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Research Communication

Effect of crop density and herbicides on weed dynamics and yield of maize (*Zea mays*)

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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 plant crop geometry and herbicide treatment on weeds, growth and yield of rainy maize. The experiment was conducted in a Randomized Complete Block Design design with two factors, crop geometry and weed management. In crop geometry, lower weed density and dry weight was observed in 60 cm × 15 cm as compared to 60 cm × 20 cm. However, atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS recorded 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*. Significantly higher grain yield (0.51 t/ha) was registered 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).

***Key words*:** Crop geometry, Tembotrione, Topramezone, Weed-control efficiency, Weed index

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 thresholds (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 reduce yield 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 communicate density to limit plant competition and to provide higher yields. The crop geometry combinations of 60 cm × 20 cm were discovered to help achieve a greater grain yield of maize (Getaneh *et al*. 2016). Topramezone and halosulfuron methyl are the selective, post-emergence herbicides in maize introduced recently. ALS (Acetolactate synthase) inhibiting herbicides are most effective for weed control by inhibiting amino acid synthesis (Singh *et al*., 2015). HPPD (4-hydroxyphenylpyruvate dioxygenase) inhibiting herbicide, 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. 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

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University, Varanasi. 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 potash (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: more crop density (110556 plants/ha) 60 cm × 15 cm, S_2: less crop density (83000 plants/ha) 60 cm × 20 cm, W_1-Atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS, W_2-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*. The recommended dose of nutrients @ 150-60-40 NPK 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 were collected after post emergence herbicide application was assessed for the enzyme activities viz., dehydrogenase, microbial biomass carbon and phosphatase. The total protein content was determined in the leaves of Maize at 30 DAE. The number of chlorophylls "a" and "b" and total

Table 1. Effect of crop geometry and weed management treatments on weed density (No./m^2) and weed dry weight (g/m^2) at 30 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*
A. Plant crop geometry										
60 cm × 15 cm	4.53 (23.16)	4.26 (22.33)	3.03 (10.16)	3.26 (11.00)	3.13 (11.66)	4.99 (33.17)	4.47 (26.77)	3.06 (11.24)	3.21 (11.13)	2.72 (9.42)
60 cm × 20 cm	5.14 (30.83)	4.63 (25.41)	3.27 (11.66)	3.59 (13.41)	3.43 (13.00)	5.42 (37.23)	4.93 (31.36)	3.28 (12.39)	3.68 (14.28)	3.09 (11.58)
SEm±	0.23	0.14	0.06	0.07	0.05	0.09	0.08	0.34	0.11	0.07
CD (P=0.05)	NS	NS	0.20	0.11	0.17	0.30	0.26	0.11	0.33	0.23
Weed management										
Atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS	5.05 (23.66)	5.38 (28.66)	2.28 (4.83)	3.55 (12.16)	3.73 (13.50)	6.07 (36.48)	5.02 (24.89)	1.97 (3.43)	3.41 (11.30)	3.72 (13.43)
Atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS	3.3 (10.16)	3.35 (10.83)	3.84 (14.3)	3.09 (9.16)	2.54 (6.00)	3.90 (15.11)	3.43 (11.35)	4.20 (17.18)	2.94 (8.48)	1.82 (2.94)
Atrazine 1.0 kg/ha *fb* 1 hand weeding at 20-25 DAS	2.70 (7.83)	1.78 (2.83)	1.76 (2.66)	2.26 (4.66)	1.66 (2.33)	1.50 (1.95)	1.52 (1.96)	1.52 (1.98)	2.29 (4.87)	1.06 (0.72)
Weedy	8.25 (66.33)	7.28 (53.16)	4.72 (21.83)	4.81 (22.83)	5.19 (26.5)	9.36 (87.23)	8.85 (78.07)	5.00 (24.67)	5.14 (26.18)	5.03 (24.90)
SEm±	0.33	0.20	0.09	0.11	0.08	0.14	0.12	0.11	0.15	0.10
CD (P=0.05)	1.01	0.62	0.28	0.33	0.24	0.42	0.38	0.34	0.47	0.32

