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Research Article

Bio efficacy of Atrazine Herbicide for Maize Weed Control in the Red and Laterite Zone of West Bengal

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ABSTRACT

A field experiment was conducted during two consecutive summer season of 2021-2022 at the Regional Research Station (RRSS), BCKV, Raghunathpur, Purulia, West Bengal, to evaluate the efficacy of Atrazine in suppressing weed growth, improving maize crop growth and yield, and to determine the optimum application dose for effective weed management in the Red and Laterite Zone. The study included seven treatments with Atrazine 50% Wettable Powder (WP) applied at different rates: 1.0 kg ha^{-1} (T_1), 1.5 kg ha^{-1} (T_2), 2.0 kg ha^{-1} (T_3), 1.0 kg ha^{-1} (T_4 - Market sample), 2.0 kg ha^{-1} (T_5 - Market sample), weed-free check at 20 and 40 days after sowing (DAS) (T_6), and control (T_7), along with Atrazine 50% WP (Rainbow) @4.0 kg ha^{-1} for phytotoxicity observation. The weed complex included Echinochloa colona, Echinochloa formosensis, Digitaria sanguinalis, Eleusine indica, and Brachiaria mutica. The highest grain yield (4.45 t ha^{-1}) was recorded in the two-hand weeding treatment. Among herbicide treatments, the lowest weed population was observed in plots treated with Atrazine 50% WP (Rainbow) @ 2 .0 kg ha^{-1} and market sample @2.0 kg ha^{-1}, which also observed the lowest weed dry weight. No phytotoxicity symptoms were observed at any applied dose of Atrazine 50% WP (Rainbow) during experimentation.

Keywords: *Maize, Atrazine, Weed, Atrataf, Yield.*

INTRODUCTION

Queen of cereal, maize (*Zea mays* L.) is the world's leading crop and is one of the most versatile emerging crops, having wider adaptability. Central Mexico is the origin of maize, transformed from wild grass called Teosinte. This C4 plant, maize, is the third most important food crop after rice and wheat in India. India ranks 4th in area and 7th in production among the maize growing countries.

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During 2018-2019, the maize area reached 9.2 million ha (DACNET, 2020). India used to produce 1.73 million MT (during 1950-51), which increased to 30.67 million MT during 2023-24, recording a close to 18 times increase in production (ICAR- IIMR and ANGRAU, 2024; Devesh et al., 2023). In West Bengal, generally, maize is cultivated in *the rabi* season when the weather is suitable for growing maize. Application of a large amount of fertilizer and the required amount of timely irrigation water causes weed infestation, which is high if it is not controlled in the early stage of crop growth. It may cause a 50-60% reduction in yield (Verma et al., 2009; Sharma & Rayamajhi, 2022). Depending upon the intensity and types of weed flora, the potential yield loss in maize is 18-65% (Alptekin, 2023). Maize is infested with various types of weeds like *Echinochloa colona*, *Echinochloa formesis*, *Digitaria sanguinalis*, *Brachiaria mutica*, *Elusine indica*, *Cyperus rotundus* etc. Systemic and selective herbicide atrazine is used as a pre-emergence herbicide for controlling the annual grasses and broadleaf weeds. The objective of this experiment was to evaluate the efficacy and phytotoxicity effect of new formulation of Atrazine for controlling weeds in Maize.

MATERIALS AND METRHODS

2.1. Experimental Site

The field experiment was conducted in two consecutive seasons during the summer season of 2021-2022 in the Red and Laterite Zone at the Regional Research Sub Station, Bidhan Chandra Krishi Viswavidyalaya, Raghunathpur, Purulia, West Bengal, which lies between 22.60 degrees and 23.50 degrees north latitudes and 85.75 degrees and 86.65 degrees east longitudes, 225 m high from the mean sea level. The fine loamy and coarse loamy textured, acidic soil is found here, which is rich in iron oxide, aluminium compound consisting of 0.04% nitrogen, 0.005% P_2O_5, 0.01% K_2O and a very small amount of organic matter with pH 5.5-6.6.

