



## Productivity of zero-till wheat (*Triticum aestivum*) under different establishment methods, seed rate and weed control

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### ABSTRACT

Field experiment was planned to investigate the integration of establishment methods, variable seed rates and weed control in zero-till wheat (*Triticum aestivum* L.). The experiment was conducted in split-plot design with four replications. Treatments consisted of two establishment methods, i.e. zero till wheat with residue, viz. ZT+R (6 t/ha) and zero till wheat without residue, viz. ZT-R (0 t/ha), two levels of wheat seed rate (100 kg/ha (recommended) and 150 kg/ha) and four levels of weed control (weedy check, weed free, clodinafop + metribuzin 275 g/ha (recommended) and clodinafop + metribuzin 206.3 g/ha). The results revealed that clodinafop + metribuzin 275 g/ha in ZT + R had significantly lower *P. minor* biomass (25-27%) than ZT-R; however 16 and 14% biomass of broadleaved weeds were recorded at 90 days after sowing. Interaction effect revealed that in 2017–18, under weedy check, ZT+R had lower weed biomass and gave 14.9% higher grain yield than ZT-R; however in 2016-17, both ZT+R and ZT-R methods recorded almost similar yield. Integrated use of clodinafop+metribuzin 275 g/ha in zero till wheat sown in paddy residues gave the highest wheat grain yield (5465-5531 kg/ha) which was similar to weed free.

**Keywords:** Clodinafop, Metribuzin, Paddy straw residue, Wheat yield

Sustainability of rice-wheat system is affected by large number of factors like increased cost of cultivation, degradation of natural resources, lower land and water productivity (Bhatt *et al.* 2016), declining underground water (Humphreys *et al.* 2010) and increased insects, pests and weed infestation. Almost all rice fields in Punjab are harvested by combine harvesters and residue management is the major challenge in this region due to short window of time for wheat (*Triticum aestivum* L.) sowing. Presently on-farm residue management is the major issue in the prevailing rice-wheat cropping system. Zero tillage (ZT) is gaining high concern day by day because now the availability of suitable machines like Happy Seeder makes possible the wheat seeding in rice residues and further it is a compulsion because of the ban on residue burning. The major drivers of its adoption are the lower cost of wheat cultivation, timely sowing of wheat, saving of irrigation water as pre-sowing irrigation is needed for conventional wheat, reduced sowing window of wheat resulting in its timely sowing and higher yields, decreased emergence of most problematic weeds like *Phalaris minor* and *Chenopodium album* (Kumar and Ladha

2011) and the ban on residue burning which raises interest in this emerging technology. Despite numerous benefits of ZT, weed control remains a major challenge in wheat. Herbicide resistant *Phalaris minor* is another major challenge posing serious threat in north-western plains causing more than 65% wheat yield loss (Kumar *et al.* 2013) and showing multiple resistance to different modes of action, i.e. photosystem II, ACCase and ALS starting from isoproturon, fenoxaprop, clodinafop, sulfosulfuron and pinoxaden.

Alternative management strategies are needed to reduce dependence on herbicides and minimize risks associated with their overuse, including evolution of herbicide resistance. The integrated approach, consisting of establishment methods, seed rate and herbicide, may be considered as a long-term resistance management strategy that will help to sustain wheat productivity and farmers' income. Keeping these points in view, the present investigation was undertaken to evaluate the effect of establishment methods, seed rate and weed control methods on weed dynamics, growth and productivity of zero till wheat.

### MATERIALS AND METHODS

The study was carried out in *rabi* 2016–17 and 2017–18 at Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana (30°54' N latitude, 75°48' E longitude) and at 247 m height above sea level, characterized by sub-tropical and semi-arid climate. The experimental soil (0-15 cm) was a loamy sand with 69.85%

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sand, 17.63% silt, 12.52% clay, pH 7.7, 0.38% organic carbon and 0.42 dS/m EC. The total rainfall of 99.1 mm and 86.4 mm was recorded during 2016-17 and 2017-18, respectively. Standing stubbles of paddy variety PR 121 were chopped with Paddy Straw Chopper cum Spreader in residue plots. After chopping of paddy straw, wheat variety PBW 677 was sown with PAU Happy Seeder attached with press wheels in residue retention plots. Wheat was sown with zero-till drill in without residue plots after harvesting the paddy crop from the ground in rows 20 cm apart on 8<sup>th</sup> November, 2016 and 30<sup>th</sup> October, 2017, respectively. Recommended doses of fertilizers of 125 kg N per ha through urea and 62.5 kg P per ha through Diammonium Phosphate (DAP) were applied. Half nitrogen and full phosphorus at sowing and remaining half dose of nitrogen was applied before the first irrigation.

Experiment was conducted in split-plot design with four replications. The treatments consisted of two establishment methods, i.e. zero-till wheat with residue, viz. ZT+R (6 t/ha) and zero till wheat without residue, viz. ZT-R (0 t/ha), two levels of wheat seed rate (100 kg/ha (recommended) and 150 kg/ha) and four levels of weed control (weedy check, weed free, clodinafop + metribuzin 275 g/ha (recommended) and clodinafop + metribuzin 206.3 g/ha). Herbicide metribuzin 42% + clodinafop propargyl 12% (Shagun 21-11) was applied as post-emergence as per the treatment using knap sack spray pump fitted with flat fan nozzle using 375 l of water per ha.

