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RESEARCH NOTE

Maize establishment methods and weed management effect on weeds, maize productivity and economics

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ABSTRACT

A field experiment was conducted during rainy *(Kharif)* season of 2019 at N.E.B. Crop Research Centre of GBPUA&T, Pantnagar with an objective to identify the best establishment method and weed management treatment for maize to attain higher maize growth, yield and economic returns. The experiment was conducted in split-plot design with three replications comprising of three establishment methods as main plot factor and seven weed management treatments as sub-plot factor, replicated thrice. Among the establishment methods, raised bed system was found most effective in reducing weed growth. The highest weed control efficiency of 85.7% was recorded with pre-emergence application (PE) of atrazine 1000 g/ha *fb* post-emergence application (PoE) of tembotrione 120 g/ha which was followed by rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE and tembotrione 120 g/ha PoE alone. Raised bed system resulted in 8.0% higher maize grain yield over zero till system and highest net return and B:C ratio. Among the weed management treatments, highest maize grain yield, net return and B:C ratio were recorded with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE.

Keywords: Atrazine, Maize establishment, Rice straw mulch, Tembotrione, Weed management

Maize is the third most important cereal crop in the world after wheat and rice. It is cultivated in nearly 190 Mha area all over the world. In India, maize is cultivated in 9.5 mha area and holds an important position in the Indian economy (DAC&FW 2018). In India, maize is mostly grown in the rainy *(Kharif)* season which is characterized by heavy downpours, high relative humidity, low sunshine hours. The prevailing weather conditions favor higher weed growth. The slower initial growth of maize allows weeds to grow abundantly at initial stage necessitating adoption of suitable weed management practices for attaining higher maize production. Proper maize establishment method may provide maize a significant competitive advantage over weeds with a head start to manage weeds problem while providing the crop with better resources availability and improved water and nutrient use efficiency (Kaur *et al.* 2020). A better establishment method coupled with a strategically planned weed management can result in better maize yields, resource use efficiency and better returns. Thus, the current experiment was conducted with an objective to identify the best establishment method and weed management treatment for maize to attain higher maize growth, yield and economic returns.

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The current experiment was conducted in the rainy *(Kharif)* season of 2019 at the N. E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar. The soil of the experimental site was clay loam in texture having a near neutral pH of 6.75, medium organic carbon (0.72%), 282.1 kg/ha available nitrogen, 25 kg/ha available phosphorus and 184.0 kg/ha available potassium. During the experimentation period (June to September), total rainfall was received 1119.4 mm with average maximum and minimum temperatures of 33.99°C and 25.08°C and relative humidity of 81.98% and 61.13%, respectively. The experiment was conducted in split-plot arrangement with three replications comprising of three levels of main plot factor (flatbed method, raised bed method and zero till method) and seven weed management treatments in the sub-plots include: pre-emergence application (PE) of atrazine 1000 g/ha, atrazine 1000 g/ha PE + rice straw mulching 5 t/ha; post emergence application (PoE) of tembotrione 120 g/ha; atrazine 1000 g/ha PE followed by (*fb*) tembotrione 120 g/ha PoE; rice straw mulching 5 t/ha *fb* tembotrione 120 g/ha PoE; weed free and weedy check. The treatment's gross plot size was 5.0 × 3.6 m, and the net plot size is 5.0 m x 1.2 m. Except for zero till planted plots, plots were prepared by one ploughing *fb* two cross harrowing. For raised bed planting, land shaping was done using tractor drawn bed maker.

Sowing in zero till system was done with tractor drawn zero till drill. Pre-emergence application of herbicides was done using knapsack sprayer (flat fan nozzle with triple boom) with 600 litre/ha water at one day after sowing (DAS) whereas post-emergence application was done using knapsack sprayer (flat fan nozzle) with 500 litre/ha water at 17 DAS. Maize variety '*P-1899*' was sown on 17th June, 2019 and harvested on 21st September, 2019. Maize plant dry matter accumulation, height, yield and yield attributing characters were recorded at harvest. Weed dry matter accumulation (biomass) and density were recorded using a 0.25 m^2 quadrat at 50% tasseling (60 DAS) of the crop. Benefit-cost (B:C) ratio was calculated by dividing net returns with cost of cultivation. Data for the weed biomass and density were subjected to $\sqrt{(x+1)}$ transformation for appropriate normalization before conducting analysis of variance. Analysis of variance of the data was done according to Fisher's Least Significant Difference method at p=0.05 using SPSS v.23 (IBM Corp 2017).

