Indian Journal of Weed Science (2024) **56**(1): 84–86
http://dx.doi.org/10.5958/0974-8164.2024.00014.5

RESEARCH NOTE

Effects of tank-mix herbicides on weed growth and maize productivity

Rajan Shukla[1], Amit Bhatnagar[1], Virendra Pratap Singh[1], N. Tony Manoj Kumar[1], Anjali Rawat[1], Sk Asraful Ali[1] and Satyam Rawat[2]

Received: 27 July 2023 | Revised: 28 January 2024 | Accepted: 30 January 2024

ABSTRACT

An experiment was carried out during 2021-22 at the Norman E. Borlaug Crop Research Center, G. B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar District, Uttarakhand to evaluate the effects of sequential and tank mix application of pre- and post-emergence herbicide on weed growth and performance of maize. Among the diverse weed flora observed, *Eleusine indica* L., *Digitaria sanguinalis* L., *Echinochloa colona* L. and *Eragrostis japonica* L. were dominant grassy weeds, where *Phyllanthus niruri* L., *Commelina benghalensis* L., *Cucumis melo* L. and *Cleome viscosa* L. were major broad-leaved weeds. *Cyperus rotundus* L. was the only sedge, where *Eleusine indica* dominated in the field during entire crop growth period. Chemical weed management through either sole application of topramezone and tembotrione or tank-mix application with atrazine recorded almost similar grain yield along with weed free check. The single tank mix application of atrazine - 0.75 kg/ha long with either tembotrione 120 g/ha or topramezone 25.2 g/ha at 15 DAS as single application can be recommended as a cost-effective method of weed control in maize owing to reduced weed biomass by 57.0 and 58.7%, respectively over weedy plot at 40 DAS while increased the grain yield by 41.6 and 46.7%, respectively under the respective treatments.

Keywords: Atrazine, Maize, Tembotrione, Tank-mix, Topramezone, Weed density, Weed dry matter

Maize (*Zea mays* L.) is a globally significant crop and ranks as one of the most important crops worldwide. In India, it is the third-largest crop in terms of production, following rice and wheat. In India, maize is cultivated over 9.57 million hectares (mha) area with a production of 28.8 million tonnes (mt) and productivity of 3.0 t/ha during the year 2019-20 (Indiastat 2021). Maize cultivation in India primarily takes place during the *Kharif* (rainy) season which is characterized by heavy rainfall and higher relative humidity, its wider rows provide ample space for weed growth, leading to severe competition and led to marked grain yield losses which was only 46.6% as compared to yield under weed free condition (Ehsas *et al*. 2016). Albeit, both manual removal and chemical application provide better weed control but become inaccessible under scarce labor at peak period of weed growth in case of former one, while not feasible under untimely rainfall in the latter situation. Increased incidence of untimed rainfall, non-uniform weed seed proliferation, and optimum soil moisture favor the weed flush emergence. Compared to sole application of atrazine, tank mix application along with new generation herbicides, *viz.* tembotrione and topramezone have been found effective for weed control in maize (Ghrasiram *et al.* 2020). The combined or sequential application of pre-emergence and/or post-emergence herbicides are necessary for effective weed control. Atrazine is widely used in maize crop for effective control over a broad range of weeds and can be applied both before and after emergence. Recently, two new post-emergence herbicides, tembotrione and topramezone have been introduced for effective control of both broad- and narrow-leaved weeds in maize within a short period of 2-5 days after treatment. Swetha *et al.* (2018) reported that the post-emergence application of tembotrione (105 g/ha) + atrazine (250 g/ha) at 15-20 days after maize sowing resulted in a significant reduction in weed biomass and higher weed control efficiency. These new generation herbicides have proven their potential to control diverse weed flora, their inclusion in crop cultivation ensure effective and swift weed control with ensured economic returns. Therefore, further exploration is needed to investigate the use of these new post-emergence herbicides (tembotrione and topramezone) in optimal combinations with atrazine to provide efficient and inclusive weed control in maize.

