**Effect of Herbicides on Weed dynamics, Grain yield and Economics of *rabi* Maize**

**ABSTRACT**

A field experiment was carried out at the District Seed Farm (AB-Block) of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal during *rabi* season of November 2022 to March 2023 to assess the effect of weedicides to control weeds in *rabi* maize. Randomized Block Design was used to set up the experiment, which included nine weedicides and three replications. The findings showed that the weed free plot had the lowest weed density and dry weight of grassy, sedge, and broadleaf weeds. The pre-emergence application of atrazine @ 750 g ha-1 followed by topramezone @ 25.2 g ha-1 at 25 DAS had low weed density and dry weed biomass which was statistically equivalent to the application of topramezone @ 25.2 g ha-1 + atrazine @ 750 g ha-1 at 15 DAS. The weed free treatment had the highest weed control efficiency (46.65). Lowest weed index (8.10) was recorded in atrazine @ 750 g a.i ha-1 followed by topramezone @ 25.2 g a.i. ha-1 at 25 DAS which exhibited the maximum benefit cost ratio. Pre-emergence application of atrazine @ 750 g ha-1 followed by topramezone @ 25.2 g ha-1 at 25 DAS and topramezone @ 25.2 g ha-1 + atrazine @ 750 g ha-1 at 15 days after sowing were found to be most effective in controlling weeds in maize with higher benefit cost ratio.

***Keywords*:** Weed management, herbicides, weed control efficiency, weed index, r*abi* maize

1. **INTRODUCTION**

After wheat and rice, maize (*Zea mays* L.), popularly known as corn, is the third-most significant cereal crop in the world. Due to several restricting constraints, India ranks fourth in terms of area and seventh in terms of production among nations that grow maize; this accounts for about 4% of the world's total maize area and 2% of its production. Among these factors, inadequate weed control practices result in significant losses in maize production. Maize prefers wide space among them and shows slow initial growth (Nagalakshmi et al., 2006 and Hatti et al*. ,* 2014). ) which favours most of the weeds to grow and covers the fallow portion. The weeds hinder the early vegetative growth of maize up to 6 weeks growth period. The surrender misfortunes detailed in maize due to uncontrolled weed development extended from 30 to 100%. Singh et al.,1997 detailed that weeds diminish edit surrender by competing for light and carbon dioxide, meddled with collecting and increment the fetched included in edit generation. Dalley et al.(2006) reported that season long weed competition caused considerable yield losses in maize. Manual weeding though very effective in controlling weeds, very often is cumbersome, labour intensive, expensive and time consuming. Of late due to shift in traditional agricultural labours to non-agricultural sectors, the availability of labour in a required number of manual weeding is becoming a difficult year by year (Shukla et al., 2023) . Hence, there is a need to look for alternative methods of weed control to manual weeding (Triveni et al.2017). The use of herbicides for weed control can be an alternative strategy as they can control the weeds timely, effectively, and at lower cost (Reddy, 2018, Madhavi et al. *,* 2014), and Gantoliet al. ,2013). Atrazine is a “broad-spectrum” herbicide but it acts mainly on grasses with some action on broad leaved weeds in maize and millets by blocking the electron transport in PS II when an electron is carried from quinine or plastoquinone A to plastoquinone or plastoquinone B, respectively (Srividya et al. , 2011). Topramezone, could be a profoundly particular herbicide compound for control of warm season grasses and dicotyledonous weeds in maize. It represses the protein 4-hydroxy-phenyl-pyruvate dioxygenase (4-HPPD) included in biosynthesis of plastocyanin and carotenoids driving to the disturbance of the blend and work of chloroplasts (Deshmukh et al*. ,* 2014, Bollman et al. (2008) and Roy et al. (2008) and Swetha et. al., 2015). The choice of weed control strategies, therefore, depends largely on effectiveness and economics (Mukhtar et al.*,* 2007). With diminished work drive and expanded taken a toll in manual weeding, herbicides not as it were control the weeds convenient and successfully but moreover offer more prominent scope for minimizing the taken a toll of weed control independent of the circumstance. So, the present investigation was conducted to find out the best performing herbicide or herbicide combinations to control most of the weeds and to increased yield and economics of maize.

