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Short communication

Zero-till sowing and residue mulching in rainy season maize: Effect on weeds, crop productivity and profitability

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Weeds pose serious problems in *Kharif* maize owing to its wide spacing, slow early vegetative growth, vagaries of monsoon which favour weeds due to congenial growing conditions like high temperature and humidity. Weeds emerge fast and grow rapidly thus competing with the crop severely for growth resources, *viz*. nutrients, moisture, sunlight and space during entire vegetative phase; and early reproductive stages and reduce the photosynthetic efficiency leads to lower dry matter production and grain yield of maize. Hence, managing weeds is very critical for higher yields and therefore, their effective management is needed to realize higher yields. Raised bed sowing is the conventional method of establishment for maize crop. No tillage with residue retention and herbicide use can be the alternative technologies for weed management (Dahal and Karki 2014). Information on weed dynamics under different planting methods and residue management are lacking. In this regard, the present experiment was planned to study the effect of zero-tillage sowing and residue mulching on weeds, crop productivity and profitability of *Kharif* maize.

A field experiment was conducted at Regional Research Station, Karnal of CCS Haryana Agricultural University during *Kharif* 2015. The experiment was laid out in split plot design with three replications. Main plot treatments comprised of four planting methods *viz*., raised bed with residue (RB+R), raised bed without residue (RB-R), zero tillage with residue (ZT+R) and zero tillage without residue (ZT-R). Three maize hybrids, *viz. HQPM-1, HM-4* and *HM-10* in combination with two weed control treatments, *viz*. atrazine 750 g/ha pre-emergence (PRE) followed by (*fb*) 1 hand weeding (HW) at 30 days after sowing (DAS) and unweeded check were kept as sub-plots. The soil of experimental field was clay loam in texture with medium in organic carbon (0.41%), low in available N (123.0 kg/ha); and medium in available P (11.0 kg/ha) and K (185.9 kg/ha) with slightly alkaline pH (8.4) and EC of 0.31 dS/m. Sowing in raised bed was done with bed planter and in flat bed with zero-till seed drill keeping row to row spacing of 75 cm using seed rate of 20 kg/ha on June 25, 2015. All the recommended package of practices was adopted to raise the crop. Atrazine was applied as pre-emergence spray to the soil surface as per treatments at 0-3 DAS through knapsack sprayer fitted with flat-fan nozzles delivering water 500 l/ha. Data on weed density and weed biomass were recorded at 60 DAS using quadrate of 0.5 m × 0.5 m twice in a plot and converted into number of weeds/m^2 and g/m^2, respectively. Data on weed density were subjected to square root transformation $(\sqrt{x+1})$ before statistical analysis. Harvesting of maize hybrid *HM-4* was done manually on September 22, 2015; and *HQPM-1* and *HM-10* on September 29, 2015 from each plot manually.

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Density and dry weight of weeds

The most dominating weed species observed in the experimental plots were *Dactyloctenium aegyptium, Brachiaria reptans* and *Eragrostis tenella* among grassy weeds, *Portulaca oleracea*, *Ammania baccifera* among broad-leaf weeds (BLW) and *Cyperus rotundus* among sedges. The lowest density and dry weight of grassy weeds and dry weight of sedges were recorded under ZT+R *fb* RB+R, ZT-R and highest in RB-R; however, dry weight of sedges in RB+R and ZT+R were at par with each other (**Table 1** and **2**). The lowest density and dry weight of BLW was recorded under ZT+R *fb* RB+R, RB-R and highest in ZT-R. In sedges, the lowest density was recorded in RB+R *fb* ZT+R, RB-R and highest in ZT-R. In general, residue retention resulted in lower density and reduced biomass of all type of weeds under both methods of planting. The density of grassy weeds was lower under ZT than raised bed, while BLW and sedges were less under raised bed; however, the differences in the case of sedges were not always significant (**Table 1**). In general, dry

weight of weeds was lower under ZT as compared to raised bed except for BLW which was slightly higher under ZT (**Table 2**). The lower density of grassy weeds in ZT might be due to the killing of weeds with glyphosate before sowing of crop and non-disturbance of the soil surface. However, slightly higher sedges under ZT, particularly at initial stages, might be due to the regeneration of some of the weeds even after spray; but at later stages, ZT and raised bed became at par with each other. Dahal and Karki (2014) has also reported that ZT+R and atrazine applied at 1.5 kg/ha as pre-emergence had significantly lowered density and dry weight of grassy weeds and BLW as compared to conventional tillage, residue removed and manual weeding at 30 DAS.