Weeds were counted species wise by randomly placing quadrat (1 m × 1 m) at two spots per plot at 90 days after sowing (DAS). The weeds present inside the randomly placed quadrat were cut at the ground level at 90 DAS. The weed samples were first sun-dried and then dried in the hot air oven at 60±2°C till constant weight. For crop data analysis, 10 wheat plants were randomly selected from each plot and then the data were averaged. Data on grain yield were recorded from net plot size of 5 m × 1.85 m. The data on weeds and crop were analyzed by the analysis of variance (ANOVA) for split-plot design. ANOVA indicated that treatment effects were significant at P≤0.05 using Fisher's Protected Least Significant Difference (LSD) test. The data on weed density and biomass were subjected to square root transformation.

## RESULTS AND DISCUSSION

*Effect on weed biomass:* *Phalaris minor* was the dominant grass weed, whereas *Medicago denticulata* and *Rumex dentatus* were the dominant broad leaf weeds in the experimental plots. Interaction effect of establishment methods, seed rate and weed control methods indicated that zero till with residue plots had significantly lower weed biomass than zero till without residue. Weedy check in zero till with residue recorded 21 and 22% less *P. minor* biomass, 8 and 7% less biomass of *M. denticulata* and 12% each less biomass of *R. dentatus* (Table 1) as compared to zero till without residue plots during 2016–17 and 2017–18, respectively. The lower weed biomass in ZT+R, as compared

Table 1 Interaction effect of establishment methods and weed control treatments on *P. minor*, *M. denticulata* and *R. dentatus* biomass at 90 DAS and grain yield in wheat

Treatment	<i>P. minor</i> biomass* (g/m <sup>2</sup> )				<i>M. denticulata</i> biomass* (g/m <sup>2</sup> )				<i>R. dentatus</i> biomass* (g/m <sup>2</sup> )				2016-17		2016-17		2017-18		2017-18	
	2016-17		2017-18		2016-17		2017-18		2016-17		2017-18		2016-17		2017-18		2016-17		2017-18	
	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)	ZT-R (0 t/ha)	ZT+R (6 t/ha)
Weedy check	7.37 (53)	6.55 (42)	6.16 (37)	5.50 (29)	8.71 (75)	8.33 (69)	8.68 (74)	8.35 (69)	7.22 (51)	6.82 (46)	7.87 (61)	7.39 (54)	4035	4010	4035	4010	3830	4401	3830	4401
Weed free	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	5391	5524	5391	5524	5393	5569	5393	5569
CLOD + METRI <sup>#</sup> 275 g/ha	4.54 (20)	3.84 (14)	4.37 (18)	3.66 (13)	5.35 (28)	4.77 (22)	5.46 (29)	4.97 (24)	4.67 (21)	3.98 (15)	4.99 (24)	4.33 (18)	5232	5465	5232	5465	5302	5531	5302	5531
CLOD + METRI 206.3 g/ha	4.71 (21)	4.04 (15)	4.53 (20)	3.73 (13)	5.49 (29)	4.93 (23)	5.58 (30)	5.09 (25)	4.83 (22)	4.15 (16)	5.12 (25)	4.49 (19)	5027	5308	5027	5308	4996	5409	4996	5409
LSD (P=0.05)	0.13	0.10	0.12	0.10	0.14	0.12	0.14	0.14	0.09	0.09	0.12	0.12	156	156	156	156	145	145	145	145

\*Figures in parentheses are means of original values. <sup>#</sup>CLOD + METRI-Clodinafop+Metribuzin

to ZT-R, would probably be due to thorough and uniform mulch in inter-row spaces in pressed form which helps in reducing density and diversity of weed flora significantly. Paddy straw residue formed mulch on soil surface, thus restricting the weed emergence by restricting sunlight and causing physical barrier hence weed growth was less in residue plots at all stages of growth. Thus residue mulch contributed for weed suppression which provided an edge and provided almost weed free environment to the crop.

Among the weed control treatments, clodinafop + metribuzin 275 g/ha significantly reduced biomass of weeds followed by 206.3 g/ha. This might be due to less weed density in zero-till residue plots. So presence of residue significantly reduced dry weight of weeds (Rahman *et al.* 2005). Zero tillage (ZT) with 100% maize residue retention (ZT+R) resulted in significant reduction in weed dry matter by 14 and 25.2% than conventional tillage (CT) and ZT without residue (ZT-R), respectively (Susha *et al.* 2018). Weed biomass was higher under clodinafop+metribuzin 206 g/ha compared to 275 g/ha due to lower efficacy of herbicide at lower dose due to higher weed density. Paul *et al.* (2017) reported higher weed control efficiency at higher dose of herbicide than lower dose.

