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Effect of pre-emergence plant extracts for weed control on yield and economics of maize (*Zea mays* L.)

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Abstract

Weeds are a major constraint in maize cultivation, significantly reducing maize yield. by 28-95%. Although chemical weed control is predominant there is need to explore ecofriendly alternatives to synthetic herbicides. Some pot culture experiments conducted earlier highlighted potential weed control abilities in plant extracts which needed to be evaluated in field conditions. Thus, A field experiment entitled "Effect of Pre-Emergence Plant Extracts for Weed Control on Yield and Economics of Maize (*Zea mays* L.)" was conducted during the *kharif* season 2024 at the Instructional Farm of Dr. Sharadchandra Pawar College of Agriculture, Baramati (Maharashtra). The field experiment was laid out in randomized block design with three replications There were eleven treatments viz., *Cassia tora*, *Datura metel*, *Azadirachta indica*, and *Mangifera indica* aqueous leaf extracts at 25 and 50 percent as pre-emergence followed by one hand weeding at 30 DAS, Atrazine at 1.0 kg a.i. ha⁻¹ as pre-emergence followed by one hand weeding at 30 DAS, weed-free check (Hand weeding at 15, 30, 45 and 60 DAS) and weedy check. The results showed that the yield contributing characters like number of cobs plant⁻¹, length of cob (cm), cob girth (cm), seed index (g), weight of cob (g) were recorded higher with treatment weed free which were at par with Atrazine at 1.0 kg a.i. ha⁻¹ as pre-emergence followed by one hand weeding at 30 DAS. Among the plant extract treatments, *Datura metel* aqueous leaf extracts at 50 percent followed by one hand weeding at 30 DAS showed next best results in enhancing yield attributes, yield and suppressing weed growth. Economic analysis also showed higher net returns (142860 ₹ ha⁻¹, 129541 ₹ ha⁻¹) and benefit-cost ratios (2.98, 2.84) with use of Atrazine at @1.0 kg ai ha⁻¹ and *Datura metel* aqueous leaf extract at 50% as pre-emergence *fb* one hand weeding on 30 DAS respectively. The study concludes that atrazine followed by hand weeding on 30 DAS is the most effective strategy for maximizing maize yield and economic returns, while *Datura metel* aqueous leaf extract at 50% as pre-emergence *fb* one hand weeding on 30 DAS presents a viable and sustainable alternative for integrated weed management.

Keywords: Maize, weed management, plant extracts, *Datura metel*, atrazine, yield and economics

1. Introduction

Maize (*Zea mays* L.) is one of the most significant cereals cultivated in India, ranking third after wheat and rice. It is grown for both grain and fodder. Due to its high yield potential, maize is often referred to as the "Queen of Cereals" or the "Miracle Crop." Maize has many uses because of its global distribution and relatively lower price. It is consumed directly by humans, processed into industrial food products such as corn flakes, snacks, and steamed items, and used as livestock feed. Additionally, it is used in the production of non-food industrial products like starch, acids, alcohols, pharmaceuticals, cosmetics, films, textiles, and gums. Recently, there has been increased interest in using maize for ethanol production as an eco-friendly alternative to petroleum-based fuels. (Teli, 2024) [16].

Maize is grown during the *kharif* season, and due to continuous rainfall, the fields often become heavily infested with a variety of weeds, including grasses, broadleaf weeds, and sedges. The critical period of weed competition in maize typically occurs between 30 to 45 days from sowing (Kamble *et al.*, 2005) [5]. Yield losses in maize due to weeds can range from 28 percent to 93 percent, depending on the type and intensity of the weed infestation and the duration of competition between the crop and weeds (Sharma and Thakur, 1998) [12]. As concerns about the negative effects of excessive agrochemical use on human health and the environment continue to

rise, there is increasing global research focused on finding alternative weed management strategies. This research reflects a growing effort to develop more sustainable and environmental friendly solutions for addressing weed problems in agriculture. (Teli, 2024) [16].

Herbicide use can be significantly decreased by applying allelopathic water extracts. This method not only utilizes the natural allelopathic properties of certain plants but also promotes a more sustainable and eco-friendly approach to weed management. It presents a promising strategy for achieving effective weed control while minimizing the reliance on chemicals in agriculture. Allelopathic crops are readily available in most farms, and farmers can easily prepare these extracts, reducing production costs that would otherwise be spent on herbicides. This approach is particularly beneficial for small-scale farms and organic agriculture, as it aligns with the principles of organic farming, which emphasizes natural and sustainable cultivation practices. (Kabirinejad *et al.*, 2014) [4].

