Indian Journal of Weed Science (2025) **57**(1): 127–130
http://dx.doi.org/10.5958/0974-8164.2025.00020.8

RESEARCH NOTE

Effect of crop geometry, ALS and 4-HPPD inhibitor herbicides on weeds, soil enzymes and yield of maize

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Received: 24 January 2024 | Revised: 23 December 2024 | Accepted: 26 December 2024

ABSTRACT

A field experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during rainy season of 2022 to study the effect of crop geometry and herbicide treatment on weeds, soil enzymes and yield of maize. The experiment was conducted in a Randomized Complete Block Design with two factors, crop geometry and weed management. Narrower crop geometry (60 x 15 cm) recorded lower weed density and dry weight as compared to wider crop geometry (60 x 20 cm). However, in case of herbicidal treatment, atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS had lower weed density and dry weight in comparison to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS except *Cyperus esculentus*. Grain and stover yields were significantly higher (0.52 and 0.77 t/ha) in narrower crop geometry (60 x 15 cm) as compared to wider crop geometry (60 x 20 cm) 0.43 and 0.66 t/ha, respectively. Significantly higher grain yield (0.51 t/ha) was observed in atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS as compared to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS (0.47 t/ha).

Keywords: Crop geometry, Halosulfuron, Soil enzymes, Tembotrione, Topramezone

Maize (*Zea mays* L.) is one of the important cereal crops of the world, known as "Queen of cereals" due to its great importance in human and animal diet, and has immense potential for higher yield. It is known for its wider adaptability and multipurpose uses as food, fodder and industrial products (Murdia *et al.* 2016). There are numerous reasons for the lower production of maize in our country. Among them, weed infestation in maize is the key detrimental factor causing huge grain yield loss, because of slow initial crop growth and wide row spacing along with frequent rains during the rainy season. Crop yield loss was recorded up to 90% depending upon weed flora and density when weed species reaches above the critical population threshold level (Lavanya *et al*. 2021). The most critical period for crop weed competition is the first six weeks after crop planting owing to initial slow growth and wider row spacing coupled with congenial weather for weed growth, yield reduction may be up to by 28–100% (Dass *et al.* 2012). Maize production is significantly more impacted by variable planting density than other grass family members, because of its monoecious floral arrangement and its low tillering cognition, in order to provide a greater yield, maize should be planted with the ideal plant population (Ali *et al*. 2017). Therefore, it is recommended that current maize hybrids be grown at optimal density to limit plant competition and to provide higher yields. The crop geometry combinations of 60 x 20 cm were discovered to help achieve a greater grain yield of maize (Getaneh *et al.* 2016). There is a good pre-emergence herbicidal option available in maize, however, results on post-emergence herbicides are scarce. Topramezone and halosulfuron methyl are the selective, post-emergence herbicides in maize introduced recently. These HPPD (4-hydroxyphenylpyruvate dioxygenase) and ALS (acetolactate synthase) inhibiting herbicides are most effective for weed control by bleaching developing tissues (Singh *et al.* 2015). Topramezone [3-(4, 5-Dihydro-3-isoxazolyl)-2-methyl-4-(methylsulfonyl) phenyl] (5-hydroxy-1-methyl-1H- yrazol-4-yl) methanone] inhibits the hydroxylphenyl pyruvate dioxygenase enzyme of carotenoid biosynthesis (pigment). It is selective to maize by rapidly metabolizing the herbicide into non-active substances and used primarily to manage broad and narrow leaved weeds. Soil enzyme activity is a crucial indicator of biological activity, with significant implications for both agriculture and ecology.

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Enzymes, being protein catalysts, drive all biological reactions in soil. Soil hosts a diverse group of enzymes, shaping metabolic processes influenced by soil's physical, chemical, microbiological, and biochemical attributes. These enzymes are pivotal in vital soil functions, including nutrient cycling and energy transformations, as they catalyze a multitude of chemical, physiological, and biological reactions (Pan *et al.* 2020). Therefore, keeping above facts in view present study was carried out to find suitable crop geometry and weed management treatments for weed control in rainy season maize.