1. **MATERIAL AND METHODS**

A field experiment was conducted during the *rabi* season of November 2022 to March 2023 at the District seed Farm (AB-Block) of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India. The experimental farm was situated at 22°57´ N latitude and 88°20´ E longitude with an average altitude of 9.75 m above the mean sea level. It is situated in the New Alluvial Zone of West Bengal. The soil was silty clay soil in surface having pH 7.32, medium in natural carbon (0.53 %), accessible N 145.28 kg ha-1, accessible P 28.82 kg ha-1 and accessible K 282.24 kg ha-1. The experiment was laid down in Randomized Block Design with three replications and nine weed management practices viz. T1: Control (Weedy check); T2: Weed free; T3: Atrazine @ 1000 g a.i ha-1 as “pre-emergence” *fb* Hand weeding at 25 DAS; T4: Atrazine (750 g a.i ha-1) as “pre-emergence” *fb* Topramezone 25.2 g a.i ha-1 at 25 DAS as “post-emergence”; T5: Atrazine (750 g a.i ha-1) as “pre-emergence” *fb* Tembotrione (120 g a.i ha-1) at 25 DAS as “post-emergence”; T6: Atrazine (1000 g a.i ha-1) as “pre-emergence” *fb* Topramezone (25.2 g a.i ha-1) at 25 DAS as “post-emergence”; T7: Atrazine (1000 g a.i ha-1) as “pre-emergence” *fb* Tembotrione (120 g a.i ha-1) at 25 DAS as “post-emergence”; T8: Topramezone (25.2 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS; T9: Tembotrione (120 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS. Seeds of maize variety, P- 3396 was sown manually at a spacing of 60 cm x 20 cm @ 20 kg ha-1. Nitrogen, phosphorus, and potassium were applied @ 150:75:75 kg ha-1 in the form of urea, single super phosphate, and muriate of potash, respectively. The full dose of P & K and one-third of nitrogen were applied as basal; one-third nitrogen was applied at the knee-height stage and rest one-third nitrogen was applied at tasselling. Herbicides were connected as per treatment plan and herbicidal arrangement related to the assistance of Backpack sprayer fitted with a level fan spout with a splash volume of water 600 ml ha-1. Weed populace was taken as a quadrate strategy and dry weight of weeds was done as per standard strategy. The density and weed dry weight were analysed after subjecting the original data to the square root transformation [√x+0.5]. The treatment effects were compared using transformed means.

The abdicate was recorded and dissected as per Gomez and Gomez (1984). The treatment comparisons were made utilizing t-test at 5 % level of noteworthiness. The economies were calculated based on winning nearby advertise cost of maize grains and taken a toll of inputs.

