Print ISSN : 0972-8813
e-ISSN : 2582-2780
[Vol. 23(2) May-August 2025]

Pantnagar Journal of Research

(Formerly International Journal of Basic and Applied Agricultural Research ISSN : 2349-8765)

G.B. Pant University of Agriculture & Technology, Pantnagar

PANTNAGAR JOURNAL OF RESEARCH

Vol. 23(2) May-August, 2025

CONTENTS

Weed management approaches for improving maize productivity in *Tarai* Belt of India

AKHILESH JUYAL and VINEETA RATHORE*

Department of Agronomy, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar-263145 (U. S. Nagar, Uttarakhand)
**Corresponding author's email id: vineetaagron@gmail. com*

ABSTRACT: A field study was carried out on weed infestation in *kharif* maize in the *Tarai* region of India in RBD having 12 different weed management treatments, *viz*., Atrazine 1.0 kg a. i. /ha (PE) *fb* hand hoeing at 21 DAS; Tembotrione 34.4% SC at 120 g a. i. /ha at 20 DAS; Topramezone 33.6% SC at 25.2 g a. i. /ha at 20 DAS; Atrazine 1.0 kg a. i. /ha (PE) *fb* tembotrione 34.4% SC at 120 g a. i. /ha at 20 DAS; Atrazine 1.0 kg a. i. /ha (PE) *fb* topramezone 33.6 % SC at 25.2 g a. i. /ha at 20 DAS; Tembotrione 34.4% SC at 120 g a. i. /ha at 20 DAS *fb* halosulfuron methyl 67.5 g a. i. /ha at 30 DAS; Topramezone 33.6% SC at 25.2 g a. i. /ha at 20 DAS *fb* halosulfuron methyl 67.5 g a. i. /ha at 30 DAS; Atrazine 1.0 kg a. i. /ha (PE) + residue of Wheat as mulch 5t/ha; Maize + Mungbean (1:1) intercropping; at 20 and 40 DAS Hand Weeding, Weed-free and weedy in 03 replications at Pantnagar during *kharif* 2023. Hand weedings at 20 days after sowing controlled the weed density by 81.1% at 30 DAS and at 40 days after sowing reduced the density of weeds 67.8% after 60 days of sowing and produced the highest grain yield (6.4 t/ha) compared to the weedy check plot, followed by application of atrazine 50% WP at 1000 g a. i. /ha *fb* hand hoeing at 21 DAS (6.14 t/ha grain yield), atrazine 50% WP at 1.0 kg a. i. /ha *fb* tembotrione 34.4% SC at 120 g a. i. /ha (6.03 t/ha grain yield), and atrazine 50% WP at 1.0 kg a. i. /ha *fb* topramezone 33.6% SC at 25.2 g a. i. /ha (5.96 t/ha grain yield), proving effective weed-free treatments.

Keywords: Atrazine, halosulfuron methyl, hand hoeing, hand weeding, maize, tembotrione, topramezone, weed density, weed management

Globally, after rice and wheat, maize (*Zea mays* L.) is an important crop from family Poaceae in India, it is the seventh highest producer with 2.7 percent share in global maize production (www. pjtau. edu. in, 2023). It has high genetic productivity and is referred to as "the queen of cereals. Maize is highly adaptable and thrives in various soil and climatic conditions. As a C_4 plant, maize efficiently utilizes solar energy, making it suitable for diverse agro-ecological regions and growing seasons. In India, during 2023-24, maize was cultivated in 11.24 million hectares with an average yield of 3351 kg/ha and production of 37.67 million tonnes while global maize production of 2023 year reached 1.2 billion tonnes (DAC & FW, 2023-24).