Effect on weeds

The dominant weeds (based on relative density at 60 DAS given in parenthesis) in the weedy check were: *Echinochloa colona* (9.5%), *Eleusine indica* (8.3%) among grasses, *Celosia argentea* (32.4%), *Trianthema monogyna* (8.3%) among broad-leaved weeds and *Cyperus iria* (21.4%) the sedge. Among the establishment methods, raised bed planting resulted in lowest weed density for all the weed species at 60 DAS whereas zero-tillage resulted in the highest weed density (**Table 1**). The raised bed system resulted in 27.7 and 49.7% reduction in density of grassy weeds like *Echinochloa colona* and *Eleusine indica*, respectively. The density of broad-leaved weeds *Celosia argentea* and *Trianthema monogyna* was also lower by 16.7 and 53.7%, respectively in raised bed system compared to zero tilled plots. However, density of *Celosia argentea* was statistically at par in all the establishment treatments. Both the flat bed method and raised bed methods were effective in reducing the density of *Cyperus iria* at 60 DAS. The total weed density was highest in zero tilled plots (93.5 no./m^2) which was at par with flatbed method and followed by raised bed methods. Higher weed density in the zero-tillage system in initial years with the dominance of annual weeds in initial years and greater dominance of perennial weeds in later years was also reported by Khedwal *et al.* (2017). Among weed management treatments, atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE caused the lowest density of *Echinochloa colona* and *Eleusine indica* compared to other weed management treatments. The lowest density of *Celosia argentea* was recorded with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE and it was at par with tembotione 120 g/ha PoE alone as well as rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE. Atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE was also found effective in reducing the density of *Cyperus iria* amongst all the weed management treatments. Total weed density at 60 DAS was also lowest with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE which was closely followed by rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE (**Table 1**). Interaction effects of establishment methods and weeds management treatments on weed density at 60 DAS were found statistically non-significant.

The biomass of grassy weeds, *viz. Echinochloa colona* and *Eleusine indica* was significantly lower in raised bed system than both the zero tilled and flatbed

Table 1. Effect of maize establishment methods and weed management treatments on different weeds density at 60 days after sowing (DAS)

Treatment	Weed density at 60 DAS (no./m^2)					
	Echinochloa colona	*Eleusine indica*	*Celosia argentea*	*Trianthema monogyna*	*Cyperus iria*	Total
Establishment method						
Flat bed	2.9(9.9)	3.0(10.5)	3.4(21.5)	2.7(8.4)	3.5(16.2)	8.0(89.7)
Raised bed	2.4(8.1)	2.5(7.4)	3.1(17.9)	2.1(5.7)	3.0(12.9)	7.7(64.1)
Zero till	3.2(11.2)	3.7(15.2)	3.7(21.5)	3.3(12.2)	3.8(19.5)	8.2(93.5)
LSD (p=0.05)	0.30	0.38	NS	0.54	0.26	0.38
Weed management						
Atrazine 1000 g/ha PE	4.2(16.9)	4.3(17.8)	4.5(19.6)	3.2(9.3)	3.4(10.7)	11.6(132.9)
Atrazine 1000 g/ha + rice straw mulch 5 t/ha	3.6(12.2)	3.2(10.2)	2.8(7.1)	2.8(7.6)	3.4(8.4)	8.0(63.1)
Tembotrione 120 g/ha PoE	3.0(8.0)	2.7(7.1)	1.9(3.2)	2.2(4.9)	3.1(11.1)	7.2(50.4)
Atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE	1.9(3.1)	1.9(3.6)	1.4(1.3)	1.8(2.7)	1.7(2.7)	4.5(19.1)
Rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE	2.6(5.6)	2.5(5.8)	1.9(3.1)	2.0(3.6)	3.0(9.3)	5.4(28.4)
Weed free	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)
Weedy check	5.6(31.1)	5.8(32.9)	10.3(105.8)	5.8(33.3)	8.5(71.1)	18.2(329.8)
LSD (p=0.05)	0.45	0.58	0.61	0.44	0.55	0.20
Interaction	NS	NS	NS	NS	NS	NS

