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RESEARCH NOTE

Chemical weed control strategies in grain sorghum

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ABSTRACT

A field investigation was carried out during rainy *(Kharif)* 2022 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, India (*Sorghum bicolor* (L.) Moench). The study involved twelve treatments, including pre-emergence application of atrazine and bentazone, both either alone or in combination and atrazine in combination with varying doses of 2,4-D dimethylamine salt, mesotrione and topramezone as well as mechanical and hand weeding practices. and it was found that application of atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS registered the lowest density and dry matter of monocot, dicot and total weeds at 30 DAS (0.00) along with highest grain yield (3.88 t/ha), net return (₹ 82966/ha) and B C ratio (2.57). this treatment further registered a gain of 70.6 and 92.7% gain in grain yield and net return over weedy check.

Keywords: 2,4-D, Atrazine, Bentazone, Mesotrione, Sorghum, Topramezone, Weed management

Sorghum (*Sorghum bicolor* (L.) Moench), known as 'jowar' in Hindi speaking belt of India, holds a vital position in global cereal production, especially in regions with semi-arid climates. Weeds pose a significant challenge to sorghum cultivation, reducing yields substantially by 15-97% (Thakur *et al*. 2016), prompting the need for effective management strategies. Chemical weed control, notably with atrazine, which is cost-effective and efficient, faces resistance challenges (Vinayaka *et al*. 2020). The advent of p-hydroxy-phenyl-pyruvate dioxygenase (HPPD) inhibitive herbicides, such as topramezone and tembotrione, marks a pivotal shift, offering comprehensive weed control while addressing resistance problems. Additionally, integrating mechanical techniques with pre and post-emergence herbicides proves to be an effective strategy, synergistically curbing weed growth and promoting optimal crop development (Verma *et al*. 2017). This study aims to identify sustainable weed management practices in sorghum for semi-arid regions of the country.

A field investigation was carried out during rainy *(Kharif)* 2022 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur (24° 35' N, 73° 42' E, 579.5 m above mean sea level). The soil of the experimental site was non-saline (electrical conductivity: 0.76 dS/m), alkaline (8.1 pH), sandy clay loam soil with medium organic carbon (0.61%), available N and K (286.4 and 354.4 kg/ha) and high available P (21.2 kg/ha). Sorghum variety '*SPV 2510*' was sown on 2nd July 2022 at a crop geometry of 45 x 15 cm and was later thinned to one plant per stand at 15 DAS. Fertilizers, *viz*. 80 kg N, 40 kg P and 40 kg K/ha were applied as recommended for grain sorghum in the area. Application of herbicides was done as per treatment with knapsack sprayer using 500 litres of water per hectare. A rainfall of 699.1 mm was received during the crop season (*Kharif* 2022) and the crop did not face any moisture stress. The experiment comprising 12 weed management treatments *i.e.*, atrazine 750 ha PE *fb* 2,4-D ethyl ester 500 g/ha PoE, atrazine 750 g/ha PE *fb* 2,4-D dimethylamine salt 750 g/ha PoE, atrazine + mesotrione (RM) 438 g/ha PoE, atrazine + mesotrione (RM) 656 g/ha PoE, atrazine 500 g/ha + topramezone 18.9 g/ha EPoE (tank mix), atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix), atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS, bentazone 960 g/ha PoE, atrazine 500 g/ha PE, atrazine 500 g/ha PE *fb* bentazone 960 g/ha PoE, two hand weeding at 20 DAS and 40 DAS and weedy check was laid out in a randomized complete block design (RCBD) with 3 replications. Data on species-wise weed density (no./m^2) was recorded at 30 DAS at 3 quadrates of 0.5 × 0.5 m/plot. These weeds were categorized as monocots and dicots and their dry weight was recorded. Data on weed density and

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weed dry matter was subjected to $\sqrt{x+0.5}$ transformation before analysis. However, for better understanding, original values are given in parenthesis. Weed control efficiency (WCE %) was calculated as per the standard formulae considering weed dry matter. At harvest, the plant population in each net plot was counted and and converted to 000/ ha. Data on yield attributes were recorded from 5 randomly selected plants, while yield was on net plot basis at harvesting. Based on the phytotoxicity-rating scale (PRS) for the sprayed herbicides, observations of phytotoxicity were done on sorghum plants at 7, 14, and 21 days after treatment (DAT) at 0-10 scale. All the parameters were subjected to statistical analysis at 5% level of significance and interpretation as per Gomez and Gomez (1984).

