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RESEARCH NOTE

Effect of planting methods, hybrids and weed management on weeds and productivity of rainy season maize

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ABSTRACT

A field experiment was conducted at Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Karnal during rainy season (*Kharif*) 2015. Two planting methods, *viz.* zero tillage and raised beds each with and without residues were evaluated with three maize hybrids (HQPM-1, HM-4 and HM-10) and two weed management treatments *viz.* pre-emrgence application (PE) of atrazine 750 g/ha followed by (*fb*) hand weeding (HW) at 30 days after seeding (DAS) and unweeded check, in a split plot design. *Dactyloctenium aegyptium, Brachiaria reptans, Eragrostis tenella, Portulaca oleracea*, *Ammania baccifera* and *Cyperus rotundus* along with some other broad-leaved weeds (BLW) predominated the experimental field. Zero tillage with residues and atrazine 750 g/ha PE *fb* 1 HW at 30 DAS recorded the lowest density and biomass of weeds, at 20 and 40 DAS, greater number of grains/cob, grain yield and net returns. However, the benefit- cost ratio (B:C) was maximum with zero tillage without residue. Lower weed density was observed with maize hybrid HM-10 and HM-4 as compared to HQPM-1. The minimum biomass of BLW, maximum number of grains/cob, grain yield, net returns and B:C were observed with hybrid HM-4, while the minimum biomass of grassy weeds and sedges was with HM-10.

Keywords: Crop residues, Economics, Maize hybrids, Planting methods, Weed management, Zero-tillage

Maize is predominantly a rainy season crop that constitutes 85% of the total maize area in India. Maize contributes almost 9% to India's food basket and 5% to world's dietary energy supply (Yakadri *et al.* 2015). Maize in the rice- wheat system and alternate tillage systems will help sustainability of cropping systems in Indo-Gangetic Plains. In India, maize is cultivated in 9.5 million hectare (ha) area and holds an important position in the Indian economy (DAC&FW 2019). Weeds emerge fast and grow rapidly competing with the crop severely for growth resources, *viz.* nutrients, moisture, sunlight and space during entire vegetative and early reproductive stages of maize causing the maize yield reduction of 27-60%, depending upon several factors (Kumar *et al.* 2015). Hence, managing weeds is most critical for attaining the higher yields. Among pre-emergence (PE) herbicides, atrazine is the most prevalently used herbicide for weed management in *Kharif* maize, which has greater importance in view of its higher effectiveness from the initial stages. It may be supplemented with one hand weeding (HW) at 30-40 DAS if weeds emerge (Dahal and Karki 2014). Crop residue retention is a crucial element of sustainable farming systems that raises the quality of the soil, increases its capacity for nutrients and lessens the negative consequences of burning leftover (Kong 2014). However, information on interactive effect of varying planting and residue management methods; and hybrids on weed dynamics is lacking in maize. Hence, present experiment was conducted to study the effect of varying methods of planting and residue management; and hybrids on weeds in *Kharif* maize hybrids and their productivity.

A field experiment was conducted at Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Regional Research Station, Karnal, Haryana (India) during *Kharif* 2015. The experiment was laid out in split plot design with three replications. Treatments assigned to four main plot treatments (planting methods) were raised beds (RB) with residue (RB+R), raised bed without residue (RB-R), zero tillage (ZT) with residue (ZT+R) and zero tillage without residue (ZT-R), and six sub-plot treatments which were combination of three maize hybrids *viz.*, HQPM-1, HM-4 and HM-10 and two weed management treatments, *viz.* pre-emergence application (PE) of atrazine 750 g/ha followed by (*fb*)1 HW at 30 DAS and unweeded check. Soil of the experiment field was clay loam (sand 48.4%, silt 24.1 and clay 29.4%) in texture, medium in organic carbon

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(0.41%), low in available N (123.0 kg/ha) and medium in available P (25.2 kg/ha) and K (225.0 kg/ha) with slightly alkaline in reaction (pH 8.4) and EC 0.31 dS/m. After the harvest of *Rabi* crop of wheat in April 2015, land preparation was done as per treatments. The tractor drawn harrow was run twice in RB and remaining field left for ZT as it was. After the pre-sowing irrigation, on RB two harrowing + two ploughings followed by planking was done as preparatory tillage to bring soil to a fine tilth before sowing and preparing beds with help of RB planter in RB treatments. The sowing was done on remaining field with ZT seed-cum-fertilizer drill keeping row to row spacing of 75 cm. Sowing of three maize hybrids was done on June 25, 2015 using a seed rate of 20 kg/ha. After that surface application of wheat residue 4 tonne (t)/ha mulching was done in RB and ZT sowing as per treatments.