The major uses of maize in India include poultry feed (47%), cattle feed (13%), processed food (7%) and starch (14%), accounting for 81% of the overall production (Kumar *et al.,* 2022). Despite the increasing demand, maize productivity in India remains low compared to that in developed countries. Weeds pose a significant challenge by competing with maize mainly during the early vegetative growth stages, causing 18–85% yield losses (Jagadish and Prashant, 2016). Manual weeding is not feasible due to manpower, time and cost constraints. Intercropping is a cost-effective cultural practice that reduces weed growth compared to sole cropping (Mishra *et al.,* 2020). Herbicides are used widely to control the weeds because they are economical and cost-effective, but over-reliance on a single herbicide can lead to resistance as continuous use of Atrazine in maize crop leads to a shift in weed flora and the development of resistance in weeds, globally 45 weed species have developed resistance herbicides that inhibit photo-system II. Therefore, it is essential to enhance the utilization of Atrazine in combination with other herbicides in order to combat herbicidal resistance. It is important to include post-emergence herbicides like Tembotrione, Topramezone and Halosulfuron-methyl to ensure effective weed management and promoting crop growth. Relying solely on single method for weed management may not always be economically and environmentally sustainable due to the limitations and benefits of each control method. Hence, it is crucial to explore cultural, manual, mechanical, chemical method and integrate them wisely for weed control in *Kharif* maize. This thorough study aimed to provide highest production by sequential pre- and post-emergence herbicide applications on weed control, maize growth, and yield by considering that this balanced strategy not only enhances productivity but also reduces environmental impact and making maize cultivation more sustainable as well as profitable.

MATERIALS AND METHODS

A field experiment was carried out in G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand at N. E. Borlaug Crop Research Centre during *Kharif* 2023. The experiment site was located at 29°N latitude and 79.3°E longitude, within the *Tarai* belt of the Shivalik range of the Himalayan foothills. The region has a humid subtropical climate, characterized by hot and humid summers and mild winters. During the study, average temperatures ranged from 13.8°C to 34.3°C, with 807.4 mm of rainfall over 26 days.

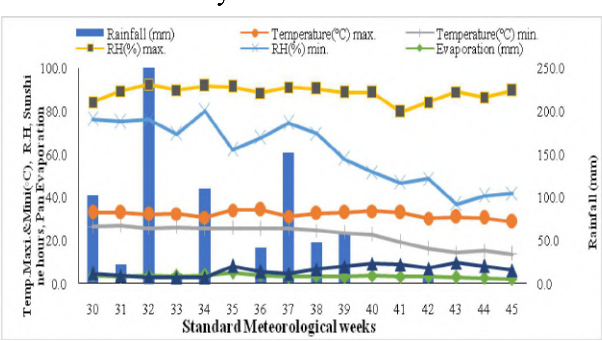

Fig.1: Weekly meteorological weather data during the experimentation

The relative humidity varied between 36.9% and 92.4%, daily sunshine ranged from 2.7 to 9.7 h, weekly evaporation rates ranged from 2.2 to 5.2 mm, and wind speeds ranged from 0.2 to 3.6 km/h (Fig.1). The soil of experimental site has sandy loam soil texture and 6.9 pH. It had medium levels of organic carbon (0.72%), low available nitrogen (221.5 kg/ha), and medium in available phosphorus and potassium (16.5 and 162.4 kg/ha, respectively). The experiment included 12 treatments: atrazine 50% WP at 1.0 kg/ha (PE) *fb* hand hoeing done after 21 DAS, tembotrione 34.4% SC 120 g/ha (PoE), topramezone 33.6% SC at 25.2 g/ha (PoE), atrazine 50% WP at 1000g a. i. /ha (PE) *fb* tembotrione 34.4% SC 120 g/ha (PoE)at 20 DAS, atrazine 50% WP at 1.0 kg a. i. /ha (PE) *fb* topramezone 33.6% SC 25.2 g/ha at 20 DAS (PoE), tembotrione 34.4% SC 120 g/ha at 20 DAS*fb* halosulfuron-methyl 75% WG 67.5 g/ha (PoE at 30 days after sowing), topramezone 33.6% SC 25.2 g/ha (PoE) *fb* halosulfuron-methyl 75% WG 67.5 g/ha (PoE), atrazine 50% WP as (PE) + residue mulch of wheat 5t/ha, intercropping with mungbean in a 1:1 ratio, two manual weeding at 20 DAS and 40 DAS, weed-free control, and weedy check. Sowing of maize hybrid 'DKC 9144' was done at a spacing of 60 cm × 25 cm. A 25 m² quadrat had been used and subsequently standardized to a 1 m² area. The data concerning the weed count were converted to square root transformation. Yield parameters were calculated at maturity and converted to a per-hectare basis for analysis.