1. **RESULTS AND DISCUSSION**

**3.1 The Effect on weed population and weed dry weight**

The weed population and dry weight of weed in maize (Table 1) significantly varied among the herbicide treatments. The lowest grassy, sedges and broad leaves “weed” density and dry weight of weeds were observed in weed free plot (T2) as there was no weed due to regular control of weed. But among the herbicide treated plots, the application of Atrazine (750 g a.i ha-1) as pre-emergence fb Topramezone 25.2 g a.i ha-1 at 25 DAS as post-emergence, was significantly recorded lower weed density (1.94, 4.56 and 1.77 grass, sedge and broadleaves m-2) and weed dry weight (4.56 g, 4.18 g and 1.84 g grass, sedge and broadleaves m-2) which was statistically at par with T8 [Topramezone (25.2 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS]. The results are in conformity with the findings of Singh et al. (2012). All the other weed management treatments also recorded significantly low grassy, sedges and broad leaves “weed” density and weed dry weight as compared with the weedy check.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 1: Effect of weed management on weed population and weed dry weight in maize | | | | | | |
| Treatment | No. of weeds m-2 at harvest | | | Weed dry weight m-2 at harvest (g) | | |
| Grasses | Sedges | BLW | Grasses | Sedges | B  LW |
| T1: Control (Weedy check) | 6.54 (42.33) | 7.89 (61.70) | 6.01 (35.67) | 7.89 (61.70) | 7.33 (53.30) | 2.90 (7.90) |
| T2: Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| T3: Atrazine @ 1000 g a.i ha-1 as pre-emergence *fb* Hand weeding at 25 DAS; | 3.10 (9.13) | 6.22 (38.30) | 2.87 (7.73) | 6.22 (38.30) | 5.92 (34.60) | 2.85 (7.60) |
| T4: Atrazine (750 g a.i ha-1) as pre-emergence *fb* Topramezone 25.2 g a.i ha-1 at 25 DAS as post-emergence; | 1.94 (3.27) | 4.56 (20.30) | 1.77 (2.63) | 4.56 (20.30) | 4.18 (17.00) | 1.84 (2.90) |
| T5: Atrazine (750 g a.i ha-1) as pre-emergence *fb* Tembotrione (120 g a.i ha-1) at 25 DAS as post-emergence; | 2.90 (7.92) | 5.85 (33.70) | 2.52 (5.87) | 5.85 (33.70) | 5.49 (29.70) | 2.61 (6.30) |
| T6: Atrazine (1000 g a.i ha-1) as pre-emergence *fb* Topramezone (25.2 g a.i ha-1) at 25 DAS as post-emergence; | 2.76 (7.13) | 5.77 (32.30) | 2.28 (4.70) | 5.77 (32.30) | 5.22 (26.80) | 2.55 (6.00) |
| T7: Atrazine (1000 g a.i ha-1) as pre-emergence *fb* Tembotrione (120 g a.i ha-1) at 25 DAS as post-emergence; | 1.37 (10.40) | 6.12 (37.00) | 3.18 (9.60) | 6.12 (37.00) | 5.76 (32.70) | 2.81 (7.40) |
| T8: Topramezone (25.2 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS; | 2.23 (4.50) | 5.37 (28.40) | 2.01 (3.53) | 5.37 (28.40) | 4.84 (22.90) | 2.19 (4.30) |
| T9: Tembotrione (120 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS. | 2.42 (5.40) | 5.85 (33.70) | 2.71 (6.83) | 5.67 (31.70) | 5.21 (26.60) | 2.37 (5.10) |
| SEm (±) | 0.12 | 0.39 | 0.08 | 0.37 | 0.33 | 0.16 |
| CD at 5% | 0.35 | 1.20 | 0.27 | 1.08 | 0.98 | 0.52 |
| \**The data were transformed before statistical analysis using square root transformation [√x+0.5]. Figures in parenthesis are the original value for respective data* | | | | | | |