Data are subjected to $\sqrt{x+1}$ transformation before analysis. Original values are given in parentheses. PE: Pre-emergence; PoE: Post-emergence

systems (**Table 2**). *Celosia argentea* biomass did not significantly vary amongst different establishment methods at 60 DAS. Biomass of *Trianthema monogyna* was also lowest and was 44.8% lower with raised bed system than the zero till system. Similar trend was also recorded for biomass of *Cyperus iria*. The total biomass was also lowest in raised bed system which was 18.1 and 3.9% lower than the zero tilled and flatbed system, respectively at 60 DAS (**Table 2**). Lower weed density and higher crop vigour due to better nutrient and water availability to maize in raised bed system was also reported by Verma *et al*. (2018). Among the weed management treatments, lowest biomass of *Echinochloa colona* and *Eleusine indica* was observed in atrazine 1000 g/ ha PE *fb* tembotrione 120 g/ha PoE than other weed management treatments. For, *Celosia argentea*, atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE as well as rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE resulted in lowest biomass in weed free plots. These treatments were equally effective in reducing biomass of Trianthema *monogyna* and *Cyperus iria*. Total weed biomass accumulation at 60 DAS was lowest with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE which was closely followed by rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE and tembotrione 120 g/ha PoE alone (**Table 2**). Low weed biomass with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE is due to the management of early appearing weeds upto 15-20 DAS by the pre-emergence application of atrazine where weeds emerged at later stages were effectively reduced by post-emergence application of tembotrione. Similar effect was found in rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE but efficiency of rice straw in *Kharif* season was hindered by displacement of mulch by heavy downpours.

On the basis of weed biomass at 60 DAS, the highest weed control efficiency (WCE) of 85.7% was recorded with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE which was followed by rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE and tembotrione 120 g/ha PoE alone with WCE of 81.3 and 80.0%, respectively. Weed index was found lowest with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE which was only 8.3% in comparison to weed free plots. Due to complex weed appearance, an overwhelming 41% weed index value was recorded in the weedy check (**Table 3**).

Effect on maize yield and economics

The highest grain yield of maize was recorded with raised bed method which was statistically at par with flatbed system. The improvement in the yield in raised bed system in comparison to zero till system was in the range of 8.0% which may be due to lower weed pressure, better management of excess water and improved availability of water and nutrients to maize that might have given the crop a competitive advantage over weeds especially at early stages (Yadav *et al*. 2021). Among the weed management treatments, highest grain yield was recorded with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE which was statistically at par with rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE and tembotrione 120 g/ha PoE alone and was comparable with weed free. Atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha resulted in 27.7% yield increase over atrazine 1000 g/ha PE alone confirming the findings of Dey and Pratap (2018).

Table 2. Effect of maize establishment methods and weed management treatments on different weeds biomass at 60 DAS in maize

Treatment	Weed biomass at 60 DAS (g/m^2)					
	Echinochloa colona	*Eleusine indica*	*Celosia argentea*	*Trianthema monogyna*	*Cyperus iria*	Total
Establishment method						
Flat bed	5.4(36.7)	2.3(5.2)	1.8(3.0)	1.6(2.0)	2.4(9.3)	8.0(56.8)
Raised bed	5.1(33.5)	2.1(4.3)	1.6(2.4)	1.5(1.6)	2.3(8.6)	7.7(54.6)
Zero till	5.5(37.9)	2.6(6.6)	1.9(3.8)	2.0(2.9)	2.7(10.5)	8.2(66.7)
LSD (p=0.05)	0.21	0.08	NS	0.06	0.08	0.04
Weed management						
Atrazine 1000 g/ha PE	7.7(59.1)	3.1(8.5)	2.1(3.8)	2.0(3.0)	2.2(3.7)	10.4(108.0)
Atrazine 1000 g/ha + rice straw mulch 5 t/ha	7.4(54.5)	2.9(7.5)	1.9(4.3)	1.8(2.3)	2.0(3.1)	9.9(97.7)
Tembotrione 120 g/ha PoE	4.5(19.9)	2.0(3.0)	1.4(0.9)	1.5(1.5)	1.7(1.9)	6.6(43.4)
Atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE	2.8(8.2)	1.5(1.6)	1.1(0.3)	1.3(0.7)	1.5(1.4)	5.4(28.3)
Rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha PoE	4.2(17.4)	2.0(3.1)	1.1(0.3)	1.4(0.9)	1.6(1.7)	6.2(38.3)
Weed free	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)
Weedy check	9.7(93.2)	3.8(13.9)	3.5(11.4)	3.0(8.2)	7.1(49.0)	16.1(256.1)
LSD (p=0.05)	0.78	0.14	0.22	0.17	0.32	0.06
Interaction	NS	NS	NS	NS	NS	NS