Weed control efficiency (%) was determined by using the formula following

$$WCE = \frac{WDC\text{-}WDT}{WDC} \times 100$$

Where, WDC - Weed dry weight in control plot (g/m^2), WDT - Weed dry weight in treated plot (g/m^2) Grain yield was measured by shelling cobs, sun-drying the grains to 15% moisture, and recording the weight in t/ha.

RESULTS AND DISCUSSION

In maize experimental fields, most dominant weeds *Digitaria sanguinalis* L., *Echinochloa colona* L., *Dactyloctenium aegyptium* L., *Eleusine indica* L., *Panicum maximum* L., *Celosia argentia* L., *Trianthema monogyna* L., *Cleome viscosa* L., *Phyllanthus niruri* L., *Mollugo pentaphylla* L. and *Cyperus rotundus* L. *Cyperus rotundus* was predominant weed which infested the crop at nearly all stages of its development.

Total Weed density

Weed density was initially low at 30 DAS, reached

Table 1: Effect of weed control treatments on total weed density (No. /m²) and total weed dry matter accumulation (g/m²) at various stages of crop growth

Treatments	Weed density (No. /m²)			Weed dry matter (g/m²)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1: Atrazine 1.0 kg a. i. /ha (PE) *fb* hand hoeing at 21 DAS	2.5 (6.7)	8.1 (65.3)	6.5 (41.3)	1.3 (0.8)	5.4 (28.6)	5.0 (25.3)
T_2: Tembotrione 120 g a. i. /ha at 20 DAS	8.0 (64.0)	13.3 (177.3)	9.3 (86.7)	3.5 (11.9)	8.9 (79.1)	7.0 (50.3)
T_3: Topramezone 25.2 g a. i. /ha at 20 DAS	8.1 (66.7)	13.3 (176.0)	9.4 (88.0)	3.7 (12.5)	9.1 (81.9)	7.0 (50.8)
T_4: Atrazine 1.0 kg a. i. /ha (PE) *fb* tembotrione 120 g a. i. /ha at 20 DAS	6.7 (44.0)	10.7 (114.7)	8.2 (66.7)	2.7 (6.3)	7.0 (48.8)	6.1 (37.0)
T_5: Atrazine 1.0 kg a. i. /ha (PE) *fb* topramezone 25.2 g/ha at 20 DAS	6.8 (45.3)	10.8 (117.3)	8.2 (66.7)	2.8 (6.9)	7.1 (49.3)	6.4 (39.9)
T_6: Tembotrione 120 g a. i. /ha at 20 DAS *fb* halosulfuron methyl 67.5 g a. i. /ha at 30 DAS	8.1 (65.3)	10.9 (118.7)	8.4 (70.7)	3.5 (11.3)	7.2 (50.5)	6.7 (44.9)
T_7: Topramezone 25.2 g a. i. /ha at 20 DAS *fb* halosulfuron methyl 67.5 g a. i. /ha at 30 DAS	8.3 (69.3)	10.9 (118.7)	8.5 (72.0)	3.7 (12.4)	7.4 (54.2)	6.8 (45.4)
T_8: Atrazine 1.0 kg a. i. /ha (PE) + Wheat residue mulch 5t/ha	9.3 (85.3)	13.9 (194.7)	10.7 (113.3)	4.0 (15.1)	9.5 (88.8)	8.7 (75.7)
T_9: Maize + Mungbean (1:1) intercropping	13.0 (170.7)	16.6 (274.7)	12.0 (144.0)	5.9 (33.7)	12.1 (145.6)	10.2 (104.7)
T_{10}: Two Hand Weeding at 20 and 40 DAS	3.1 (9.3)	6.3 (38.7)	5.9 (34.67)	1.3 (0.9)	3.1 (8.5)	4.2 (16.4)
T_{11}: 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)
T_{12}: Weedy check	16.4 (268.0)	19.6 (386.7)	14.6 (213.3)	8.4 (70.6)	14.7 (214.5)	12.3 (150.2)
SEm ±	0.5	0.6	0.5	0.2	0.4	0.4
CD (5%)	1.5	1.9	1.5	0.7	1.2	1.2