The experimental trial was conducted during rainy season of 2022 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh). The soil of the experimental field was sandy clay loam in texture and alkaline in nature (pH 7.2), 0.17 dS/m EC, low in organic carbon (0.341%) and available nitrogen (188.1 kg/ha), and medium in available phosphorus (20.45 kg/ha) and potassium (122.52 kg/ha). The experiment was laid out in a randomized complete block design (RCBD) with three replications and the factors were crop geometry and four weed management treatments. These treatment combinations were S_1: narrower crop geometry (60 x 15 cm), S_2: wider crop geometry (60 x 20 cm), atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS, atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS, W_3-Atrazine 1.0 kg/ha *fb* one hand weeding at 25 DAS and W_4- Weedy. The herbicide doses were calculated as per the treatments and applied as aqueous spray 400 l/ha water using a knapsack sprayer fitted with a flat fan nozzle. Pre-emergence herbicide atrazine 1.0 kg/ha was applied as per the treatments in W_1, and W_2 within two days after sowing of the crop. Pre-emergence followed by post-emergence application of herbicide was done at 25 DAS in W_1 and W_2. A hand weeding was also done in W_3 treatment at 25 DAS with the help of *khurpi* (local hand spade). The recommended dose of nutrients 150-60-40; N-P-K kg/ha with 33% basal N for Varanasi region in hybrid maize (CP-858) was applied at the time of sowing and the rest of N was applied in two equal splits at knee high and tasseling stages. The soil samples collected after post-emergence herbicide application was assessed for the enzyme activities, *viz.* dehydrogenase, soil microbial biomass carbon and phosphatase. The methods involved in determination of dehydrogenase activity in the soil was spectrophotometry of Tri Phenyl Formazon (TPF) produced when soil is treated with Triphenyl Tetrazolium Chloride (TTC), given by (Cassida *et al.* 1964). Likewise the acid and alkaline phosphatase activity was assayed by quantifying the amount of p-nitrophenol released and expressed as µg of p-nitrophenol released/g soil/h as described by (Tabatabai and Bremner 1972).

The observation on the weed density and dry weight of grasses, broad-leaved weeds and sedges was recorded at 60 DAS. The weed control efficiency (Mani *et al.* 1973) and weed index (Yadav *et al.* 1997) were also calculated with observed data on weed dry weight and grain yield, respectively. For analysis of variance (ANOVA) the data on weed density and weed dry weight were transformed by square root to obtain homogeneity of variances.

Effect on weeds

The field was infested with the grassy weeds *Echinochloa colona*, *Digitaria sanguinalis* and *Dactyloctenium aegyptium*, *Trianthema portulacastrum*, *Commelina benghalensis* and *Cyperus esculentus* during experimentation (**Table 1**). At 60 days after sowing (60 x 15 cm) characterized by narrower crop geometry, exhibited significantly lower weed density and dry weight compared to S_2 (60 x 20 cm) wider crop geometry except *Cyperus esculentus.* However, weed density and dry weight of *Echinochloa colona* and *Digitaria sanguinalis* were found statistically at par in both the crop geometry, respectively. Amongst weed management treatments, the density and dry weight of *Echinochloa colona*, *Digitaria sanguinalis*, *Trianthema portulacastrum* and *Commelina benghalensis* were statistically lower compared to atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha as compared to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS except *Cyperus esculentus*. However, density and dry weight of *Commelina benghalensis* were reported to be at par to each other in both weed management treatments. Narrower crop geometry (60 x 15 cm), showed higher weed control efficacy compared to the wider crop geometry (60 x 20 cm). However, atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha recorded higher weed control efficiency as compared to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS. Weed index was found to be higher in wider crop geometry (60 cm x 20 cm) in comparison to narrower crop geometry (60 cm x 15 cm). Atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha had lesser weed index as compared to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS. This might be due to effective control of weeds by sequential application of pre as well as post emergence herbicide application.

Table 1. Effect of crop geometry and weed management treatments on weed density and weed dry weight at 60 DAS in maize

Treatment	Weed density (no./m^2)					Weed dry weight (g/m^2)				
	Echinochloa colona	*Digitaria sanguinalis*	*Cyperus esculentus*	*Trianthema portulacastrum*	*Commelina benghalensis*	*Echinochloa colona*	*Digitaria sanguinalis*	*Cyperus esculentus*	*Trianthema portulacastrum*	*Commelina benghalensis*
Plant crop geometry										
60 cm x 15 cm	4.26 (19.41)	3.99 (18.58)	2.57 (7.25)	1.93 (3.58)	2.38 (5.00)	3.67 (14.16)	3.62 (14.43)	2.24 (5.32)	2.24 (5.01)	1.79 (3.04)
60 cm x 20 cm	4.66 (23.25)	4.55 (23.41)	2.86 (9.75)	2.18 (4.83)	2.70 (7.25)	4.22 (19.33)	3.95 (17.46)	2.54 (6.80)	2.53 (6.34)	2.08 (4.20)
LSD (p=0.05)	0.28	0.45	NS	0.23	0.24	0.41	NS	0.11	0.10	0.25
Weed management										
Atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS	5.09 (25.66)	4.80 (23.33)	1.60 (4.16)	2.18 (4.33)	2.53 (6.00)	4.45 (19.59)	4.46 (19.51)	1.74 (2.63)	2.56 (6.13)	1.93 (3.29)
Atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS	3.58 (12.50)	3.23 (10.00)	3.25 (11.50)	1.69 (2.50)	2.20 (4.16)	3.15 (9.75)	2.78 (7.34)	2.90 (8.13)	1.88 (3.07)	1.78 (2.76)
Atrazine 1.0 kg/ha *fb* one hand weeding at 20-25 DAS	2.87 (7.83)	2.25 (4.66)	2.11 (2.66)	1.34 (1.33)	1.70 (2.83)	2.57 (6.23)	2.21 (4.62)	1.45 (1.70)	1.74 (2.56)	1.34 (1.36)
Weedy	6.28 (39.33)	6.79 (46.00)	3.90 (15.66)	3.05 (8.66)	3.44 (11.50)	5.61 (31.42)	5.69 (32.31)	3.47 (11.79)	3.38 (10.76)	2.72 (7.05)
LSD (p=0.05)	0.40	0.64	0.43	0.33	0.34	0.58	0.56	0.16	0.15	0.36