Nitrogen, phosphorus and potassium were applied uniformly at the rate of 150, 60 and 60 kg/ha through urea (46% N), diammonium phosphate (DAP) (46% P, 18% N) and muriate of potash (MOP) (60% K), respectively. At time of maize sowing, 50% N and entire recommended dose of P and K were applied as basal dose. Remaining 50% N was applied in two splits at 25 and 45 DAS. Atrazine PE was applied just after sowing by knapsack sprayer fitted with flat fan nozzles using water 500 l/ha. In order to maintain spacing of 75 × 20 cm need based thinning and gap filling was done manually at 20 DAS. Hand weeding in plots treated with atrazine was also done at 30 DAS. Data on weed density and biomass was recorded at 20 and 40 DAS using quadrat of 0.5 × 0.5 m by randomly placing twice in each of the plot. The density is expressed as number of weeds/m^2 and the biomass as g/m^2. Data on weed density was subjected to square root transformation $(\sqrt{X+1})$. Manual harvesting of maize hybrid HM-4 was done on September 22, 2015 and; HQPM-1 and HM-10 were harvested on September 29, 2015. Net returns were computed for each treatment after subtraction of total cost of cultivation from gross returns and B:C was calculated by dividing gross returns with total cost of cultivation.

Effect on weeds

Among the planting methods, the lowest density of grassy weeds at 20 and 40 DAS was recorded under ZT+R followed by RB+R, ZT-R and the highest in RB-R (**Table 1**). Similar trend was found with respect to density of broad-leaved weeds (BLW) except at 40 DAS, where RB+R produced the lowest density of BLW. The lowest density of sedges was recorded in RB+R followed by ZT+R and RB-R however, the highest in ZT-R. In general, density of all type of weeds was lower under residue retention as compared to without residue. Lower density of grassy weeds in ZT might be due to killing of weeds with glyphosate before sowing of crop and non-disturbance of the soil surface thereafter. However, slightly higher sedges under ZT particularly at initial stages might be due to regeneration of some of the weeds even after spray of glyphosate. However, at later stages ZT and raised beds became at par with each other. Kumar *et al*. (2013) also reported lower density of weeds under ZT as compared to conventional tillage (CT) maize.

Among the three maize hybrids, the lowest density of grassy weeds and sedges was recorded under HM-10 followed by HM-4 and HQPM-1 at 20 and 40 DAS (**Table 1**). But in case of BLW, the lowest weed density was recorded under HM-4 followed by HM-10 and the highest in HQPM-1. Faster initial growth of HM-10 than other hybrids could be the reason for lower infestation of weeds under HM-10 as compared to other hybrids as the crop growth is inversely related to weed infestation. All grassy weeds, BLW and sedges were significantly lower density (**Table 1**) and biomass (**Table 2**) under atrazine 750 g/ha PE *fb* 1 HW at 30 DAS supporting findings of Khedwal *et al*. (2017).

The weed biomass followed almost similar trend as the density of weeds at different stages with minor variations (**Table 2**). Among the different planting methods, the lowest biomass of grassy weeds and sedges at 20 and 40 DAS was recorded under ZT+R followed by RB+R and ZT-R, whereas the highest in RB-R. Furthermore, RB-R and ZT+R were at par with each other at 40 DAS for grassy weeds (Table-2). The lowest biomass of BLW at 20 and 40 DAS was recorded under ZT+R followed by RB+R, RB-R and the highest in ZT-R. Lower infestation of weeds under ZT as compared to CT maize has been reported by earlier workers as well (Kumar *et al*. 2013). The lowest biomass of grassy weeds and sedges were recorded under HM-4 at 20 DAS, under HM-10 at 40 DAS, which were significantly superior to HQPM-1, but in case of grassy weeds, HM-4 and HM-10 were at par with each other at 20 and 40 DAS (**Table 2**). The lowest biomass of BLW was recorded under HM-4 at 20 and 40 DAS, which was significantly superior to HM-10 and HQPM-1, while HM-4 and HM-10 were at par with each other at 20 DAS. In general, biomass of weeds was the lowest under HM-10 followed by HM-4 and HQPM-1 (**Table 2**).