2.2. Experiment and Treatment Details

The experiment was laid out in randomized block design with 3 replications. 5m×4m sized plot was prepared for the maize crop. There were 7 bio-efficacy treatments like Atrazine 50% WP (Rainbow) @ 1.0 kg ha^{-1} (T_1), Atrazine 50% WP (Rainbow) @ 1.5 kg ha^{-1} (T_2), Atrazine 50% WP (Rainbow) @ 2.0 kg ha^{-1} (T_3), Atrazine 50% WP (Market sample - Atratаf) @ 1.0 kg ha^{-1} (T_4), Atrazine 50% WP (Market sample - Atratаf) @ 2.0 kg ha^{-1} (T_5), Weed free check @ 20 and 40 DAS (T_6), Control (T_7) and one phytotoxicity treatment like Atrazine 50% WP (Rainbow) @ 4 kg ha^{-1} only for phytotoxicity observation. All the testing samples of Atrazine 50% WP (Rainbow) were supplied by Rainbow Agrosciences Pvt. Ltd.

2.3. Agronomic Practices

The variety "Disha 3502" of maize crop comprising 107 days duration was sown on 04-11-2021 and harvested on 19-02-2022. Spacing was maintained 50cm and 20cm in row to row and plant to plant respectively. Herbicides were applied as pre-emergence treatments on 06-11-2021. All the recommended improved package of practices of maize was followed in this experiment including the plant protection measures. The test herbicide Atrazine 50% WP (Rainbow) at dosages of 1.0 kg ha^{-1}, 1.5 kg ha^{-1} & 2.0 kg ha^{-1} and market sample of Atrazine 50% WP (Atratаf) @1.0 kg ha^{-1} and 2.0 kg ha^{-1} were sprayed as pre-emergence treatments (i.e., 2 DAS) using a water volume of 500 litres ha^{-1} with knapsack sprayer fitted with flat fan deflector nozzle.

2.4. Method of collection of weed data

The population of different types of weeds (Grasses, Broadleaf, and sedge) was recorded at 30, 45 and 60 DAA (Days after herbicide Application). A quadrate with a dimension of 1 m × 1 m was placed randomly at three places in each plot and the weeds from that area were counted and expressed as number per square meter. Weeds belonging to three categories obtained in the population at 30, 45 & 60 DAA were labelled properly. The labelled samples were then sun dried for 24 hours and then oven

dried at 70^{0}C for 72 hours. The dry weight of weeds was then taken and recorded separately. Weed control efficiency is expressed as the percentage of control of weeds over unweeded control. It denotes the efficiency of the applied herbicide for comparison purpose. WCE of different treatments was computed on the basis of weed dry weight by using the following formula,

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where,

DWC = Dry weight of weeds in the untreated control plot

DWT = Dry weight of weeds in treated plot

RESULTS AND DISCUSSION

3.1. Weed population

There were different types of weed infestation found, out of those *Echinochloa sp.*, *Digitaria sanguinalis*, *Brachiaria mutica*, *Alternenthera phyloxeroides*, *Digera arvensis* were predominant. *Echinochloa sp.* effected the maize crop vigorously (27%) (fig.no.1). In this experiment, the data of the population of weed flora at 30 days and 60 days after application of the herbicide were recorded. It was revealed in table 1 that weed free check @ 20 and 40 DAS (T_6) having lowest weed density followed by Atrazine 50% WP (Rainbow) @ 2 kg ha^{-1} (T_3) and Atrazine 50% WP (Market sample - Atrataf) @ 2 kg ha^{-1}(T_5). This result was also found by Moinuddin et al. (2018). Weed dry matter were also recorded through the research work (table 2). The lowest weed density and weed dry matter accumulation were found in the hand weeding treatment at 20 and 40 DAS (Sahoo et al., 2024). Atrazine herbicide @2 kg ha^{-1} was effective against *Echinochloa sp. Digitaria sanguinalis* and *Brachiaria mutica* weeds have mostly the same WCE (weed control efficiency) (table no.3) (Iqbal et al., 2020).

