi (UP). The experiment was conducted in split plot design replicated thrice with six crop establishment method as main plot treatment *i.e.* Zero till wheat + rice residue mulching (6 t ha^{-1}), Conventional till wheat + residue as mulch (6 t ha^{-1}), Zero till wheat – residue retention (30 cm height), Conventional till wheat - residue incorporation at 20 days before sowing (30 cm height rice residue), Zero till wheat – residue removed and Conventional till wheat-residue removed whereas weed management practices *i.e.* Weed free, Pendimethalin *fb* carfentrazone + iodosulfuron, Pendimethalin *fb* Sulfosulfuron + Metsulfuron and Weedy check. The experiment was laid out in split plot design during both the years with three replications. Crop establishment practices were allocated to main plot and weed management in sub plots. Each main plot was surrounded by a buffer of 1.5 m width whereas subplot was surrounded by 1.0 m. The detail of layout is given below. The variety of wheat taken for testing was 'MACS-6222'.

Experimental findings

Soil pH

Soil pH for both of the field experimentation years, zero tillage wheat with + rice straw mulching (ZTW+SM), zero tillage wheat with rice residue retention (30 cm) (ZTW+RR), conventional tillage practises with rice residue incorporation (CTW+RI), zero tillage wheat with no residue (ZTW-R), and conventional tillage wheat with no residue (CTW-R) show slightly lower soil pH in second compare to previous year. The difference were not significant during both the year of observation but lowest were recorded in the ZTW+SM compare to the rest of crop establishment practices. Weed management practices also affect the soil pH, it can be inferred that the pH was slightly higher in the weedy check plot during both years of observation and slightly lower in the weed free plot during the two years of observation when compared to pendimethalin at 1 kg a.i. ha^{-1} (PE) *fb* iodosulfuron + carfentrazone (PoE) @ 2.5 + 20 g a.i. ha^{-1} and pendimethalin at 1 kg *fb* sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}, PoE).

Electrical conductivity

The soil electrical conductivity for both years of field experiments is shown in Table 1. Crop establishment practices during two year of finding were not get significant variation but ZTW+SM were shown lower EC compare to rest crop establishment practices, whereas higher in conventional tillage with no residue application.

Effects of weed control methods on the soil's electrical conductivity were also presented in Table 1. From the table, it can be inferred that the weed free plot observed slightly lower electrical conductivity than the application of tank mix herbicide *viz.*, pendimethalin at 1 kg a.i. ha^{-1} (PE) *fb* iodosulfuron + carfentrazone (PoE) @ 2.5 + 20 g a.i. ha^{-1} and pendimethalin at 1 kg *fb* sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}, PoE). Slightly higher EC were observed in weedy check during both years of observation; however, the differences among treatments were not recognised up to a significant level.

Organic carbon (%)

Among crop establishment practices, zero till wheat with rice straw mulching (ZTW+SM100) shows slightly higher organic carbon *fb* conventional tillage with rice straw mulching (CTW+SM) > zero tillage wheat with rice residue retention (30 cm) (ZTW+RR) > conventional tillage practices with rice residue incorporation (CTW+RI) > zero tillage wheat with no residue (ZTW-R) and conventional tillage wheat with no residue (CTW-R); but the differences between the treatment of crop establishment practices were not get significant variation in soil organic carbon during both the year of field experimentation.

Weed management practices were also affect the on soil organic carbon which presented in Table 1. From the table it can be say that weed free plot recognised slightly more organic carbon in soil compare to pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb* iodosulfuron + carfentrazone (PoE) @ 2.5 + 20 g a.i. ha^{-1} and pendimethalin @ 1 kg a.i. ha^{-1} (PE) fb sulfosulfuron + metsulfuron (PoE) @ 30 + 2 g a.i. ha^{-1} and lowest in weedy check plot during both year of observation; but the differences among treatment not recognised upto significant level.

Available NPK

Availability of N, P and K in soil was significantly influenced by crop establishment and weed management practices during both the years, which presented in Table 2.

Among crop establishment practices, zero till wheat with rice straw mulching (ZTW+SM) shows slightly higher availability of N, P and K in soil compare to conventional tillage with rice straw mulching (CTW+SM) > zero tillage wheat with rice residue retention (30 cm) (ZTW+RR) > conventional tillage practices with rice residue incorporation (CTW+RI) > zero tillage wheat with no residue (ZTW-R) and conventional tillage wheat with no residue (CTW-R); and differences were attain significant variation during both the year of field experimentation.