The values of parentheses were the original values that had been changed to $\sqrt{x+0.5}$

Table 2. Effect of crop geometry and weed management treatments on soil enzymes at harvest, weed control efficiency (%), weed index (%), seed index, grain and stover yields and harvest index in maize

Treatment	Dehydrogenase activity (µg of TPF released/g soil 24/h)	Alkaline phosphatase (µg PNP released/g soil/h	Soil microbial biomass carbon (SMBC µg /g)	Weed control efficiency (%)	Weed index (%)	Seed index (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Plant crop geometry									
60 cm x 15 cm	13.48	99.98	260.70	35.87	8.98	23.79	0.52	0.77	40.14
60 cm x 20 cm	13.71	106.18	180.41	28.86	24.65	23.67	0.43	0.66	39.41
LSD (p=0.05)	0.19	0.42	0.62	-	-	NS	0.02	0.05	-
Weed management									
Atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS	13.53	94.22	104.99	26.74	20.29	23.60	0.47	0.65	41.75
Atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS	13.49	105.17	178.69	43.90	11.20	23.55	0.51	0.81	38.32
Atrazine 1.0 kg/ha *fb* one hand weeding at 20-25 DAS	13.47	100.78	209.62	58.82	0.00	24.70	0.57	0.88	39.31
Weedy	13.82	112.14	388.94	0.00	38.04	23.08	0.32	0.52	38.27
LSD (p=0.05)	NS	0.59	0.88	-	-	NS	0.03	0.07	-

Effect on soil enzymes

At harvest, dehydrogenase activity and alkaline phosphatase values were observed significantly higher in wider crop geometry (60 x 20 cm) in comparison to narrower crop geometry (60 x 15 cm). However, soil microbial biomass carbon was noted lesser in wider crop geometry (60 x 20 cm) compared to narrower crop geometry (60 cm x 15 cm). Amongst weed management treatment, alkaline phosphatase value and soil microbial biomass carbon were recorded significantly higher in atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha as compared to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS (**Table 2**). This exhibited the residual activity of herbicides on soil properties. In atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha treated plots, the activity of these enzymes increased at harvest due to higher dissipation of these herbicides after application. These, results were also in conformity with the finding of Tabatabai and Bremner (1972).

Effect on maize

Grain and stover yields were significantly higher (0.52 and 0.77 t/ha) in narrower crop geometry (60 x 15 cm) as compared to (0.43 and 0.66 t/ha) compared to wider crop geometry (60 x 20 cm). This might be due to lesser weed competition in narrower crop geometry. Amongst herbicide treatment, atrazine

1.0 kg/ha *fb* topramezone 25.2 g/ha had statistically superior grain and stover yields (0.51 and 0.47 t/ha) as compared to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS (0.81 and 0.65 t/ha). Harvest index was also noted to be higher (40.14 %) in narrower crop geometry (60 x 15 cm) then (39.41 %) compared to wider crop geometry (60 x 20 cm) while atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha had lesser harvest index (41.75%) than atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS (38.32 %) (**Table 2**). Narrow row spacing was found to reduce weed growth and yield enhancement. Similarly, reduction in weed competition due to weed control by pre as well as post herbicides resulted in significant grain and stover yields in these treatments. Similar results were also reported by Sanodiya *et al*. (2013).

Atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha and narrower crop geometry (60 x 15 cm) effectively suppressed weed growth, improved weed control efficiency and subsequently enhanced crop growth and yields. In context to soil enzymes, dehydrogenase activity and alkaline phosphatase values were recorded superior in wider crop geometry (60 x 20 cm) and atrazine1.0 kg/ha *fb* topramezone 25.2 g/ha.

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