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

chlorophyll in leaves. Soluble sugar content was determined in the first fully expanded leaves from the top in the normal plant by the method (Dubois *et al*., 1956) and expressed as mg g^{-1} fresh weight. The observation on the weed flora as grasses, broad-leaved and sedges was recorded at 30 DAS. The weed control efficiency and weed index were calculated with observed data on weed dry weight and grain yield. 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 *Echino-chloa colona, Digitaria sangunilais* and *Dactyloctenium aegyptium*, *Trianthema portulacastrum, Commelina benghalensis* and *Cyperus esculentus* during experimentation (Table 1). At 30 days after sowing, 60 cm × 15 cm, characterized by narrower crop geometry, exhibited significantly lower weed density and dry weight compared to S_2 (60 cm × 20 cm) wider crop geometry except *Cyperus esculentus*. Amongst weed management treatments, the density and dry weight of *Echinochloa colona*, *Digitaria sangunilais*, *Trianthema portulacastrum* and *Commelina benghalensis* were statistically lower 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 except *Cyperus esculentus*. However, density and dry wight of *Commelina benghalensis* were reported at par to each other in both weed management treatments. Narrower crop geometry, 60 cm × 15 cm, showed higher weed control efficacy compared to the wider crop geometry, 60 cm × 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 registered more in wider crop geometry, 60 cm × 20 cm in comparison to narrower crop geometry, 60 cm × 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

Table 2. Effect of crop geometry and weed management treatments on chlorophyll a, b and total chlorophyll, total leaf protein content, soluble sugar, weed control efficiency (%) at 30 DAS, weed index (%), seed index, grain and stover yields and harvest index in maize

Treatment	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll	Total leaf protein content (mg/g/FW)	Soluble sugar	Weed control efficiency (%)	Weed index (%)	Seed index (g)	Grain yield (t/ha)	Stover yield (t/ha)
A. Plant crop geometry										
60 cm × 15 cm	1.36	0.83	2.19	1.58	0.61	41.50	8.98	23.79	0.52	0.77
60 cm × 20 cm	1.47	0.87	2.34	1.91	0.68	35.84	24.65	23.67	0.43	0.66
SEm±	0.01	0.01	0.02	0.05	0.01	.	-	0.26	0.00	0.01
CD (P=0.05)	0.04	0.02	0.05	0.17	0.03	.	-	NS	0.02	0.05
B. Weed management										
Atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS	1.30	0.83	2.13	1.80	0.60	33.37	20.29	23.60	0.47	0.65
Atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha at 25 DAS	1.48	0.87	2.35	1.74	0.69	47.93	11.20	23.55	0.51	0.81
Atrazine 1.0 kg/ha *fb* one hand weeding at 20-25 DAS	1.64	0.93	2.56	2.14	0.77	73.40	0.00	24.70	0.57	0.88
Weedy	1.23	0.78	2.01	1.32	0.52	0.00	38.04	23.08	0.32	0.52
SEm±	0.02	0.01	0.02	0.08	0.02	-	-	0.38	0.01	0.02
CD (P=0.05)	0.06	0.02	0.07	0.25	0.05	-	-	NS	0.03	0.07

of weeds by pre as well as post emergence herbicide application by herbicides. Similar results were reported by Kumar *et al.* (2023).

Effect on maize

Chlorophyll a, b and total chlorophyll II, total leaf protein content and soluble sugar were exibited more in wider crop geometry, 60 cm × 20 cm than narrower crop geometry, 60 cm × 15 cm. This might be due to better crop canopy and growth. Amongst herbicide treatment, atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha had statistically higher chlorophyll a, b and total chlorophyll II, total leaf protein content and soluble sugar as compared to atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS. Grain and stover yields registered significantly higher (0.52 and 0.77 t/ha) in narrower crop geometry, 60 cm× 15 cm as compared to (0.43 and 0.66 t/ha) in wider crop geometry, 60 cm × 20 cm. This could be due to lesser weed competition in narrower crop geometry and Similar results were also reported by Kumar *et al*. (2023). 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 high (40.14 %) in 60 cm × 15 cm then (39.41 %) in 60 cm × 20 cm while atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha had less harvest index (41.75 %) than atrazine 1.0 kg/ha *fb* halosulfuron 67.5 g/ha at 25 DAS (38.32 %) (Table 2). The results were corroborated by findings of Kumar *et al*. (2023).

Atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha and narrower crop geometry, 60 cm × 15 cm effectively suppressed weed growth, reduced weed dry weight, improved weed control efficiency, enhanced crop growth and yields. In context to cholorophyll a, b and total chlorophyll II, total leaf protein content and soluble sugar were recorded superior in wider crop geometry, 60 cm × 20 cm and atrazine 1.0 kg/ha *fb* topramezone 25.2 g/ha.

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