The weed flora in the sorghum field at the experimental location was *Echinochloa colona* (L.) Link (25.75%)., *Commelina benghalensis* (L.) Beauv. (22.29%), *Setaria glauca* (L.) (15.17%) and *Eleusine indica* (L.) (13.79%) among monocot weed species whereas, *Physalis minima* L. (11.04%) and *Digera arvensis* L. (11.95%) were major dicot weeds. Verma *et al.* (2022) also reported the domination of these monocot and dicot weeds in sorghum.

When compared to weedy check, weed management techniques dramatically decreased the number of weeds and their dry weight (**Table 1**). The lowest values of weed density and weed dry weight were recorded with the application of atrazine 500 g/ ha PE *fb* mechanical weeding at 30 DAS and atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix). This might be due prolonged effectiveness of HPPD inhibiting herbicide which reduced weed growth by targeting photosystem II of both grassy and broadleaved weeds. Further, atrazine supplemented with mechanical weeding reduced the weed density and dry matter. The present study's outcomes are consistent with the research conducted by Verma *et al.* (2022) in sorghum. Moreover, atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS and atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix) produced the maximum weed control efficacy (**Table 2**). The variation in weed control efficiency is directly

Table 1. Effect of weed management on weed density at 30 DAS

Treatment	Weed density (no./m^2)						Weed dry matter (g/m^2)					
	Echinochloa colona	*Eleusine indica*	*Setaria glauca*	*Commelina benghalensis*	*Physalis minima*	*Digera arvensis*	*Echinochloa colona*	*Eleusine indica*	*Setaria glauca*	*Commelina benghalensis*	*Physalis minima*	*Digera arvensis*
Atrazine 750 g/ha PE *fb* 2,4-D ethyl ester 500 g/ha PoE	2.50 (6.00)	2.29 (5.00)	2.34 (5.00)	2.39 (5.33)	1.93 (3.33)	2.21 (4.50)	2.37 (5.10)	2.17 (4.25)	2.18 (4.25)	2.24 (4.53)	1.82 (2.83)	2.08 (3.83)
Atrazine 750 g/ha PE *fb* 2,4-D dimethylamine salt 750 g/ha PoE	2.58 (6.33)	2.36 (5.33)	2.43 (5.67)	2.45 (5.67)	2.12 (4.00)	2.32 (5.00)	2.42 (5.38)	2.24 (4.53)	2.30 (4.82)	2.30 (4.82)	1.97 (3.40)	2.18 (4.25)
Atrazine + mesotrione (RM) 438 g/ha PoE	2.18 (4.33)	2.10 (4.00)	2.03 (3.75)	1.90 (3.22)	1.68 (2.33)	1.91 (3.17)	2.03 (3.68)	1.97 (3.40)	1.92 (3.19)	1.80 (2.74)	1.57 (1.98)	1.79 (2.69)
Atrazine + mesotrione (RM) 656 g/ha PoE	1.94 (3.33)	1.86 (3.11)	1.84 (2.95)	1.74 (2.56)	1.43 (1.56)	1.77 (2.67)	1.82 (2.83)	1.77 (2.64)	1.73 (2.51)	1.63 (2.17)	1.34 (1.32)	1.66 (2.27)
Atrazine 500 g/ha + topramezone 18.9 g/ha EPoE (tank mix)	2.00 (3.67)	2.04 (3.67)	1.87 (3.11)	1.82 (2.83)	1.44 (1.83)	1.82 (2.89)	1.87 (3.12)	1.90 (3.12)	1.77 (2.64)	1.70 (2.41)	1.42 (1.56)	1.72 (2.46)
Atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Bentazone 960 g/ha PoE	2.41 (5.33)	2.31 (4.83)	2.23 (4.50)	2.31 (4.83)	1.91 (3.17)	2.14 (4.11)	2.24 (4.53)	2.15 (4.11)	2.08 (3.83)	2.14 (4.11)	1.78 (2.69)	1.99 (3.49)
Atrazine 500 g/ha PE	2.73 (7.00)	2.54 (6.00)	2.55 (6.00)	2.58 (6.17)	2.41 (5.33)	2.41 (5.33)	2.54 (5.95)	2.36 (5.10)	2.37 (5.10)	2.40 (5.24)	2.24 (4.53)	2.24 (4.53)
Atrazine 500 g/ha PE *fb* bentazone 960 g/ha PoE	2.27 (4.67)	2.21 (4.38)	2.16 (4.17)	2.15 (4.22)	1.80 (2.75)	2.09 (3.89)	2.11 (3.97)	2.05 (3.73)	2.01 (3.54)	2.00 (3.59)	1.68 (2.34)	1.95 (3.30)
Two hand weeding at 20 DAS and 40 DAS	1.83 (2.89)	1.68 (2.33)	1.78 (2.67)	1.48 (1.78)	1.09 (0.78)	1.58 (2.00)	1.71 (2.46)	1.57 (1.98)	1.66 (2.27)	1.40 (1.51)	1.05 (0.66)	1.48 (1.70)
Weedy check	6.15 (37.3)	4.53 (20.0)	4.74 (22.0)	5.73 (32.3)	4.06 (16.0)	4.22 (17.3)	5.68 (31.7)	4.18 (17.0)	4.38 (18.70)	5.29 (27.48)	3.75 (13.60)	3.90 (14.73)
LSD (p=0.05)	0.54	0.56	0.50	0.51	0.45	0.41	0.32	0.24	0.17	0.28	0.24	0.21