**3.2 The Effect on weed management practices on gain yield of maize**

The most extreme grain surrender was taken note in weed free plot (T2) that was 12.10 t ha-1 which was factually at standard with T4 treatment (Atrazine 750 g ha-1 as PE taken after by Topramezone 25.2 g ha-1 at 25 DAS) which recorded 11.12 t ha-1 grain abdicate (Table-2). T4 treatment was statistically at par with T8 treatment (Topramezone 25.2 g ha-1 + Atrazine 750 g ha-1 at 15 DAS). As the growth of the plants as well as the dry weight and yield attributes increased in Topramezone treated plots, so the grain yield also increased due to the higher accumulation of photosynthates in the grains. The lowest value of grain yield (6.45 t ha-1) was noticed in T1 (un-weeded check). The percent yield reduction was highest in an un-weeded check plot (T1) with a value of 46.69%. The percent yield increase in T4, T8, T6, and T5 was 72.40%, 57.05%, 32.56%, and 28.68% respectively over that of the un-weeded check plot (T1). These findingswere substantiating with the results of Hatti et al.(2014).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 2: Effect of weed management on grain yield, weed control efficiency and weed index in maize | | | | | |
| Treatment | Maize Grain Yield (t ha-1) | Weed Control Efficiency (%) at harvest | | | Weed Index |
| Grasses | Sedges | BLW |  |
| T1: Control (Weedy check) | 6.45 | - | - | - | 46.65 |
| T2: Weed free | 12.10 | 100.00 | 100.00 | 100.00 |  |
| T3: Atrazine @ 1000 g a.i ha-1 as pre-emergence *fb* Hand weeding at 25 DAS; | 7.45 | 37.93 | 35.08 | 3.79 | 38.43 |
| T4: Atrazine (750 g a.i ha-1) as pre-emergence *fb* Topramezone 25.2 g a.i ha-1 at 25 DAS as post-emergence; | 11.12 | 67.10 | 68.11 | 63.29 | 8.10 |
| T5: Atrazine (750 g a.i ha-1) as pre-emergence *fb* Tembotrione (120 g a.i ha-1) at 25 DAS as post-emergence; | 8.30 | 45.38 | 44.28 | 20.25 | 24.98 |
| T6: Atrazine (1000 g a.i ha-1) as pre-emergence *fb* Topramezone (25.2 g a.i ha-1) at 25 DAS as post-emergence; | 8.55 | 46.55 | 49.72 | 24.05 | 29.32 |
| T7: Atrazine (1000 g a.i ha-1) as pre-emergence *fb* Tembotrione (120 g a.i ha-1) at 25 DAS as post-emergence; | 8.14 | 40.03 | 38.60 | 6.32 | 32.73 |
| T8: Topramezone (25.2 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS; | 10.13 | 53.97 | 57.04 | 45.56 | 16.31 |
| T9: Tembotrione (120 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS. | 9.45 | 47.65 | 50.09 | 35.44 | 31.46 |
| SEm(±) | 0.40 | --- | --- | -- |  |
| CD at 5% | 1.19 | --- | --- | -- |  |

**3.3 The Effect on weed control efficiency and weed index**

The highest (100%) weed control efficiency was recorded with weed free treatment (T2) at all the stages of crop growth and was significantly superior to all the other weed control treatments (Table-2). But among the herbicide treated plots, treatment T4 [Atrazine (750 g a.i ha-1) as pre-emergence fb Topramezone 25.2 g a.i ha-1 at 25 DAS as post-emergence], recorded higher weed control efficiency ( 67.10 %, 68.11% and 63.29% of grass, sedge and broadleaves) followed by T8 [Topramezone (25.2 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS] and followed by T9 [Tembotrione (120 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS]. It shows compelling control of weeds with application of Atrazine and Topramezone. This may due to the beginning control of weed populace by tirelessness action of pre-emergence application of Atrazine and afterward developed weeds were controlled by the post-emergence herbicide of Topramezone. The comes about are in understanding with the discoveries of Paradkar and Sharma (1993), Sreenivas and Satyanarayana (1994), Mundra et al. (2002), Sinha et al. (2003), Kamble et al. (2005), Srividya et al. (2011) and Deshmukh et al. (2014). The least weed control proficiency was recorded with weedy check (T1) (Table-2). Most reduced weed file (8.10) was detailed in plots accepting herbicide Atrazine (750 g a.i ha-1) as pre-emergence fb Topramezone 25.2 g a.i ha-1 at 25 DAS as post-emergence which was taken after by T8 treatment [Topramezone (25.2 g a.i ha-1) & Atrazine (750 g a.i ha-1) at 15 DAS]. Most noteworthy weed list (46.65) was recorded in an un-weeded check plot (T1).