Data in parentheses are original values, which were transformed to $\sqrt{x+1}$ and analysed statistically; *a. i.* : active in gradient; PE: Pre-emergence application; *fb*: followed by; HW: Hand weeding; DAS: Days after sowing

Table 2: Effect of weed control treatments on weed control efficiency (%) and grain yield (t/ha) of maize

Treatments	Weed control efficiency (%)			Grain yield
	30 DAS	60 DAS	At harvest	(t/ha)
T_1: Atrazine 1.0 kg a. i. /ha (PE) *&* hand hoeing at 21 DAS	98.9	86.7	83.2	6.14
T_2: Tembotrione 120 g a. i. /ha at 20 DAS	83.1	63.1	66.5	5.55
T_3: Topramezone 25.2 g a. i. /ha at 20 DAS	82.2	61.8	66.2	5.51
T_4: Atrazine 1.0 kg a. i. /ha (PE) *fb* tembotrione 120 g a. i. /ha at 20 DAS	91.0	77.2	75.4	6.01
T_5: Atrazine 1.0 kg a. i. /ha (PE) *fb* topramezone 25.2 g/ha at 20 DAS	90.3	77.0	73.4	5.96
T_6: Tembotrione 120 g a. i. /ha at 20 DAS *fb* halosulfuron methyl 67.5 g a. i. /ha at 30 DAS	84.0	76.5	70.1	5.78
T_7: Topramezone 25.2 g a. i. /ha at 20 DAS *fb* halosulfuron methyl 67.5 g a. i. /ha at 30 DAS	82.5	74.7	69.8	5.74
T_8: Atrazine 1.0 kg a. i. /ha (PE) + Wheat residue mulch 5t/ha	78.6	58.6	49.6	4.99
T_9: Maize + Mungbean (1:1) intercropping	52.3	32.1	30.3	5.08
T_{10}: Two Hand Weeding at 20 and 40 DAS	98.7	96.0	89.1	6.42
T_{11}: Weed-free	100.0	100.0	100.0	6.65
T_{12}: Weedy check	0.0	0.0	0.0	3.18
SEm ±				0.31
CD (5%)				0.91

a. i. : active in gradient; PE: Pre-emergence application of herbicide; *fb*: followed by; DAS: Days after sowing a maximum at 60 DAS, and then reduced again at harvest (Table 1). At 30 DAS, the lowest total weed density was observed with atrazine 50% WP applied as a pre-emergence at 1.0 kg a. i. /ha followed by hoeing at 21 DAS because the application of atrazine as a PE herbicide initially suppressed the weeds by inhibiting germination and limiting early establishment, whereas hoeing removed any remaining weed plants so weed density was reduced by removing weeds before they matured and produced seeds. This disrupts the growth cycle of these insects, thereby limiting their presence in the field (Patel *et al.,* 2019). Among other treatments, the sequential pre-emergence application of atrazine 50% WP at 1.0 kg *a. i.* /ha (PE) either with tembotrione or topramezone effectively controlled the all types of weeds except sedges owing to the initial control provided by atrazine and subsequent prevention of weed emergence by post-emergence herbicides. Lavanya *et al*. (2021) reported similar findings.

Two times hand weedings resulted in a significantly reduced weed density at 60 DAS and harvest stages followed by hand hoeing at 21 DAS. The subsequent application of tembotrione or topramezone in conjunction with halosulfuron methyl demonstrated efficacy against *Cyperus rotundus* owing to their complementary modes of actions. In comparison to pre-emergence or post-emergence herbicides, halosulfuron methyl has a better efficacy in controlling sedges (Kumar *et al.,* 2016 and Kumar, 2018).