Among maize hybrids, the lowest density and dry weight of grassy weeds and sedges was recorded under *HM-10 fb HM-4* and *HQPM-1* (**Table 1** and **2**). Lower density and dry weight of BLW was recorded with *HM-4 fb HM-10* and higher in *HQPM-1*. The faster initial growth of *HM-10* than the other hybrids could be the reason for lower weed infestation and dry weight of weeds as compared to other hybrids. In general, the crop growth is inversely related to weed infestation. The dry weight of weeds exhibited an increasing trend from crop germination to harvest in unweeded check, whereas the density of weeds did not increase that much. It might be due to early germination and establishment of weeds which kept on growing with time. Significantly lower density and dry weight of all type of grassy weeds, BLW and sedges were recorded under atrazine 750 g/ha (PE) *fb* 1 HW at 30 DAS than unweeded check (**Table 1**). Higher total weed density and dry weight under unweeded check mainly was due to higher and uninterrupted growth of weeds which made the best use of the growth resources. Two HW and pre-emergence application of atrazine 1.5 kg/ha recorded lower weed density and dry weight in maize (Rao *et al.* 2009).

Grain yield and economics

Maize sown in ZT+R recorded highest grain yield (7.32 t/ha) and net returns (` 59958/ha) as compared to other establishment methods. ZT observed to be a suitable planting method with numerically higher but statistically similar grain yield to raised bed. The increase in grain yield of maize under ZT+R maize could be attributed to higher yield attributes, lesser weed infestation and to some extent better soil environment. There was less stagnation of

Table 1. Effect of planting methods, residue and weed management on density of different weeds at 60 DAS of different maize hybrids

Treatment	Density of weeds (no./m^2)*								
	Grassy weeds				Broad-leaf weeds				Sedges
	D. aegyptium	*B. reptans*	*E. tenella*	Total	*P. oleracea*	*A. baccifera*	Other	Total	*C. rotundus*
Planting method									
Raised bed with residue	2.69	1.46	1.21	2.97	1.16	1.09	8.72	8.75	5.50
	(6.7)	(1.2)	(0.6)	(8.4)	(0.4)	(0.2)	(85.6)	(86.2)	(30.2)
Raised bed without residue	3.01	1.92	2.45	4.12	1.20	1.27	12.82	12.86	8.80
	(8.6)	(3.1)	(5.7)	(17.3)	(0.5)	(1.0)	(180.9)	(182.4)	(79.1)
Zero tillage with residue	2.02	1.31	1.61	2.28	1.14	1.24	5.86	5.94	5.57
	(3.1)	(0.9)	(0.4)	(4.4)	(0.3)	(0.7)	(43.9)	(44.9)	(33.4)
Zero tillage without residue	2.72	1.78	1.33	3.23	1.17	1.44	12.78	12.85	10.67
	(6.6)	(2.3)	(0.9)	(9.72)	(0.4)	(1.3)	(183.9)	(185.7)	(119.7)
LSD (p=0.05)	0.18	0.19	0.11	0.20	NS	0.10	0.10	0.10	0.15
Maize hybrids									
HQPM-1	2.72	1.75	1.66	3.39	1.30	1.35	11.43	8.17	8.17
	(6.9)	(2.5)	(2.5)	(11.9)	(0.8)	(1.1)	(140.1)	(77.0)	(77.0)
HM-4	2.73	1.57	1.54	3.22	1.07	1.07	8.98	7.16	7.59
	(6.9)	(1.6)	(1.9)	(10.3)	(0.2)	(0.2)	(104.0)	(61.8)	(61.8)
HM-10	2.38	1.53	1.41	2.83	1.14	1.36	9.72	7.59	7.16
	(4.9)	(1.6)	(1.3)	(7.7)	(0.3)	(0.2)	(126.6)	(58.0)	(58.0)
LSD (p= 0.05)	0.10	0.16	0.11	0.15	0.08	0.07	0.09	0.08	0.08
Weed management									
Atrazine 750 g/ha (PE) *fb* 1 HW at 30 DAS	2.23	1.36	1.23	2.54	1.04	1.10	6.97	7.54	7.52
	(4.1)	(1.0)	(0.8)	(5.8)	(0.1)	(0.2)	(55.4)	(67.6)	(67.3)
Unweeded check	2.99	1.88	1.85	3.76	1.30	1.44	8.30	12.66	12.57
	(8.4)	(2.8)	(3.0)	(14.1)	(0.8)	(1.4)	(75.8)	(182.0)	(179.8)
LSD (p=0.05)	0.08	0.13	0.09	0.12	0.07	0.06	0.06	0.07	0.07