**3.4 The Effect on Net Return (Rs. ha-1) and B:C ratio**

The highest net return (Rs.1,58,840/-) was recorded in a weed free plot (T2) which was statistically at par with T4 treatment (Atrazine 750 g ha-1 as PE & Topramezone 25.2 g ha-1 at 25 DAS) which was statistically at par with T8 (Topramezone 25.2 g ha-1 + Atrazine 750 g ha-1 at 15 DAS) (Table-3). It may be due to the higher grain yield of maize and more effective control of weeds by Atrazine and Topramezone. The lowest net return (Rs. 71, 400/-) was recorded in weedy check (T1).

The benefit cost ratio did not follow the same trend because the cost of cultivation was highest in a “weed free plot” (T2) than other treatments due to the higher labour requirement. The highest benefit cost ratio (3.92) was however recorded in plots receiving Atrazine 750 g ha-1 (PE) & Topramezone 25.2 g ha-1 at 25 DAS (T4 treatment) because at this dose “Topramezone” proved to be more effective for weed control which was statistically at par with T8 (Topramezone 25.2 g ha-1 + Atrazine 750 g ha-1 at 15 DAS) (Table-3).

Table 3: Effect of weed management on economics of maize

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment | Cost of  Cultivation  (Rs. ha-1) | Gross return  (Rs. ha-1) | Net return  (Rs. ha-1) | B:C |
| T1: Weedy check | 48,400 | 1,19,800 | 71,400 | 2.48 |
| T2: Weed free check | 63,120 | 2,21,960 | 1,58,840 | 3.52 |
| T3: Atrazine 1000 g/ha (PE) fb Hand weeding at 25 DAS | 56,120 | 1,38,120 | 82,000 | 2.46 |
| T4: Atrazine 750 g/ha (PE) fb Topramezone 25.2 g/ha at 25 DAS | 52,070 | 2,03,880 | 1,51,810 | 3.92 |
| T5: Atrazine750g/ha(PE) fb Tembotrione 120 g/ha at 25 DAS | 49,811 | 1,53,260 | 1,03,449 | 3.08 |
| T6: Atrazin1000 g/ha(PE) fbTopramezone 25.2 g/ha at 25 DAS | 52,160 | 1,57,000 | 1,04,840 | 3.01 |
| T7: Atrazine 1000 g/ha(PE) fb Tembotrione 120 g/ha at 25 DAS | 49,971 | 1,50,260 | 1,00,289 | 3.01 |
| T8: Topramezone 25.2 g/ha + Atrazine 750 g/ha at 15 DAS | 52,070 | 1,85,680 | 1,33,610 | 3.57 |
| T9: Tembotrione 120 g/ha + Atrazine 750 g/ha at 15 DAS | 49,811 | 1,58,100 | 1,22,219 | 3.45 |

1. **CONCLUSION**

From the experimental results, it can be concluded that herbicide Atrazine 750 g ha-1 as per-emergence followed by Topramezone 25.2 g ha-1 at 25 days after sowing and Topramezone 25.2 g ha-1 + Atrazine 750 g ha-1 at 15 days after sowing were found to be most effective weed control measures on maize with higher benefit: cost ratio during the *rabi* season under the new alluvial zone of West Bengal.

1. **FUTURE SCOPE**

The experiment can carried out in different location and agro-climatic zones of West Bengal considering the effect of environment and soil along with useful correlation among them. Enzymatic activity and microbial activity in soil influenced by herbicides application can be studied. Residue of herbicides in soil, grain and straw can be studied.

1. **REFERENCES**

Bollman, J. D., Boerbcom,C. M., Becker, R. L. & Fritz V A. (2008). Efficacy and tolerance to HPPD-inhibiting herbicides in sweet corn. Weed Technology, 22: 666-674.

Dalley, C.D., Bernards, M.L. and Kells & J.J. (2006). Effect of weed removal timing and row spacing on soil moisture in corn (*Zea mays*). Weed Technology, 20(2):399-409.

Deshmukh, L.S., Jathure, R.S. & Raskar, S.K. (2008). Studies on nutrient and weed management in *kharif* maize under rainfed conditions. Indian Journal of Weed Science, 40(1and 2):87-89.