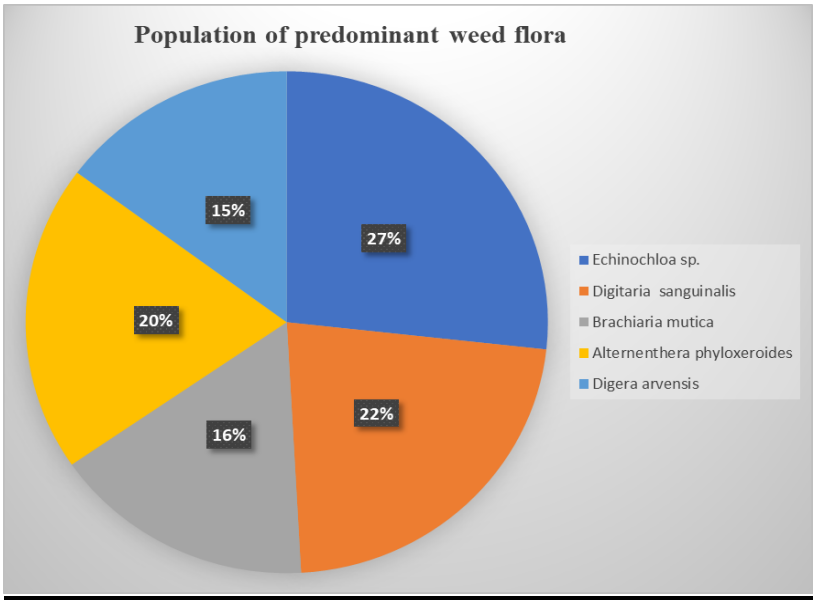

Fig. no. 1 Population of predominant weed flora

3.2. Bio-efficacy results

From the recorded results, it is clear that among the herbicide treated plots, Atrazine 50% WP (Rainbow) shows better efficacy in managing all three categories of weeds. After hand weeding treatment, the plots treated with Atrazine 50% WP (Rainbow) @ 2.0 kg ha^{-1} (T_3), as well as a market sample of Atrazine 50% WP (Market sample-Atrataf) @ 2.0 kg ha^{-1} (T_5), recorded the least population of all the weeds. The statistical analysis shows that all the above are on par among themselves and with 2 hand weeding treatment. In plots treated with different herbicides, Atrazine 50% WP

(Rainbow) @ 2.0 kg ha^{-1} (T_3) recorded the least dry weight, followed by plots treated with a market sample of Atrazine 50% WP (Market sample- Atrataf) @ 2.0 kg ha^{-1}(T_5) (Table 1-3). Atrazine is one of the effective pre-emergence herbicides for maize crop (Moinuddin et al., 2018).

3.3. Phytotoxicity results

Phytotoxicity was assessed in the treatments of Atrazine 50% WP (Rainbow) @ 2.0 and 4.0 kg ha^{-1} in maize plants. The observations on yellowing, chlorosis, wilting, scorching, hyponasty and epinasty of maize plants were recorded at 1, 3, 5, 7 and 10 DAA (days after application) of the paraquat dichloride 24% SL (Rainbow). There was no phytotoxicity symptom observed at any of the dose of Atrazine 50% WP (Rainbow) (i.e. 2.0 and 4.0 kg ha^{-1}) at all the observation days. Trial results indicate that maize is tolerant to application of Atrazine 50% WP, with no visible phytotoxic symptoms observed compared to untreated controls, even at upper dosage limits within the regulatory range. Studies using a phytotoxicity rating scale consistently rate symptoms as "absent" or "trace" at standard field rates (Oliveira, 2015).