*Effect on crop parameters:* Establishment methods influenced the yield attributes significantly during both the years. Crop sown in residue produced more yield attributes which was significantly higher than crop sown in without residue. Seed rate failed to affect these yield attributes during both the years. Significantly higher yield attributes were recorded in weed free than clodinafop + metribuzin 206.3, 275 g/ha and weedy check. Further significantly more number of yield attributes were recorded in clodinafop + metribuzin 275 g/ha than 206.3 g/ha. Lowest number of yield attributes was found in weedy check (Table 2).

Interaction effect between establishment methods

and weed control treatments on grain yield indicated that maximum grain yield was resulted from the crop sown in paddy residues which was significantly higher than the crop sown without residue during both years. Interaction showed that highest grain yield (5524 and 5569 kg/ha) was recorded from weed free plots which was similar with grain yield (5465 and 5531 kg/ha) obtained from clodinafop + metribuzin 275 g/ha under residue and significantly more than other treatments during 2016-17 and 2017-18, respectively. ZT+R increased wheat yields significantly by 6.9 and 7.5% than those obtained in CT and ZT-R treatments (Susha *et al.* 2018). Weedy check resulted in lowest grain yield (4035 and 3830 kg/ha in ZT-R and 4010 and 4401 kg/ha in ZT+R) during 2016-17 and 2017-18, respectively which was significantly lower than other weed control treatments (Table 1). This indicated that presence of paddy straw residue did not affect grain yield significantly under weedy check in first year; however in second year, residue retained plots attained higher grain yield under weedy check.

Beneficial effects of paddy straw residue resulted in attainment of better yield attributes and might be attributed to the better utilization of resources due to weed free environment that ultimately contributes towards attainment of improved grain yield. Increased yield attributes recorded in ZT+R might be due to greater sink and good growth in reproductive phase. Grain yield may be increased due to less weed-crop competition in the presence of residue retention on the soil surface (Ramadhan 2013, Kumar *et al.* 2018). The crop under recommended dose of herbicide (275 g/ha) produced more effective tillers and more yield attributing characters which ultimately reflected in higher grain yield. Treatment combination of residue plus herbicide had similar yield to weed free. This may be due to effective control of grass and broadleaf weeds with clodinafop + metribuzin at recommended rate and the supplementary effect of

Table 2 Effect of establishment methods, seed rate and weed control treatments on yield attributes of wheat

Treatment	Effective tillers (No./m <sup>2</sup> )		Number of grains per spike		1000-grain weight (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
<i>Establishment methods (A)</i>						
ZT-R (0 t/ha)	360	361	45.52	44.52	37.69	36.67
ZT+R (6 t/ha)	392	393	48.50	47.49	40.32	39.19
<i>Seed rate (B)</i>						
100 kg/ha	375	376	47.04	46.01	38.98	37.98
150 kg/ha	377	377	46.98	46.00	39.03	37.88
<i>Weed control (C)</i>						
Weedy check	360	361	45.08	44.08	37.70	36.43
Weed free	393	394	48.36	47.35	40.35	39.35
CLOD + METRI 275 g/ha	380	381	47.64	46.66	39.61	38.59
CLOD + METRI 206.3 g/ha	371	371	46.96	45.94	38.38	37.35
LSD (P=0.05)	A=8	A=9	A=1.62	A=0.92	A=1.00	A=0.57
	B=NS	B=NS	B=NS	B=NS	B=NS	B=NS
	C=6	C=9	C=1.90	C=1.18	C=1.44	C=1.49
Interaction A×B=NS; B×C=NS; A×C=NS; A×B×C=NS						

residue on weed suppression. These results indicated that ZT+R wheat could reduce weed density which can help in reducing weed seed bank in the coming years. These results indicated that recommended dose of herbicide is very important in without residue plots for getting best benefits in terms of weed management. Many reports of clodinafop, sulfosulfuron and pinoxaden resistant *P. minor* are coming from different pockets of Punjab (Kaur *et al.* 2019) which threatens the wheat sustainability. However, the results indicated that combination of zero-till sown wheat with residue and post-emergence herbicide were able to maintain effective control of broad spectrum weeds over the crop period and hence gave the highest grain yield. Crop residue as mulch and post-herbicide complement each other for the control of weeds.

Integrated sowing of zero-till wheat with residue with clodinafop+metribuzin 275 g/ha as post-emergence gave the highest wheat grain yield in both years. Zero tillage, when combined with residue retention on the surface, resulted in suppression of *Phalaris minor*, *Medicago denticulata* and *Rumex dentatus* in wheat. Thus, for wheat sown at the optimum time in north-west India, retention of paddy straw residue is beneficial in terms of reducing weed density. Farmers may harvest the benefits of residue retention for weed management by sowing zero-till wheat in paddy residues and could be adopted for sustainable weed management in wheat. However further to check the long-term effect on decrease/increase in particular weed flora, future studies need to be conducted for more years. In addition, to scale out these profitable alternative methods, there is a need to strengthen the custom hiring of mechanized sowing with ZT machine-Happy Seeder, which will enhance access to these capital-intensive technologies for small and marginal farmers.

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