Previous research has identified several plant species with allelopathic potential that can serve as eco-friendly alternatives for sustainable weed management. Leaf extracts of *Cassia angustifolia* and *Azadirachta indica* were reported to enhance germination and shoot growth in wheat (Alam, 1990) [1], aqueous extracts of *Datura stramonium* showed stimulatory effects on maize germination without adversely affecting plant height (Pacanoski *et al.*, 2014) [8]. Ramachandran (2015) [9] found increased black gram yield with pre- and early post-emergence applications of *Datura metel*, *Mangifera indica*, and *Azadirachta indica*. *Datura* leaf extracts showed comparable effects to herbicides in reducing weed biomass and enhancing barley growth (Al-Khaldy *et al.*, 2022) [2]. Recent findings by Sushmita (2023) [14] confirmed that phytoextracts, particularly from *Parthenium*, *Mangifera* and *Eucalyptus* when integrated with herbicides, significantly enhanced wheat yield and protein content.

2. Materials and Methods

A field experiment entitled “Effect of various pre-emergence plant extracts on the growth of *Parthenium hysterophorus* and other weeds in Maize (*Zea mays* L.)” was carried out during July 2024 to October 2024 Kharif season at Instructional Farm of Dr. Sharadchandra Pawar College of Agriculture, Baramat. The spacing of 75 cm × 20 cm was adopted by using 15 kg seed ha⁻¹. A recommended fertilizer dose of 120:60:40 kg N:P₂O₅:K₂O ha⁻¹ was applied to all the treatments using urea, single super phosphate (SSP), and muriate of potash (MOP). The field experiment was laid out in Randomized Block Design (RBD) with three replications. There were eleven treatments viz. T₁: *Cassia tora* aqueous leaf extract at 25% as pre-emergence fb one hand weeding on 30 DAS, T₂: *Datura metel* aqueous leaf extract at 25% as pre-emergence fb one hand weeding on 30 DAS, T₃: *Azadirachta indica* aqueous leaf extract at 25% as pre-emergence fb one hand weeding on 30 DAS, T₄: *Mangifera indica* aqueous leaf extract at 25% as pre-emergence fb one hand weeding on 30 DAS, T₅: *Cassia tora* aqueous leaf extract at 50% as pre-emergence fb one hand weeding on 30 DAS, T₆: *Datura metel* aqueous leaf extract at 50% as pre-emergence fb one hand weeding on 30 DAS, T₇: *Azadirachta indica* aqueous leaf extract at 50% as pre-emergence fb one hand weeding on 30 DAS, T₈: *Mangifera indica* aqueous leaf extract at 50% as pre-emergence spray fb one hand weeding on 30 DAS, T₉: Atrazine at 1.0 kg a.i. ha⁻¹ as pre-emergence fb one hand weeding on 30 DAS. T₁₀: Weed free check (Hand weeding at 15, 30, 45 and 60 DAS), T₁₁: Weedy check.

3. Results and Discussion

3.1 Effect on yield attributes

The data presented in Table 1 revealed that the number of cobs plant⁻¹, length of cob, Cob girth and Weight of cob (Without husk) (g) was significantly influenced by different weed management treatments.

Table 1: Number of cobs plant⁻¹, length of cob, Cob girth and Weight of cob (g) of maize as influenced by weed management treatment.

Tr. No.	Treatment	Number of cobs plant ⁻¹	length of cob (cm)	Cob girth (cm)	Weight of cob (g)
T ₁	<i>Cassia tora</i> ALE at 25% as PE fb 1 HW on 30 DAS	1.13	13.64	12.33	124.85
T ₂	<i>Datura metel</i> ALE at 25% as PE fb 1 HW on 30 DAS	1.40	14.24	13.20	132.35
T ₃	<i>Azadirachta indica</i> ALE at 25% as PE fb 1 HW on 30 DAS	1.27	13.85	12.69	129.43
T ₄	<i>Mangifera indica</i> ALE at 25% as PE fb 1 HW on 30 DAS	1.33	14.00	12.70	130.60
T ₅	<i>Cassia tora</i> ALE at 50% as PE fb 1 HW on 30 DAS	1.47	15.41	14.42	145.05
T ₆	<i>Datura metel</i> ALE at 50% as PE fb 1 HW on 30 DAS	1.67	16.87	14.74	155.04
T ₇	<i>Azadirachta indica</i> ALE at 50% as PE fb 1 HW on 30 DAS	1.53	15.70	14.51	147.87
T ₈	<i>Mangifera indica</i> ALE at 50% as PE fb 1 HW on 30 DAS	1.60	15.80	14.64	151.40
T ₉	Atrazine at 1.0 kg a.i. ha ⁻¹ as PE fb 1 HW on 30 DAS	1.73	18.22	16.02	167.74
T ₁₀	Weed free check (HW at 15, 30, 45, 60 DAS)	1.80	19.40	17.14	178.33
T ₁₁	Weedy check	1.07	10.20	10.85	113.04
	S.Em±	0.06	0.45	0.41	4.24
	C.D. at 5%	0.17	1.32	1.21	12.50
	General mean	1.45	15.21	13.93	143.25

ALE: Aqueous leaf extract, PE: Pre-emergence, HW: Hand weeding, fb: followed by, DAS: Days after sowing.