3.4. Maize yield

Among the herbicide treated plots, Atrazine 50% WP (Rainbow) @ 2.0 kg ha^{-1}(T_3) has been recorded as having the highest grain yield (4.29 t ha^{-1}), followed by the market sample of Atrazine 50% WP (Market sample- Atrataf) @2.0 kg ha^{-1}(T_5) (4.23 t ha^{-1}). Weed-free check @ 20 and 40 DAS (T_6) obtained the highest yield 4.45 t ha^{-1} (fig. no. 2) through minimizing the crop weed competition for light, air, and water. Similar kind of result was found in Iqbal et al., 2020. Application of herbicide at different doses was effective for reducing competition between weeds and maize crop plants. This information is supported by Barua et al. (2019).

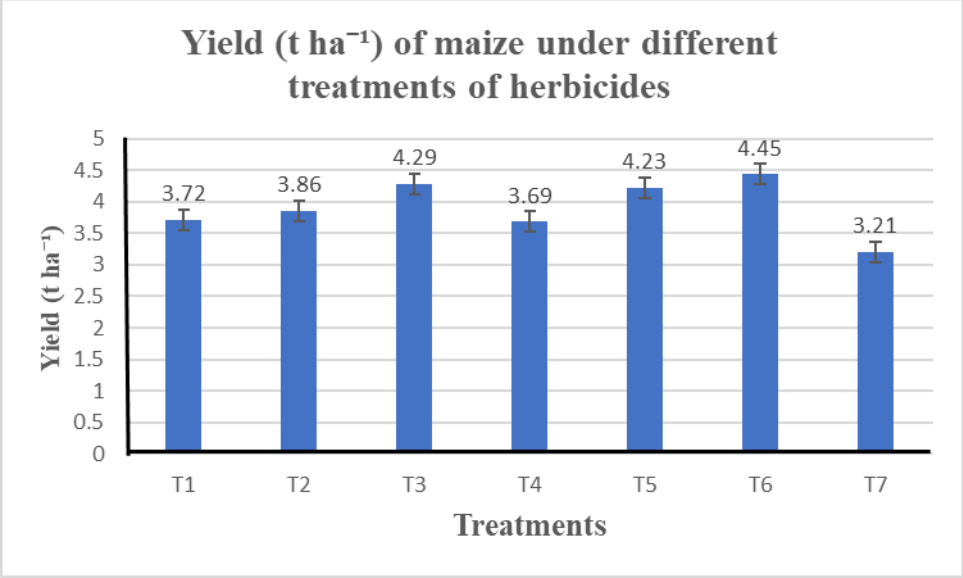

Fig. no.2 Yield (t ha^{-1}) of maize under different treatments of herbicides. T_1- Atrazine 50% WP (Rainbow) @ 1.0 kg ha^{-1}, T_2- Atrazine 50% WP (Rainbow) @ 1.5 kg ha^{-1}, T_3- Atrazine 50% WP (Rainbow) @ 2.0 kg ha^{-1}, T_4- Atrazine 50% WP (Market sample - Atrataf) @ 1.0 kg ha^{-1}, T_5- Atrazine 50% WP (Market sample - Atrataf) @ 2.0 kg ha^{-1}, T_6- Weed free check @ 20 and 40 DAS, T_7- Control.