The study was designed to assess the effect of sequential and tank mix application of pre- and post-emergence herbicides on weed growth and

[1] Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand 263145, India.

[2] Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India

* Corresponding author email: satyam8004@gmail.com

performance of maize. The experiment was conducted in silty clay loam soil at the Norman E. Borlaug Crop Research Center, G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar District, Uttarakhand during of 2021-22. Nine treatment combinations comprising weedy, weed free, pre-emergence (PE) application of atrazine 1.0 kg/ha followed by hand weeding, atrazine 0.75 kg/ha PE followed by Post Emergence (PoE) application of topramezone 25.2 g/ha, atrazine 0.75 kg/ha PE *fb* tembotrione 120 g/ha PoE, atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha PoE, atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE, early PoE application of topramezone 25.2 g/ha + atrazine 0.75 kg/ha, and early PoE application of tembotrione 120 g/ha + atrazine 0.75 kg/ha. These treatment combinations were distributed among three replications in a randomized block design. The hybrid variety '*DKC 9144*' was sown with a spacing of 60 × 25 cm on 24 June 2021 and harvested on 12 October 2021. Pre-emergence herbicides were applied immediately after sowing the crop whereas post-emergence herbicides were applied at 30 days after sowing (DAS). A single tank mix application of herbicides was performed as an early post-emergence treatment at 15 DAS. In the weed-free treatment, manual weeding was conducted three times at 18, 30 and 42 DAS to control weeds. The herbicides were applied using a flat fan nozzle, with a spray volume of 500 l/ha. Observations on the weed flora were recorded at 50 DAS. Weed samples were collected using a quadrate of 1.0 m^2 area, dried in shade for 2-3 days, and subsequently in a hot air oven at 65 ± 5^0C until a constant weight was achieved. The dry weight of the weeds was measured using a digital balance and expressed in grams per square meter (g/m^2). The data on the number and dry weight of weeds were subjected to a square root transformation. The biomass accumulation by the crop was determined after sun drying for 2-3 days followed by oven drying at 65 ± 5^0C temperature until a constant weight was achieved and grain yield was calculated at maturity from net plot area (5.4 m^2).

Effects on weeds

Eleusine indica L., *Digitaria sanguinalis* L., *Echinochloa colona* L. and *Eragrostis japonica* L. were dominant among grassy weeds. Broad-leaf weeds were *Phyllanthus niruri* L., *Commelina benghalensis* L., *Cucumis melo* L. and *Cleome viscosa* L.. *Cyperus rotundus* L. was the only sedge. *Eleusine indica* was the major dominating weed which infested the crop at almost all stages of the crop which accounted for 35.4 and 28.5 % of the total weed population in weedy crop at 40 DAS and at harvest, respectively (**Table 1**).

Weedy plot exhibited significantly maximum total weed density at 40 DAS (542.7/m^2). Weed density in weedy crop decreased with advancement of crop age (224.0/m^2 at harvest) owing to completion of life-cycle of weeds. At 40 DAS atrazine 1.0 kg/ha PE *fb* hand weeding) recorded significantly lowest total weed density. Both sequential (atrazine 0.75 kg/ha PE followed by Post Emergence (PoE) application of topramezone 25.2 g/ha, atrazine 0.75 kg/ha PE *fb* tembotrione 0120 g/ha PoE, atrazine1.0 kg/ha PE *fb* topramezone - 25.2 g/ha PoE, atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE) and tank mix (early PoE application of topramezone 25.2 g/ha + atrazine 0.75 kg/ha, and early PoE application of tembotrione - 120 g/ha + atrazine 0.75 kg/ha) application had statistically equal total weed density. At harvest, atrazine 1.0 kg/ha PE *fb* hand weeding) recorded significantly lower weed density, which was at par with weedy check. tembotrione 120 g/ha + atrazine 0.75 kg/ha recorded significantly higher total weed density, which was at par with other sequential and tank mix treatments except in atrazine 0.75 kg/ha PE followed by Post Emergence (PoE) application of topramezone 25.2 g/ha and atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha as PoE. Results showed that under tank mix treatments (included topramezone and tembotrione) applied as early post-emergence at 15 DAS had strong photo bleaching effects on shoots and reduced biosynthesis of carotenoids in early emerged weeds led to lower weed density.