Data subjected to $\sqrt{x+0.5}$ transformation and figures in parentheses are original weed count and weed dry matter.

associated with the amount of weed biomass accumulated under various treatments. Further, the integration of herbicide with weeding resulted in higher weed control efficiency which was also reported by Vinayaka *et al.* (2020) in sorghum.

Yield and economics of sorghum

The highest grain yield was recorded with atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS (**Table 2**). However, it was at par with two hand weeding at 20 and 40 DAS and atrazine 750 g/ha PE *fb* 2,4-D Ethyl ester 500 g/ha PoE. The highest stover and biological yield were observed in atrazine 500 g/ha PE *fb* mechanical weeding 30 DAS which was at par with stover and biological yield of two hand weeding at 20 and 40 DAS. This increased yield can be attributed to improved weed management, which eliminated competition for resources and provided favourable conditions such as increased availability of nutrients, moisture and light for the crop plants. In contrast, the application of atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix), atrazine 500 g/ha + topramezone 18.9 g/ha EPoE (tank mix) and atrazine + mesotrione (RM) 656 g/ha resulted in lower crop growth despite achieving higher weed control efficiency. This can be attributed to phytotoxicity, which adversely affected the growth and yield of sorghum. These outcomes are highly consistent with the findings of Vinayaka *et al.* (2020) in sorghum. The maximum net returns (**Table 2**) were realized by applying atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS which was succeeded by atrazine 750 g/ha PE *fb* 2,4-D Ethyl ester 500 g/ha PoE. The highest B C ratio was achieved by weed control through atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS which was superior to the remaining treatments. The comparatively lower cost of treatment application coupled with a good economic yield might be the reason for higher net monetary return and B C ratio. The outcomes of the current study are cognizant of the findings of Mahto *et al.* (2020).