Table No. 1: Population of weed flora (per m^2) at 30days and 60 days after application of herbicides

	Echinochloa sp.		***Digitaria sanguinalis***		***Brachiaria mutica***		***Alternanthera philoxeroides***		***Digera arvensis***		**Others weeds**	
Days / Treatments	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
T_1	5.11 (2.37)	10.22 (3.27)	4.67 (2.27)	8.56 (3.01)	3.22 (1.93)	6.22 (2.59)	4.00 (2.12)	7.56 (2.84)	2.67 (1.78)	5.67 (2.48)	6.33 (2.61)	12.78 (3.64)
T_2	3.56 (2.01)	10.00 (3.24)	3.00 (1.87)	8.22 (2.95)	2.33 (1.68)	5.78 (2.51)	2.78 (1.81)	7.22 (2.78)	2.11 (1.62)	5.44 (2.44)	5.67 (2.48)	11.89 (3.52)
T_3	2.00 (1.58)	3.67 (2.04)	1.56 (1.44)	3.00 (1.87)	1.44 (1.39)	2.11 (1.62)	1.56 (1.44)	2.56 (1.75)	1.00 (1.22)	2.00 (1.58)	3.44 (1.98)	5.67 (2.48)
T_4	5.33 (2.41)	10.56 (3.33)	4.89 (2.32)	8.56 (3.01)	3.22 (1.93)	6.78 (2.70)	4.22 (2.17)	7.89 (2.90)	2.78 (1.81)	5.78 (2.51)	6.67 (2.68)	13.11 (3.69)
T_5	2.22 (1.65)	3.89 (2.10)	1.67 (1.47)	3.22 (1.93)	1.44 (1.39)	2.22 (1.65)	1.78 (1.51)	2.78 (1.81)	1.00 (1.22)	2.22 (1.65)	3.67 (2.04)	7.00 (2.74)
T_6	1.89 (1.55)	3.44 (1.98)	1.56 (1.44)	2.89 (1.84)	1.22 (1.31)	2.11 (1.62)	1.33 (1.35)	2.56 (1.75)	1.00 (1.22)	1.89 (1.55)	3.11 (1.90)	5.33 (2.41)
T_7	21.67 (4.71)	31.89 (5.69)	17.56 (4.25)	26.33 (5.18)	13.44 (3.73)	19.44 (4.47)	16.11 (4.08)	23.67 (4.92)	11.33 (3.44)	16.78 (4.16)	27.44 (5.29)	39.44 (6.32)
S.Em (±)	**0.07**	**0.14**	**0.08**	**0.12**	**0.06**	**0.10**	**0.07**	**0.17**	**0.04**	**0.09**	**0.10**	**0.15**
CD at 5 %	**0.21**	**0.43**	**0.26**	**0.38**	**0.17**	**0.31**	**0.23**	**0.51**	**0.13**	**0.28**	**0.32**	**0.47**

*Data in the parenthesis are transformed value

**Square root transformed value of (X+0.5) was used for statistical analysis

Table No. 2: Dry mass of weed flora (g per m^2) at 30 days and 60 days after application of herbicides