Table 1. Relative weed density in weedy crop at different crop growth stages

S. No.	Weed species	Relative weed density (%)	
		40 DAS	At harvest
1.	*Cyperus rotundus*	15.2	0.0
2.	*Eleusine indica*	35.4	33.3
3.	*Echinochloa colona*	27.0	28.0
4.	*Eragrostis japonica*	5.2	19.6
5.	*Digitaria sanguinalis*	7.6	11.9
6.	*Cleome viscosa*	1.7	3.6
7.	*Commelina benghalensis*	3.2	1.2
8.	*Cucumis melo*	1.7	0.6
9.	*Phyllanthus niruri*	2.9	1.8

Under weedy condition, uncontrolled weed growth resulted into the highest weed density. Weedy plot exhibited significantly higher total weed dry matter accumulation at respective crop growth stages (330.4 and 323.2 g/m^2, respectively).

At 40 DAS, all sequential treatments exhibited significantly more dry matter than tank mix treatments. At 50 DAS, all herbicidal treatments were statistically at par with the maximum value in atrazine 1.0 kg/ha PE *fb* topramezone - 25.2 g/ha PoE.. At harvest, all sequential and tank mix application were at par with each-other. However, pre-emergence (PE) application of atrazine 1.0 kg/ha followed by hand weeding recorded significantly more dry matter than other herbicidal treatments. The further germination of susceptible weed species was prevented under

Table 2. Effects of herbicide treatments on weeds crop growth and yield of maize

Treatment	Weed density (no./m^2)		Weed dry matter (g/m^2)		Crop biomass (g/plant)		Grain yield (t/ha)
	40 DAS	At harvest	40 DAS	At harvest	40 DAS	60 DAS	
Weedy	23.3(543)	14.9(224)	18.2(330)	17.9(323)	34.9	69.7	3.46
Weed free	1.0(0)	1.0(0)	1.0(0)	1.0(0)	60.1	106.1	7.20
Atrazine -1 kg/ha PE *fb* HW	11.8(139)	14.8(219)	9.2(84)	14.0(196)	51.2	101.1	6.94
Atrazine -0.75 kg/ha PE *fb* topramezone 25.2 g/ha PoE	17.1(295)	16.6(278)	13.3(178)	10.5(110)	55.3	103.9	6.60
Atrazine -0.75 kg/ha PE *fb* tembotrione 120 g/ha PoE	17.0(291)	18.1(331)	13.2(175)	11.7(137)	52.5	102.9	6.65
Atrazine -1.0 kg/ha PE *fb* topramezone 25.2 g/ha PoE	17.4(304)	16.9(288)	13.9(193)	10.9(117)	57.8	106.0	6.67
Atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE	16.7(279)	18.8(357)	13.2(173)	11.1(125)	56.7	104.6	6.88
Topramezone 25.2 g/ha E-PoE + atrazine 0.75 kg/ha	16.1(263)	19.3(373)	11.9(142)	12.4(154)	59.6	105.0	6.42
Tembotrione 120 g/ha E-PoE + atrazine 0.75 kg/ha	15.9(253)	19.4(379)	11.7(137)	12.6(159)	54.9	107.1	6.50
LSD (p=0.05)	2.0	1.9	1.5	1.5	12.4	15.6	1.26

*Original values are given in the parentheses

herbicidal treatments which resulted in lesser population and thus lower total dry matter accumulation (Samant *et al*. 2015).