Gantoli G, Ayala VR. & Gerhards R. (2013). Determination of the critical period for weed control in corn. Weed Technology, 27: 63–71. <https://doi.org/10.56093/ijas.v93i10.136325.>

Hatti, V., Sanjay, M.T., Prasad, T.R., Kumar, B. & Kumari, G. (2014). Influence of Chemical Weed Management Practices on Growth, Yield and Economics of Irrigated Maize (Zea mays). Environment & Ecology, 33(4A):1689-1692.

Kamble, T.C., Kakade, S.U., Nemade, S.U., Pawar, R.V. & Apotikar, V.A. (2005). Integrated weed management in maize. Crop Research, 29 (3): 396-400.

Madhavi, M., Ramprakash, T., Sriniva, A. & Yakadri, M. (2014). Topramezone (33.6% SC) + Atrazine (50%) WP tank mix efficacy on maize*.* Biennial conference on “Emerging challenge in weed management” Organized by Indian Society of Weed Science,15-17, February.

Mundra, S.L., Was, A.K., Maliwal & P.L. (2002). Effect of weed and nutrient management on nutrient uptake by maize (Zea mays) and weeds. Indian Journal of Agronomy, 47(3):378-383.

Mukhtar, A. M., Eltahir, S. A.,Siraj, O. M., Hamada & A. A. (2007). “Effect of weeds on growth and yield of maize (*Zea mays* L.) in Northern State, Sudan,” Sudan Journal of Agricultural Research, 8: 1–7.

Nagalakshmi, K.V.V. (2002). Weed Management for Efficient Use of Nitrogen in *Rabi* Maize *(Zea Mays L.)* (Doctoral dissertation, ANGRAU ACB: AGRONOMY).

Paradkar, V.K. & Sharma, R.K. (1993). Integrated weed management in maize. Indian Journal of Weed Science, 25(3and4):81-83.

Reddy, C. (2018). A study on crop weed competition in field crops. Journal of Pharmacognosy and Phytochemistry, 7(4): 3235-3240.

Roy D K, Singh D, Sinha N K & Pandy D N. (2008). Weed management in winter maize + potato intercropping system. Indian Journal of Weed Science,40(1/2): 41-43.

Shukla, R., Bhatnagar, A., Singh, G., Singh, D. K., Rawat, S., Kumar & S. (2023). Effects of sequential and combined application of tank-mix herbicides on weed growth and productivity of maize (*Zea mays*)**.** Indian Journal of Agricultural Sciences, 93 (10): 1153–1155.

Singh, V., Ankush, C.M. & Punia, S.S. (2017). Study on yield and yield attributes of maize as affected by application of different herbicides. Journal of Pharmacognosy and Phytochemistry, *6*(5): 2328-2332.

Singh, V.P., Guru, S.K., Kumar, A., Banga, A. & Tripathi, N. (2012). Bioefficacy of tembotrione against mixed weed complex in maize. Indian Journal of Weed Science, 44(1): 1–5, 2012.

Sinha, S.P., Prasad, S.M., Singh, S.J. & Sinha, K.K. ( 2003). Integrated weed management in winter maize (Zea mays) in North Bihar. Indian Journal of Weed Science, 35 (3-4):273-274.

Sreenivas, G. & Satyanarayana, V. (1994). Integrated weed management in rainy-season maize (Zea mays). Indian Journal of Agronomy, 39(1):166-167.

Srividya, S., Chandrasekhar, K. & Veeraraghavaiah, R..(2011). Effect of tillage and herbicide use on weed management in maize (Zea mays. L). The Andhra Agricultural Journal ,58(2):123-126.

Swetha, K., Madhavi, M., Pratibha, G. & Ramprakash, T., 2015. Weed management with new generation herbicides in maize. Indian Journal of Weed Science,47(4): 432–433.

Triveni U, Patro SK & Bharathalakshmi M. (2017). Effect of different pre and post emergence herbicides on weed control, productivity and economics of maize. Indian Journal of Weed Science, 49(3): 231–235.