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On-farm assessment of conservation tillage for wheat planting in rice-wheat cropping system

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ABSTRACT

A farmer's participatory field experiment was conducted during two consecutive *Rabi* seasons of 2015-16 and 2016-17 at farmer's fields in Badkisarari village of Gwalior district of Madhya Pradesh on clay loam soils to validate zero-till sowing of wheat crop in rice-wheat cropping system for realizing higher yield. Zero till sown wheat had significantly lesser weed dry biomass per unit area as compared to wheat sown in conventional and reduced tillage besides advancement of sowing by 20-25 days over conventional and reduced tillage sowing of wheat crop. The population of *Phalaris minor, Avena ludoviciana, Avena fatua, Chenopodium album, Melilotus indica* and *Anagallis arvensis* was reduced significantly under zero tillage as compared to conventional tillage. Excellent suppression in weed density and weed dry weight with higher levels of weed control efficiency and yield were obtained with zero till sown wheat. Zero tillage was also found better in terms of lesser cost of cultivation, higher net returns and B:C ratio.

Rice–wheat is the world's largest agricultural production system occupying around 12.3 Million ha in India (Bhatt *et al*. 2016). Wheat (*Triticum aestivum* L.) crop is grown in 5.91 and 1.36 m ha area in state of Madhya Pradesh and Gwalior district, respectively during the year 2015-16 with the average productivity of 3.11 and 3.78 t/ha, respectively in the state of Madhya Pradesh and Gwalior district (Anonymous 2015-16). Wheat is grown in rotation with rice on 40 and 60% area in the country and Gwalior district, respectively during the year 2015-16. It was observed in the participatory rural appraisal survey of the village Badkisarai in Harsi command area of the Gwalior district that very less switch over time is left to the farmers for subsequent sowing of wheat after rice harvest at the recommended time. Due to this reason sowing of wheat crop was delayed by at least 20-25 days. The delayed sowing was observed as big stumbling block in realizing the yield potential of newer varieties of wheat despite a seed replacement rate of above 40% among the farmers in the villages.

Farmers were realizing the consequences of late planting of wheat in terms of less tillering and forced maturity in crop due to increased terminal atmospheric temperature. Delay in time of sowing in the rice-wheat cropping system is perhaps one of the major factors responsible for low crop yield (Kasana *et al*. 2015).

Invasion of wheat crop with weeds like *Phalaris minor*, *Avena ludoviciana* and *Avena fatua* were also reported by the farmers during the pre-adoption participatory survey of the village beside the increased cost of cultivation and reduced yield of the subsequent wheat crop in rice- wheat system. When land is cultivated to raise crops, weeds spring-up naturally along with the crop plants. Weeds represent one of the greatest limiting factors to efficient crop production (Kasana *et al.* 2018).Zero till seed drill machine is able to sow the wheat crop after the harvest of transplanted rice in standing rice stubbles. The reduction in wheat yield due to delay in sowing has been recorded as one per cent of total yield/ha/ day (Pal *et al.* 1996). Zero tillage has an advantage of early planting, reduced cost of production as well as chances of green-house gas emission (Hobbs 2002). It has been established in various field experiments under climate resilient technology development research projects in Indo-Ganagetic plains (IGP) that zero tillage technique not only overcomes the problem of delayed planting of wheat, but also reduced the infestation of weeds like *Phalaris minor*, *Avena ludoviciana* and *Avena fatua*. Keeping in view above eventualities of rice-wheat system the present investigation was planned to assess the performance and profitability of zero till wheat sowing technique in

clay loam soils atfarmer's fields in the adopted village *Badkisarai* under *Bhitarwar* block of district Gwalior.

Farmers' participatory on-farm trials (OFTs) were conducted for two consecutive years during *Rabi* seasons 2015-16 and 2016-17 at farmer's fields of village Badkisarai in Bhitarwar block of Gwalior district to validate zero till sowing of wheat crop in rice-wheat system for timely sowing of wheat in realizing higher yield. Ten on-farm trials were conducted during each season at randomly selected farmer's fields in Badkisarai village under Harsi canal command area in Gwalior district of Madhya Pradesh.