Weed free plot recognised slightly higher availability of N, P and K during both the years of field experimentation compare to pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb* iodosulfuron + carfentrazone (PoE) @ 2.5 + 20 g a.i. ha^{-1} and pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb* sulfosulfuron + metsulfuron (PoE) @ 30 + 2 g a.i. ha^{-1} and lowest in weedy check and the differences among treatment were recognised upto significant level.

Table 1: Effect of crop establishment and weed management practices on soil pH, EC and organic carbon

Treatments	pH		EC (dsm^{-1})		OC (%)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Crop establishment practices						
R_1: Zero till wheat residue as mulch	7.26	7.19	0.287	0.281	0.438	0.464
R_2: Conventional till wheat residue as mulch	7.26	7.20	0.288	0.281	0.437	0.463
R_3: Zero till wheat - residue retention at 30 cm height	7.29	7.23	0.288	0.282	0.437	0.463
R_4: Conventional till wheat - rice residue incorporation at 20 days before sowing	7.30	7.23	0.287	0.283	0.435	0.461
R_5: Zero till wheat without residue removed	7.30	7.23	0.288	0.283	0.437	0.463
R_6: Conventional till wheat - residue removed	7.30	7.24	0.289	0.283	0.435	0.461
SEm±	0.17	0.17	0.007	0.006	0.011	0.011
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
Weed management						
W_1: Weed free	7.28	7.22	0.288	0.282	0.436	0.462
W_2: Pendimethalin (1 kg ha^{-1}, PE) *fb* iodosulfuron + carfentrazone (2.5 + 20 g ha^{-1}, PoE)	7.30	7.23	0.288	0.282	0.437	0.463
W_3: Pendimethalin (1 kg ha^{-1} PE) *fb* sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}, PoE)	7.27	7.21	0.287	0.282	0.436	0.462
W_4: Weedy check	7.29	7.22	0.288	0.283	0.437	0.463
SEm±	0.11	0.11	0.013	0.012	0.007	0.007
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
Interaction (R x W)	NS	NS	NS	NS	NS	NS
Initial	7.28	7.25	0.264	0.236	0.432	0.456

Table 2: Effect of crop establishment and weed management practices on available NPK content in soil (kg ha^{-1})

Treatments	Nitrogen		Phosphorus		Potash	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Crop establishment practices						
R_1: Zero till wheat residue as mulch	261.23	263.36	20.58	20.90	198.03	196.24
R_2: Conventional till wheat residue as mulch	260.42	259.89	19.90	20.36	190.46	190.07
R_3: Zero till wheat - residue retention at 30 cm height	250.95	253.51	19.26	19.82	184.16	184.71
R_4: Conventional till wheat - rice residue incorporation at 20 days before sowing	252.25	251.71	17.60	18.18	176.38	177.27
R_5: Zero till wheat without residue removed	230.75	222.33	17.06	17.48	167.13	166.29
R_6: Conventional till wheat - residue removed	223.45	223.22	16.52	17.17	164.45	165.93
SEm±	5.35	5.38	0.75	0.75	4.75	6.45
LSD (p=0.05)	16.87	16.95	2.35	2.35	14.96	20.33
Weed management						
W_1: Weed free	266.30	265.49	19.49	19.99	194.72	194.69
W_2: Pendimethalin (1 kg ha^{-1}, PE) *fb* iodosulfuron + carfentrazone (2.5 + 20 g ha^{-1}, PoE)	259.59	258.78	19.33	19.83	187.54	187.52
W_3: Pendimethalin (1 kg ha^{-1} PE) *fb* sulfosulfuron + metsulfuron (30 + 2 g ha^{-1}, PoE)	246.70	245.85	17.97	18.47	176.67	176.67
W_4: Weedy check	213.45	212.56	17.16	17.65	161.46	161.47
SEm±	2.96	2.97	0.47	0.47	3.44	3.06
LSD (p=0.05)	8.49	8.51	1.35	1.35	9.88	8.77
Interaction (R x W)	NS	NS	NS	NS	NS	NS
Initial	232.25	235.61	18.63	19.75	178.54	184.36

Conclusion

On the basis of above results it can be concluded that zero till wheat with 100% rice straw mulching with pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb* iodosulfuron + carfentrazone (PoE) @ 2.5 + 20 g a.i. ha^{-1} for weed management is beneficial to lowering the pH, EC whereas improve in soil organic carbon and availability of NPK.

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