Effect on yield attributes and yield

Maize sown in ZT+R recorded higher grains/ cob and grain yield were statistically similar to RB+R (**Table 2**). Increase in grain yield of maize under ZT+R could be attributed to less weed competition, better water management techniques and increased water and nutrient availability for maize may have provided the crop a competitive edge over weeds, particularly in the early stages (Yadav *et al.* 2021). Residue retention (4 t/ha) resulted in improved grains/ cob and grain yield as compared to without residues under both methods of planting confirming (Khedwal *et al.* 2017). HM-4 provided maximum grain yield which was significantly higher than HM-10 and HQPM-1 in succession (**Table 2**). Increase in grain yield could be attributed to the higher number of grains/cob. In weed management treatments, significantly higher grain yield was obtained under atrazine 750 g/ha PE *fb* 1 HW at 30 DAS (**Table 2**) due to minimum crop-weed competition throughout

Table 1. Effect of varying methods of planting, hybrids and weed management on density of weeds

Treatment	Density of weeds (no./m^2)*																	
			Grassy weeds						Broad-leaved weeds								Sedges	
	D. aegyptium		*B. reptans*		*E. tenella*		Total		*P. oleracea*		*A. baccifera*		Other weeds		Total		*C. rotundus*	
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
Planting methods																		
Raised bed with residue	2.87	2.24	2.62	2.10	3.39	2.61	4.98	3.81	1.58	1.11	1.80	1.05	9.75	7.84	9.90	7.86	6.50	5.06
	(8.3)	(4.9)	(5.9)	(3.5)	(11.0)	(6.2)	(25.2)	(14.6)	(1.6)	(0.3)	(2.4)	(0.1)	(103.9)	(70.3)	(108.5)	(67.2)	(42.5)	(25.4)
Raised bed without residue	3.97	3.12	3.12	2.39	4.17	3.13	6.49	4.89	1.63	1.24	2.38	1.22	16.95	13.02	17.07	13.06	12.22	9.44
	(15.8)	(9.3)	(10.4)	(5.6)	(18.1)	(9.8)	(44.3)	(24.7)	(1.8)	(0.7)	(5.2)	(0.6)	(301.3)	(177.3)	(305.5)	(178.6)	(158.9)	(94.4)
Zero tillage with residue	2.67	1.96	2.32	1.75	2.76	2.21	4.29	3.15	1.41	1.09	1.41	1.77	9.37	7.80	9.72	7.98	7.23	5.10
	(6.8)	(3.1)	(4.7)	(2.3)	(6.9)	(4.0)	(18.4)	(9.4)	(1.2)	(0.2)	(1.2)	(2.6)	(102.2)	(66.8)	(106.7)	(73.1)	(56.3)	(26.6)
Zero tillage without residue	3.28	2.48	2.94	2.28	3.74	2.64	5.67	4.13	1.85	1.52	2.86	2.19	17.70	13.83	17.98	14.03	13.11	10.65
	(11.6)	(6.9)	(8.7)	(4.9)	(16.1)	(6.8)	(36.1)	(18.6)	(2.5)	(1.5)	(7.8)	(4.1)	(321.1)	(196.0)	(331.2)	(201.6)	(180.7)	(122.7)
LSD (p=0.05)	0.11	0.22	0.10	0.15	0.08	0.11	0.09	0.18	0.11	0.11	0.21	0.20	0.06	0.09	0.05	0.09	0.31	0.24
Maize hybrids																		
HQPM-1	3.34	2.53	2.93	2.31	3.79	2.78	5.74	4.27	1.72	1.48	2.43	1.70	13.82	10.90	14.09	11.42	10.20	8.40
	(11.2)	(6.6)	(8.3)	(4.8)	(16.1)	(7.5)	(35.6)	(19.0)	(2.1)	(1.4)	(5.8)	(2.5)	(216.3)	(132.1)	(224.1)	(136.0)	(121.4)	(80.1)
HM-4	2.24	2.52	2.68	2.03	3.51	2.68	5.32	3.97	1.48	1.07	1.90	1.48	12.24	9.63	12.47	9.72	9.84	7.85
	(11.0)	(6.2)	(6.4)	(3.3)	(12.4)	(6.8)	(29.6)	(16.3)	(1.3)	(0.2)	(3.2)	(1.5)	(201.9)	(122.6)	(205.7)	(124.3)	(106.7)	(77.1)
HM-10	3.01	2.30	2.68	2.05	3.24	2.49	5.01	3.75	1.65	1.17	2.01	1.50	14.27	11.34	14.45	11.05	9.25	6.44
	(9.7)	(5.4)	(7.6)	(4.1)	(10.6)	(5.8)	(27.7)	(15.2)	(1.8)	(0.5)	(3.4)	(1.5)	(203.9)	(128.2)	(209.1)	(130.1)	(100.7)	(44.7)
LSD (p=0.05)	0.10	0.11	0.11	0.13	0.09	0.12	0.12	0.13	0.13	0.07	0.11	0.09	0.08	0.09	0.09	0.09	0.23	0.10
Weed management																		
Atrazine 750 g/ha PE *fb* 1 HW at 30 DAS	2.25	1.65	2.33	1.82	2.67	2.04	4.01	2.93	1.44	1.05	1.71	1.25	11.94	9.44	12.08	9.47	11.94	6.88
	(4.5)	(2.1)	(4.8)	(2.6)	(6.6)	(3.3)	(15.7)	(8.0)	(1.2)	(0.1)	(2.2)	(0.7)	(160.3)	(98.9)	(163.7)	(99.8)	(160.3)	(58.6)
Unweeded check	4.15	3.25	3.19	2.44	4.36	3.26	6.71	5.06	1.80	1.42	2.50	1.87	14.95	11.81	15.26	11.99	14.95	8.24
	(16.7)	(9.9)	(10.1)	(5.6)	(19.5)	(10.0)	(46.2)	(25.6)	(2.3)	(1.2)	(6.1)	(3.0)	(253.9)	(156.3)	(262.3)	(160.4)	(253.9)	(75.9)
LSD (p=0.05)	0.08	0.09	0.09	0.12	0.08	0.10	0.09	0.11	0.10	0.05	0.09	0.07	0.07	0.07	0.07	0.07	0.07	0.08