	Echinochloa sp.		***Digitaria sanguinalis***		***Brachiaria mutica***		***Alternanthera philoxeroides***		***Digera arvensis***		**OTHER WEEDS**	
Days / Treatments	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
T_1	4.23 (2.17)	12.81 (3.65)	3.52 (2.00)	9.63 (3.18)	2.23 (1.65)	5.58 (2.47)	5.63 (2.48)	11.85 (3.51)	3.46 (1.99)	7.58 (2.84)	7.25 (2.78)	16.28 (4.10)
T_2	2.75 (1.80)	12.03 (3.54)	1.96 (1.57)	9.23 (3.12)	1.53 (1.42)	5.39 (2.43)	3.21 (1.93)	11.30 (3.44)	2.15 (1.63)	7.25 (2.78)	5.09 (2.36)	15.87 (4.05)
T_3	1.77 (1.51)	6.14 (2.58)	1.36 (1.36)	4.48 (2.23)	0.93 (1.20)	2.82 (1.82)	1.87 (1.54)	5.24 (2.40)	1.38 (1.37)	3.67 (2.04)	3.50 (2.00)	8.35 (2.97)
T_4	4.48 (2.23)	13.12 (3.69)	3.60 (2.02)	9.70 (3.19)	2.36 (1.69)	6.05 (2.56)	5.70 (2.49)	12.07 (3.55)	3.73 (2.06)	7.67 (2.86)	7.58 (2.84)	17.15 (4.20)
T_5	1.85 (1.53)	6.37 (2.62)	1.41 (1.38)	4.65 (2.27)	0.96 (1.21)	3.00 (1.87)	1.98 (1.57)	5.67 (2.48)	1.45 (1.40)	3.85 (2.09)	3.63 (2.03)	8.52 (3.00)
T_6	1.56 (1.44)	5.73 (2.50)	1.21 (1.31)	4.16 (2.16)	0.92 (1.19)	2.38 (1.70)	1.76 (1.50)	5.05 (2.36)	1.30 (1.34)	3.28 (1.94)	3.32 (1.95)	7.91 (2.90)
T_7	17.55 (4.25)	39.54 (6.33)	12.82 (3.65)	29.49 (5.48)	9.00 (3.08)	17.69 (4.27)	21.43 (4.68)	36.93 (6.12)	14.05 (3.81)	22.49 (4.79)	30.73 (5.59)	52.06 (7.25)
S.Em (±)	**0.09**	**0.11**	**0.06**	**0.10**	**0.06**	**0.09**	**0.10**	**0.13**	**0.07**	**0.12**	**0.08**	**0.21**
CD at 5 %	**0.27**	**0.34**	**0.18**	**0.30**	**0.17**	**0.27**	**0.32**	**0.41**	**0.21**	**0.38**	**0.24**	**0.64**

*Data in the parenthesis are transformed value

**Square root transformed value of (X+0.5) was used for statistical analysis

Table No. 3: Weed control efficiency (%) of weed flora at 30 days and 60 days after application of herbicides

	Echinochloa sp.		***Digitaria sanguinalis***		***Brachiaria mutica***		***Alternanthera philoxeroides***		***Digera arvensis***		**OTHER WEEDS**	
Day / Treatments	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
T_1	75.90	67.60	72.54	67.34	75.22	68.46	73.73	67.91	75.37	66.30	76.41	68.73
T_2	84.33	69.58	84.71	68.70	83.00	69.53	85.02	69.40	84.70	67.76	83.44	69.52
T_3	89.91	84.47	89.39	84.81	89.67	84.06	91.27	85.81	90.18	83.68	88.61	83.96
T_4	74.47	66.82	71.92	67.11	73.78	65.80	73.40	67.32	73.45	65.90	75.33	67.06
T_5	89.46	83.89	89.00	84.23	89.33	83.04	90.76	84.65	89.68	82.88	88.19	83.63
T_6	91.11	85.51	90.56	85.89	89.78	86.55	91.79	86.33	90.75	85.42	89.20	84.81
T_7	-	-	-	-	-	-	-	-	-	-	-	-

CONCLUSION

Based on the study on the evaluation of the bio-efficacy and the phytotoxicity of the Atrazine 50% WP (Rainbow) applied on maize, it has been observed that Atrazine 50% WP (Rainbow) @ 2.0 kg ha^{-1} is the optimum dose for controlling the weeds, showing results which are on par with market sample of Atrazine 50% WP @ 2.0 kg ha^{-1}. Atrazine 50% WP (Rainbow) proved better control of the recorded weeds, which consequently resulted in a higher yield of maize without any phytotoxicity at any rate of the doses. It can be concluded that Atrazine 50% WP (Rainbow) @ 2.0 kg ha^{-1} can be recommended for effective control of weeds of maize as pre-emergence herbicide application.

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Conflict of interest:

The authors declare that they have no conflicts of interest related to this study.

Author Contribution:

Chaitan Soren conceived the idea of the review, surveyed the literature, and conducted the research; Anusri Mandi, Manoj Mandal and Gagan Mudi drafted the manuscript equally; Soumen Bera scrutinised and corrected the manuscript to its final version. All the authors read and approved the final version of the manuscript prior to its submission.

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