Phytotoxicity scoring

The data about phytotoxicity scoring at different intervals is depicted in **Table 3**. The data highlights that slight injury was observed in atrazine + mesotrione (RM) 438 g/ha PoE, atrazine + mesotrione (RM) 656 g/ha PoE, atrazine 500 g/ha + topramezone 18.9 g/ha EPoE (tank mix), bentazone 960 g/ha PoE and atrazine 500 g g/ha PE *fb* Bentazone 960 g/ha PoE. The highest phytotoxicity was recorded in atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix) which causes moderate toxicity on crop plants. Identical results were also published by Verma *et al.* (2018).

Table 2. Effect of weed management on weed control efficiency, plant population grain, stover and biological yield and harvest index

Treatment	Weed control efficiency (%) Total weeds	Plant population at harvest (000/ha)	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)	Net returns (₹/ha)	B-C ratio
Atrazine 750 g/ha PE *fb* 2,4-D ethyl ester 500 g/ha PoE	79.88	183	3.39	10.18	1.38	24.99	70185	2.28
Atrazine 750 g/ha PE *fb* 2,4-D dimethylamine salt 750 g/ha PoE	77.93	180	3.32	9.95	1.36	24.90	67644	2.18
Atrazine + mesotrione (RM) 438 g/ha PoE	85.64	150	1.89	5.76	7.65	24.64	25040	0.80
Atrazine + mesotrione (RM) 656 g/ha PoE	88.84	141	1.69	5.07	6.77	25.06	17697	0.54
Atrazine 500 g/ha + topramezone 18.9 g/ha EPoE (tank mix)	87.59	145	1.82	5.47	7.30	24.87	21316	0.65
Atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix)	100.00	125	1.46	4.38	5.84	25.00	9262	0.27
Atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS	100.00	195	3.88	11.63	15.50	24.93	82966	2.57
Bentazone 960 g/ha PoE	81.52	156	1.99	5.99	7.99	24.94	28996	0.95
Atrazine 500 g/ha PE	75.28	174	3.17	9.52	12.69	24.96	65041	2.22
Atrazine 500 g/ha PE *fb* bentazone 960 g/ha PoE	83.38	161	2.19	6.57	8.75	24.93	33569	1.06
Two hand weeding at 20 DAS and 40 DAS	91.41	188	3.65	11.02	14.67	24.92	66516	1.57
Weedy check	0.00	101	1.14	3.53	4.67	24.46	6040	0.21
LSD (p=0.05)	-	0.20	0.53	0.93	1.30	**NS**	12.58	0.38

Table 3. Effect of weed management on visual phytotoxicity scoring of herbicides at different stages

Treatment	Herbicidal phytotoxicity (0-10)		
	7 DAHA	14 DAHA	21 DAHA
Atrazine 750 g/ha PE *fb* 2,4-D ethyl ester 500 g/ha PoE	0	0	0
Atrazine 750 g/ha PE *fb* 2,4-D dimethylamine salt 750 g/ha PoE	0	0	0
Atrazine + mesotrione (RM) 438 g/ha PoE	2	1	0
Atrazine + mesotrione (RM) 656 g/ha PoE	3	2	0
Atrazine 500 g/ha + topramezone 18.9 g/ha EPoE (tank mix)	3	2	0
Atrazine 500 g/ha + topramezone 25.2 g/ha EPoE (tank mix)	4	2	0
Atrazine 500 g/ha PE *fb* mechanical weeding at 30 DAS	0	0	0
Bentazone 960 g/ha PoE	2	1	0
Atrazine 500 g/ha PE	0	0	0
Atrazine 500 g/ha PE *fb* bentazone 960 g/ha PoE	2	1	0
Two hand weeding at 20 DAS and 40 DAS	0	0	0
Weedy check	0	0	0

Conclusion

The study found that applying atrazine at a rate of 500 g/ha followed by mechanical weeding at 30 days after sowing (DAS) emerged as the most effective herbicide weed management strategy for rainy season grain sorghum in Rajasthan. However, the investigation also revealed that while newer post-emergence herbicides like topramezone and tembotrione exhibited high efficacy in weed control, their application at tested doses resulted in significant phytotoxicity, rendering them currently impractical. Further research avenues should explore the possibility of testing these herbicides at lower doses for effective weed management.

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