Note: Data are subjected to $\sqrt{x+1}$ transformation before analysis. Original values are given in parentheses. PE = Pre-emergence; PoE = Post-emergence

Table 3. Effect of establishment methods and weed management treatments on weed control efficiency, weed index, grain yield and economics of maize

Treatment	Weed control efficiency (%)	Weed index (%)	Grain yield (t/ha)	Cost of cultivation (`/ha)	Gross return (`/ha)	Net return (`/ha)	B:C ratio
Establishment method							
Flat bed	-	-	4.97	35,446	84,954	49,507	2.40
Raised bed	-	-	5.01	36,646	85,638	48,992	2.34
Zero till	-	-	4.61	32,246	76,547	44,299	2.37
LSD (p=0.05)	-	-	0.35	-		-	
Weed management							
Atrazine 1000 g/ha	56.2	28.2	4.33	30,569	71,978	41,407	2.35
Atrazine 1000 g/ha + rice straw mulch 5 t/ha	59.1	26.4	4.44	33,705	81,222	45,182	2.41
Tembotrione 120 g/ha	80.0	15.8	5.08	33,369	87,675	54,296	2.62
Atrazine 1000 g/ha *fb* tembotrione 120 g/ha	85.7	8.3	5.53	34,369	99,679	63,667	2.90
Rice straw mulch 5 t/ha *fb* tembotrione 120 g/ha	81.3	15.4	5.10	36,505	90,819	54,314	2.48
Weed free	100.0	0.0	6.03	46,005	1,09,668	65,208	2.38
Weedy check	0.0	41.0	3.56	28,833	54,142	25,308	1.87
LSD (p=0.05)	-	-	0.53	-		-	-
Interaction	-	-	S	-	-		-

Among the maize establishment methods, the cost of cultivation was lowest with zero till system which was 9.9 and 13.6% lower than flat bed system and raised bed system, respectively due to higher land preparation cost. However, initial higher cost involved in raised bed system has compensated the highest net return achieved which was 26.2% higher than zero till system. Similarly, B:C ratio was also 11.7 and 9.3% higher in raised bed system than zero till and flatbed system, respectively (**Table 3**). Among different weed management treatments, the highest net return (₹ 63,662/ha) and highest B:C ratio 2.90 was obtained with atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE which was comparable to weed free plots.

It was concluded that raised bed planting amongst maize planting methods and atrazine 1000 g/ha PE *fb* tembotrione 120 g/ha PoE amongst weed management treatments were better in terms of effectiveness to manage weed and improving the crop productivity and economic returns.

REFERENCES

DAC&FW 2019. *Annual Report 2018*. Krishi Bhawan, New Delhi, p. 4.

Dey P and Pratap T. 2018. Variations in morpho-physiological traits of sweet corn in response to weed management. *Indian Journal of Weed Science* **50**(4): 365–368.

IBM Corp. 2017. *IBM SPSS Statistics for Windows*, Version 25.0. IBM Corporation, New York.

Kaur R, Kaur C and Kaur T 2020. Zero-till sowing and residue mulching in rainy season maize: Effect on weeds, crop productivity and profitability. *Indian Journal of Weed Science* **52**(1): 82–88.

Khedwal RS, Yadav DB, Hooda VS, Dahiya S and Singh M. 2017. Zero-till establishment and residue and residue mulching in rainy season maize. *Indian Journal of Weed Science* **49**(2): 198–200.

Verma G, Maurya SK and Kumar ACS 2018. Effect of crop establishment methods and weed management practices on narrow leaf weeds in kharif maize (*Zea mays* L.). *Crop Research* **53**: 123–126.

Yadav GS, Das A, Babu S, Mohapatra KP, Lal R and Rajkhowa D 2021. Potential of conservation tillage and altered land configuration to improve soil properties, carbon sequestration and productivity of maize based cropping system in eastern Himalayas, India. *International Soil and Water Conservation Research* **9**: 279–290.