The soil of the farmer's fields was clay loam in texture with low organic carbon (0.3-0.8%) and available nitrogen (N, 201-242 kg/ha), medium in available phosphorous (P, 15.5-18.6 kg/ha) and available potassium (K, 180-240 kg/ha) with pH 8.2-8.6. The experiments were laid out in a randomized block design comprising three planting methods of wheat after rice harvest *viz.* conventional tillage, reduced tillage and zero tillage on 10 farmers' fields considering each field as separate replication. Wheat variety '*MP4010*' was sown during last week of November and first week of December during the year 2015-16 and 2016-17 in zero tillage and during last week of December and first week of January in conventional tillage practice which include burning of rice residues 8-10 days after its harvesting followed by pre-sowing irrigation and 3-4 cultivations after getting workable field conditions in 20-25 days after application of pre sowing irrigation during both the year. The wheat crop was sown in rows, 20 cm apart, while wheat crop was sown after one follow up cultivation after rice harvest followed by pre sowing irrigation, and one cultivation under reduced tillage treatment. The zero tillage (ZT) treatment consisted of direct drilling of wheat seed (100 kg/ha) with di- ammonium phosphate (125 kg/ha), urea (80 kg/ha) and mureate of potash (66 kg/ha) by using zero till seed–cum-ferti drill without any pre-sowing tillage operation in presence of sufficient moisture condition after rice harvest in anchored residues. The remaining dose of nitrogen was applied through two equal doses of urea (65 kg/ha each) in split application after first and second irrigation at the appropriate moisture level in fields. The reduced tillage (RT) consisting of burning of crop residues *fb* pre-sowing irrigation due to loss of residual moisture after burning of rice crop residues 8-10 days after its harvesting and 2 ploughings with simultaneous planking operation before sowing. While the conventional tillage (CT); the farmers practice (FP) consisted of burning of rice crop residues 8-10 days after its harvest *fb* one pre-sowing irrigation *fb* 3-4 ploughings with planking and sowing with conventional seed cum ferti-drill. Uniform dose of nutrients was applied in all the tillage treatments. The ZT and RT sowing were carried out in advance by 25-30 and 2-5 days, respectively as compared to CT/ FP on the farmer's fields. The crop was grown with all other similar package of practices under all the planting methods.

The population and above ground weed dry weight was also recorded at 60 DAS by using a quadrate of 0.5 x 0.5 m for major grassy weeds and broad-leaved weeds. Standard methods were followed for weed, crop and economical analysis. The data collected were analyzed statistically using MS Excel Analysis Tool Pack-two factors without replication and LSD test was applied at 5% probability level to compare treatment means.

In economical analysis, the cost of cultivation was worked out taking into account the prevailing lobour and field operation charges in the locality, cost of inputs and the extra treatment costs in ₹/ha. The gross returns was calculated on the local market prices of wheat and its straw and expressed on per hectare basis.

Effect on weed

The farmer's fields in Harsi canal command area under rice-wheat cropping system were profoundly infested with grassy weeds, *viz. Phalaris minor*, *Avena ludoviciana* and *Avena fatua* beside broad-leaved weeds mainly *Chenopodium album, Chenopodium murale, Anagallis arvensis, Melilotus alba* and *Rumex dentatus* under wheat crop sown in conventional tillage (FP) and reduced tillage. On the other hand zero till sowing resulted in very effective suppression of narrow-leaved weeds with a fewer number of BLWs, *viz. Chenopodium album, Chenopodium murale, Anagallis arvensis, Melilotus alba* and *Rumex dentatus*. Zero till planting of wheat gave significantly lower weed density and weed dry weight for narrow-leaved weeds (NLWs) during both the years over farmers practice (CT) which gave 85.8 and 89.2% control efficiencies for NLWs in the year 2015-16 and 2016-17, respectively at 60 DAS **(Table 1)**. The similar trends were also observed by Sinha and Singh (2005), Prasad *et al.* (2005) and Radhey Shyam *et al.* (2014). The control efficiencies for NLWs under zero till planting method were

statistically superior to the rest of the two planting methods used for wheat in rice-wheat system. Singh (2014) also reported better control of narrow-leaved weeds in ZT planting of wheat in rice-wheat cropping system. The poor performance of CT in managing the NLWs in rice–wheat system might be due to movement of weed seeds from lower layers to upper layer (0-5 cm) of the soil by excessive tillage operations. These seeds got the opportunity to germinate under favorable micro ecological conditions under CT planting of wheat crop.

The planting methods could not produce any significant difference with respect to dry weight of broad-leaved weeds however these were observed in fewer numbers at different locations **(Table 1)**. Statistically, significant difference was observed for the density of BLWs under different planting methods. Significantly lower broad-leaved weeds density was recorded under ZT and RT as compared to CT during both the years.