Effect on maize growth

At 40 DAS, weed free crop attained maximum dry matter accumulation (60.1 g/plant) which was at par with those grown under herbicidal treatments. Dry matter accumulation was significantly lowered by 42.0 and 41.5% in weedy plot in comparison to weed free treatment and in early PoE application of topramezone - 25.2 g/ha + atrazine 0.75 kg/ha treatment, respectively. The same results were found at 60 DAS where tembotrione 120 g/ha + atrazine 0.75 kg/ha Early PoE) being at par with all weed control treatments attained the highest dry matter accumulation which was more than weedy plot (**Table 2**). Weedy treatment had significantly lowest dry matter accumulation of crop. Results indicated that herbicide treatments effectively controlled the weeds due to their broad-spectrum nature. The lower weed density under herbicidal treatments resulted into reduced crop-weed competition and helped the crop to make efficient utilization of solar radiation, space, moisture and nutrients. More plant height and leaf area index resulted into higher dry matter accumulation in plants grown in herbicidal and weed free treatments (Swetha *et al.* 2018).

Effect on grain yield

The weed-free treatment achieved the highest grain yield, measuring 7.2 t/ha. This value was similar to the grain yield of all herbicide-treated crops and significantly higher than the grain yield of the weedy crop. Among the herbicide treatments, both sequential and tank mix applications showed similar results. The weedy crop had the lowest grain yield, measuring 3.4 t/ha, which was 51.9% lower than the yield of the weed-free crop. The sequential application of herbicides (atrazine 0.75 kg/ha PE followed by Post Emergence (PoE) application of topramezone 25.2 g/ha, atrazine 0.75 kg/ha PE *fb* tembotrione 120 g/ha PoE, atrazine 1.0 kg/ha PE *fb* topramezone 25.2 g/ha PoE, atrazine 1.0 kg/ha PE *fb* tembotrione 120 g/ha PoE) resulted in significantly higher grain yields of 90.9%, 92.4%, 92.7% and 98.8%, respectively compared to the weedy treatment. Similarly, the tank mix application (early PoE application of topramezone 25.2 g/ha + atrazine 0.75 kg/ha and early PoE application of tembotrione 120 g/ha + atrazine 0.75 kg/ha) increased the grain yield by 85.5% and 88.1%, respectively compared to the weedy treatment (**Table 2**).

The findings suggested that tank mix application of atrazine at a reduced dosage of 0.75 kg/ha combined with either tembotrione at 120 g/ha or topramezone at 25.2 g/ha at 15 DAS as single application can be recommended as a cost effective method of weed control in maize.

REFERENCES

Ehsas J, Desai LJ, Ahir NB and Joshi JR. 2016. Effect of integrated weed management on growth, yield and yield attributes and weed parameters on summer maize (*Zea mays* L.) under South Gujarat condition. *International Journal of Environmental Science and Technology* **5**(4): 2050–2056.

Ghrasiram, Kumar M, Kumar V, Kumar M and Laik R K. 2020. Effect of alone and tank mix application of herbicides on weed infestation and productivity of *Kharif* Maize (*Zea mays* L.). *Journal of Cereal Research* **12**(3): 264–269.

Indiastat. (2022). Area, production and productivity statistics of Maize for the year 2020. *IndiaAgristat*. https://www.indiastat.com/data/agriculture/maize-17199.

Samant TK, Dhir BC and Mohanty B. 2015. Weed growth, yield components, productivity, economics and nutrient uptake of maize (*Zea mays* L.) as influenced by various herbicide applications under rainfed condition. *Indian Journal of Weed Science* **2**(1B): 79–83.

Swetha K, Madhavi M, Pratibha G and Ramprakash T. 2018. Impact of topramezone and tembotrione tank mix application with atrazine on growth and yield of maize. *Research Journal of Agricultural Science* **9** (3): 607–611.