Total weed dry matter accumulation

The highest dry matter accumulation was observed in weedy plots at all stages and then in the mung bean intercropped plots (Table 1). A significant reduction in total weed dry matter accumulation was recorded in twice hand-weeded plots at 20 and 40 days after sowing, followed by pre-emergence application of atrazine 50% WP (PE) in sequence with hand hoeing at 21 DAS. This is because the combined herbicidal applications effectively reduced the total weed population in a timely manner. Pre-emergence herbicide application followed by weeding is very effective method for managing the complex weed flora (Swetha *et al.,* 2015) whereas sequential herbicidal applications effectively reduce the total weed population by controlling the initial weed flush through pre-emergence herbicides, along with the prevention of weed emergence at later growth stages due to post-emergence herbicides. Jayabhaye *et al.,* 2020 and Kakade *et al.,* 2020 also reported similar findings.

Weed Control Efficiency (WCE %)

In the initial 30 days, the significantly highest WCE (98.9%) was observed with atrazine 50% WP at 1.0 kg a. i. /ha (PE) *fb* hand hoeing at 21 DAS. While, at 60 DAS and harvest stage, two manual weedings at 20 and 40 days stages resulted in the highest WCE 96.0% and 89.1%, respectively followed by the treatment pre-Emergence application of atrazine 50% WP at 1.0 kg a. i. /ha after that hand hoeing at 21 DAS (86.7% and 83.2%, respectively). This is because removing of weeds during key growth phases reduced the weed density and ultimately enhances the efficiency weed control strategies (Gupta *et al.,* 2023 and Manjulatha *et al.,* 2024).

Maize grain yield (t/ha)

Atrazine 50% WP application at the rate of 1000 g a. i. /ha (pre-emergence) followed by manual hoeing at 21 (DAS) treatment resulted the maximum grain yield, statistically followed by atrazine 50% WP as pre-emergence *f/b* tembotrione 34.4% SC at 120 g a. i. /ha (20 DAS), atrazine 50% WP at 1.0 kg a. i. /ha (pre-emergence) followed by topramezone 33.6% SC at 25.2 g a. i. /ha (20 DAS), tembotrione 34.4% SC at 120 g a. i. /ha applied at 20 DAS followed by halosulfuron methyl at 67.5 g a. i. /ha applied at 30 DAS, topramezone 33.6% SC at 25.2 g a. i. /ha applied at 20 DAS followed by halosulfuron methyl at 67.5 g a. i. /ha applied at 30 DAS, and two hand weedings (Table 2). The positive outcomes resulted from the reduced population of weeds, their dry matter, and ensuring a weed-free environment in the critical growth stages as maize crops fully utilize all resources for growth, development and yield (Rani *et al.,* 2021; Kumar *et al.,* 2023). Higher yields in herbicide-treated plots were due to pre-emergence applied herbicides at initial stages to control the weeds, while in the later stages of crops; application of post-emergence herbicides had significant effect in controlling the weeds. The weedy crop had a 52.1% lower grain yield than the weed-free treatment.

CONCLUSION

Notably, weed management practices had significant effect on the yield of *Kharif* maize. Based on observations from a one-year study, the integrated method of applying atrazine at 1.0 kg a. i. /ha as pre-emergence followed by manual hoeing at 21 DAS was recorded as the significant effective weed control treatment for yield parameters. Among chemical control strategies, the of atrazine 50% WP application at the rate of 1.0 kg/ha (PE) *f/b* tembotrione 34.4% SC at 120 g a. i. /ha at 20 days stage or topramezone 33.6% SC at 25.2 g a. i. /ha at 20 days stage was very effective. Additionally, if labor is available, two times manual weeding may be one option to the enhance weed control efficiency by reducing the weed density.