Effect on crop

Wheat sown under ZT recorded significantly higher number of effective tillers/m^2 and test weight over reduced and conventional tillage systems during both the years **(Table 2)**. Significantly higher values for the test weight of wheat seed under ZT planting could be ascribed to higher accumulation of photosynthates in seed due to congenial ambient temperature, the crop received during maturity under ZT due to advanced planting. Higher dry matter accumulation was also reported by Jat *et al.* (2013) under ZT planting in wheat after mungbean. Further, lesser competition received by the crop from NLWs for growth resources under ZT planting of wheat over the rest of the two planting methods which had an added advantage for enhanced growth and development of the crop. The higher values for the yield attributes, *viz*. effective tillers and test weight, might be transformed into significantly higher grain yield under ZT over RT and CT. The ZT produced 5.74 and 4.81 t/ha grain yield of wheat in 2015-16 and 2016-17, respectively which was 15.31 and 11.86% higher over CT. The present findings corroborated the results obtained by Singh (2014) and Radhey Shyam *et al.* (2014).

Economics

The maximum net returns and benefit: cost ratio was observed for ZT during both the years, followed by the RT **(Table 3)**. The lowest net returns (₹ 52449 and ₹ 47377/ha) and B: C (3.35 and 3.00), during 2015-16 and 2016-17, respectively, were recorded under conventional tillage. The highest values of the economical parameter could be attributed by higher grain yield and reduced cost of cultivation under ZT and RT as compared to CT. Similar findings were reported by Bhatt *et al*. (2016) in conservation agricultural practices.

Table 1. Effect of tillage practices on weeds in wheat crop at farmers' field

Treatment	Weed density NLWs (no./m^2)		Weed dry weight NLWs (g/m^2)		Weed control efficiency -NLWs (%) at 60 DAS		Weed density BLWs (no./m^2)		Weed dry weight BLWs(g/m^2)		Weed control efficiency- BLWs (%) at 60 DAS	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Zero tillage (ZT)	24.6	14.8	22.6	20.6	86.18	90.30	17.65	19.04	29.22	28.43	1.65	6.93
Reduced tillage	132.6	120.5	102.6	96.5	25.64	21.00	19.60	19.63	29.94	29.90	-0.75	2.33
Farmers practice (CT)	178.6	152.6	116.4	112.6	0.00	0.00	21.85	19.07	29.72	30.14	0.00	0.00
LSD (p=0.05)	5.4	2.5	108.1	97.0	2.33	1.51	0.55	0.58	NS	NS	-	-

NLWs- Narrow-leaved weeds; BLWs- Broad-leaved weeds, DAS- Days after sowing

Table 2. Effect of tillage practices on yield attributes and yields of wheat crop at farmers' field Add straw yield, and some more yield attributes like number of grains/spike, spike length

Treatment	Effective tillers (no./m^2)		Test weight (g)		No. of grains/spike		Spike length (cm)		Grain yield (t/ha)		Straw yield (t/ha)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Zero tillage (ZT)	408	395	42.2	40.8	48.88	45.35	9.65	9.0	5.74	4.81	6.89	5.82
Reduced tillage (RT)	390	382	41.5	38.6	45.18	42.87	9.20	8.40	5.15	4.45	6.35	5.43
Farmers practice (CT)	326	308	38.5	37.4	41.18	40.47	8.20	7.80	4.86	4.24	6.13	5.35
LSD (p=0.05)	6	4	0.9	1.2	1.7	1.8	1.0	0.5	0.17	0.16	0.2	0.2

Table 3. Economics of different tillage practices in wheat crop at farmers' field

Treatment	Gross cost of cultivation (x10^3 ₹/ha)		Gross returns (x10^3 ₹/ha)		Net returns (x10^3 ₹/ha)		B:C ratio	
	2015-16	2016-17	205-16	2016-17	2015-16	2016-17	2015-16	2016-17
Zero tillage (ZT)	18.35	19.65	87.81	80.00	69.46	60.35	4.79	4.07
Reduced tillage	19.95	20.53	79.04	74.04	59.09	53.51	3.96	3.61
Farmers practice (CT)	22.35	23.65	74.80	71.03	52.45	47.38	3.35	3.00

Sale price of wheat during 2015-16 (₹ 13500/t) and 2016-17 (₹ 14500/t) and for straw 2015-16 (₹ 1500/t) and 2016-17 (₹ 1750/t). Total cost of cultivation was calculated on the basis of prevailing prices of Inputs used.

On the basis of two year farmers led field experimentation, it was concluded that ZT wheat sowing was found much effective in suppression of weed density and weed dry weight of narrow-leaved weeds, *viz*. *Phalaris minor*, *Avena ludoviciana* and *Avena fatua* in comparison to CT which was also observed significantly lower over reduced till sowing of wheat crop. However, differences among planting methods with respect to weed density of broad-leaved weeds were not observed statistically significant. The significantly higher grain yield of wheat and higher monitory returns were also achieved under ZT during both the year over the rest of the planting methods.

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