*Original values in parentheses were subjected to square root transformation $(\sqrt{x+1})$ before statistical analysis

Table 2. Effect of planting methods, residue and weed management on dry weight of weeds at 60 DAS, grain yield and economics of different maize hybrids

Treatment	Dry weight of weeds (g/m^2)				Grain yield (t/ha)	Net returns ($x10^3$ `/ha)	Benefit-cost ratio
	Grassy weeds	Broad-leaf weeds	Sedges	Total weeds			
Planting method							
Raised bed with residue	24.81	4.37	2.87	32.05	7.00	50.87	1.88
Raised bed without residue	43.90	5.89	5.56	55.36	6.29	50.79	2.08
Zero tillage with residue	20.84	3.20	3.24	27.28	7.32	59.96	2.13
Zero tillage without residue	31.49	7.39	9.41	48.29	6.42	57.47	2.35
LSD (p=0.05)	1.83	0.36	0.78	2.40	0.43	-	-
Maize hybrids							
HQPM-1	42.15	6.02	7.00	55.17	6.40	49.23	2.01
HM-4	27.38	4.46	5.11	36.96	7.04	58.75	2.18
HM-10	21.24	5.16	3.70	30.10	6.83	56.39	2.14
LSD (p=0.05)	1.10	0.27	0.38	1.26	0.18	-	-
Weed management							
Atrazine 750 g/ha (PE) *fb* 1 HW at 30 DAS	3.84	3.24	3.72	10.81	7.70	66.59	2.29
Unweeded check	56.68	7.18	6.82	70.68	5.81	42.95	1.93
LSD (p=0.05)	0.90	0.22	0.31	1.03	0.15	-	-

water after higher downpour. Higher grain yield under flat sowing ZT also might be due to a longer grain filling duration resulting in bolder grains (Ram *et al*. 2010). However, the benefit-cost ratio (B: C) was maximum under ZT-R (2.35) *fb* ZT+R (2.13), RB-R (2.08) and RB+R (1.88). In general, B: C was more under ZT than raised bed, but less under residue (**Table 2**). This was due to the counting of the cost of wheat residue used in this experiment. However, if we opt for some other crop residue having less economic value then ZT+R may be superior in B: C as well. Jat *et al*. (2013) also found that the no-till flat and no-till bed systems provided similar net returns in the maize-wheat system as compared to conventional till flat system.

Residue mulch resulted in improved grain yield (7.00-7.32 t/ha) and net returns as compared to without residues under both methods of planting, *viz*. ZT and raised bed. *HM-4* provided maximum grain yield (7.04 t/ha), net returns (` 58749/ha) and B: C (2.18) *fb HM-10* and *HQPM-1*. Significantly higher grain yield (7.70 t/ha), net returns (` 66593/ha) and B: C (2.29) were observed under atrazine 750 g/ha (PRE) *fb* 1 HW at 30 DAS than unweeded check (**Table 2**). Higher grain yield, net returns and B: C of maize were recorded with two HW and PRE application of atrazine 1.5 kg/ha *fb* HW at 30 DAS in maize (Rao *et al*. 2009).

SUMMARY

Zero tillage sowing of maize with residue mulching was found a viable alternatives method of crop establishment as compared to conventional raised bed sowing without residue. Thus, zero tillage sowing of maize with residue mulching resulted in lower weed infestation, higher productivity and economics returns. Atrazine 750 g/ha (as pre-emergence) *fb* 1 HW was effective in controlling weeds in maize crop.

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