*Original values in parentheses were subjected to square root transformation ($\sqrt{x+1}$) before statistical analysis; PE = pre-emergence application, HW = hand weeding, DAS = days after seeding; *fb*= followed by

Table 2. Effect of varying methods of planting, hybrids and weed management on weed biomass, no. of grains/cob, grain yield and economics

Treatment	Weed biomass (g/m^2)						No. of grains/ cobs	Grain yield (t/ha)	Net returns (x10^3 ₹/ha)	Benefit-cost ratio
	Total grassy weeds		Total BLW		Total sedges					
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS				
Planting methods										
Raised bed with residue	4.69	14.41	1.02	1.55	0.94	1.92	432.1	7.00	50.87	1.88
Raised bed without residue	6.76	22.97	1.64	3.06	2.43	6.66	420.8	6.29	50.79	2.08
Zero tillage with residue	3.97	13.51	0.85	2.07	0.74	1.73	441.9	7.32	59.96	2.13
Zero tillage without residue	5.69	20.25	1.99	3.34	2.07	5.06	426.4	6.42	57.47	2.35
LSD (p=0.05)	0.43	1.42	0.06	0.30	0.07	0.74	7.24	0.43	-	-
Maize hybrids										
HQPM-1	5.46	23.26	1.96	3.83	1.91	5.10	417.0	6.40	49.23	2.01
HM-4	5.17	15.37	1.05	1.62	1.32	3.93	449.7	7.04	58.75	218
HM-10	5.24	14.42	1.12	2.07	1.42	2.50	424.2	6.83	56.39	2.14
LSD (p=0.05)	0.24	0.94	0.07	0.26	0.05	0.31	4.57	0.18	-	-
Weed management										
Atrazine 750 g/ha PE *fb* 1 HW at 30 DAS	0.72	1.98	0.96	1.33	0.91	2.12	463.3	7.70	66.59	2.29
Unweeded check	9.83	33.59	1.80	3.68	2.17	5.56	397.4	5.81	42.95	1.93
LSD (p=0.05)	0.20	0.77	0.06	0.21	0.04	0.25	3.73	0.15	-	-

*BLW = broad-leaved weeds; PE = pre-emergence application; HW = hand weeding, DAS = days after seeding; *fb*= followed by the crop growth period, giving the crop better access to resources and more effective use of water and nutrients, a proper maize establishment strategy may give maize a major competitive advantage over weeds (Kaur *et al*. 2020). The lowest yield was recorded in unweeded check because of greater removal of nutrients and moisture by weeds and severe crop-weed competition resulting in poor source and sink development with poor yield attributes.

Economics

Maize sown in ZT+R recorded the highest net returns followed by (*fb*) ZT-R, RB+R and RB-R. In general, ZT resulted in higher net returns than raised beds. Residue retention resulted in improved net returns as compared to without residues. B:C was more under ZT than raised beds, but less under residues than without residues. This could be obviously due to escalated cost of cultivation with residue retention. The hybrid HM-4 provided maximum net returns and B: C which was superior to HM-10 and HQPM-1 in succession. The higher net returns (55.04%) and B:C were observed with atrazine 750 g/ha PE *fb* 1 HW at 30 DAS as compared to unweeded check.

It may be concluded that ZT+R with maize hybrid HM-4 and atrazine 750 g/ha PE *fb* 1 HW at 30 DAS adoption results in effective weed management and economical maize productivity.

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