REFERENCES

DAC & FW. (2024). Agricultural Statistics at a Glance 2024. Krishi Bhawan, New Delhi, 38p.

Gupta, V., Verma, A., Bhimwal, J. P., Nepalia, V. and Jain, H. K. (2023). Weed dynamics, productivity and economics of quality protein maize (*Zea mays*) as affected by weed and nutrient-management. *Indian Journal of Agronomy,* 68 (2): 182-187: https://doi. org/ 10.59797/ija. v68i2.352

Jagdish, S. and Prashant, C. (2016). A review on weed management on maize (*Zea mays* L.). *Advances in Life Sciences,* 5 (9): 3448-3455.

Jaybhaye, J., Kakade, S. U., Desmukh, J. P., Thakare, S. S. and Solanke, M. S. (2020). Effect of pre and post emergence herbicides on weed, productivity and profitability of maize (*Zea mays* L.). *Int. J. Curr. Microbiol. Appl. Sci.,*9 (5): 2797-2805.

Kakade, S. U., Deshmukh, J. P., Thakare, S. S. and Solanke, M. S. (2020). Efficacy of pre and post-emergence herbicides in maize. *Indian Journal of Weed Science,* 52 (2): 143-146.

Kumar, A., Sharma, N., Sharma, A., Mahajan, A. and Stanzen, L. (2016). Bio-efficacy of halosulfuron methyl against *Cyperus* spp. in maize (*Zea mays* L.). *Annals of Agricultural Research,* 37 (2): 189-193.

Kumar, K., Singh, J., Singh, B. R., Chandra, S., Chauhan, N., Yadav, M. K. and Kumar, P. (2022). Consumption and processing patterns of maize (*Zea mays*): A review. *The Pharma Innovation Journal,*11 (5): 51-57.

Kumar, M. (2018). Halosulfuron methyl 75% WG (Sempra)–A new herbicide for the control of *Cyperus rotundus* in maize (*Zea mays* L.) crop in Bihar. *International Journal of Current Microbiology and Applied Sciences,* **7** (3): 841-846.

Kumar, P., Sangwan, M., Mal, T. and Kumar, S. (2023). Effect of pre-and post-emergence herbicides on weed infestation, crop growth and economics of maize. *Annals of Agricultural Research,*44 (4): 417-422.

Lavanya, Y., Srinivasan, K., Chinnamuthu, C. R., Murali, P. A., Shanmugasundaram, S. and Chandrasekhar, C. N. (2021). Study on effect of weed management practices on weed dynamics and productivity of *kharif* maize. *The Pharma Innovation Journal,*10 (1): 662-665.

Manjulatha, G., Rajanikanth, E., S. D. Bamboriya, and Salakinkop, S. R. (2024). Efficacy of Herbicides on Weed Dynamics and Weed Control Efficiency and its Effect on Productivity and Economics of *Kharif* Maize. *Agriculture Association of Textile Chemical and Critical Reviews,* 12 (1): 52-56.

Mishra, G. C., Mishra, G., Nayak, B. S., Behara, M. P. and Lenka, S. K. (2020). Influence of weed management practices on weed control efficiency, growth and productivity of hybrid maize. *International Journal of Chemical Studies,*8: 2085-2089.

Patel, P. K., Patel, B. D., Patel, V. J., Chaudhary, D. D. and Dankhara, M. (2019). Influence of sequential and tank mix application of herbicides against complex weed flora and phytotoxicity in kharif maize. *International Journal of Chemical Studies,*7 (3): 4808-

4812.

Rani, B. S., Chandrika, V., Reddy, G. P., Sudhakar, P. and Sagar, G. K. (2021). Weed management with pre and post-emergence herbicides in maize under maize-green gram cropping system. *Indian Journal of Weed Science,* 53 (4): 405-410.

Swetha, K., Madhavi, M., Pratibha, G. and Ramprakash, T. (2015). Weed management with new generation herbicides in maize. *Indian J. Weed Sci*., 47 (4): 432-433.

Received: July 31, 2025
Accepted: August 11, 2025