The weed-free check (T₁₀) produced the highest number of cobs per plant (1.80), cob length (19.40 cm), maximum cob girth (17.14 cm), and highest cob weight (178.33 g), which was statistically at par with Atrazine at 1.0 kg a.i. ha⁻¹ as PE fb 1 HW on 30 DAS (T₉), which recorded number of cobs plant⁻¹ (1.73), cob length (18.22 cm), cob girth (16.02 cm), and cob weight (167.74 g). The increase in cob length, girth, and cob weight under weed-free and effective pre-emergence treatments is due to reduced competition, allowing better uptake of nutrients, moisture and light. This supports improved photosynthesis and assimilate translocation to reproductive parts, enhancing cob

development. Among the plant extract treatments, *Datura metel* ALE at 50% as PE fb 1 HW on 30 DAS 50% was the most effective, with 1.67 cobs plant⁻¹, 16.87 cm cob length, 14.74 cm girth, and 155.04 g cob weight and was next best treatment to atrazine. The weedy check (T₁₁) recorded the lowest values for all yield parameters, with 1.07 cobs plant⁻¹, 10.20 cm cob length, 10.85 cm cob girth and 113.04 g cob weight, reflecting the adverse effect of weed competition on reproductive development and cob yield. The results are in conformity with those reported by Sharma (2015) [11], Gopinath and Kundu (2008) [3].

3.2 Effect on yield

The data presented in Table 2 graphically depicted in fig. 1 reveal significant differences among the weed management treatments in terms of grain yield, straw yield and harvest index of maize. Among the treatments, the weed-free check (T₁₀: HW at 15, 30, 45 and 60 DAS) recorded the highest grain yield (90.20 q ha⁻¹), straw yield (102.37 q ha⁻¹), highest biological yield (192.57 q ha⁻¹) and harvest index (46.84%) followed closely by application of Atrazine at 1.0 kg a.i. ha⁻¹ as PE fb 1 HW on 30 DAS (T₉) recorded considerably higher grain yield (88 q ha⁻¹), straw yield (100.17 q ha⁻¹), biological yield (188.17 q ha⁻¹) and harvest index (46.76%). Among plant extract treatments *Datura metel* ALE at 50% as PE fb 1 HW (T₆) which recorded higher grain yield (81.40 q ha⁻¹), straw yield (96.79 q ha⁻¹), biological yield (178.19 q ha⁻¹) and harvest index (45.68%). Similar findings were reported by Ramachandran

(2015)^[9], who observed increased grain and stalk yield in black gram with pre- and early post-emergence application of *Datura metel*, *Mangifera indica* and *Azadirachta indica* extracts at 50% and 25% concentrations. These results indicate that higher concentrations of allelopathic extracts were effective in weed suppression, possibly due to increased presence of phytotoxic compounds such as alkaloids, phenols and flavonoids. This reduction in weed competition led to improved maize plant growth and straw production. The weedy check (T₁₁) recorded significantly lowest grain yield (54.43 q ha⁻¹), straw yield (71.73 q ha⁻¹) and harvest index (43.06%). This may be due to intense weed competition throughout the crop growth period, which limited nutrient uptake and vegetative development. Similar results were reported by Shete (2018)^[13] and Maiti and Kundu (2025)^[7].

Table 2: Grain yield, straw yield, biological yield and harvest index of maize as influenced by weed management treatment

Tr. No.	Treatment	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
T ₁	<i>Cassia tora</i> ALE at 25% as PE fb 1 HW on 30 DAS	70.04	85.95	155.99	44.90
T ₂	<i>Datura metel</i> ALE at 25% as PE fb on 1 HW 30 DAS	75.55	91.11	166.66	45.26
T ₃	<i>Azadirachta indica</i> ALE at 25% as PE fb 1 HW on 30 DAS	72.24	87.56	159.80	45.09
T ₄	<i>Mangifera indica</i> ALE at 25% PE fb 1 HW on 30 DAS	73.48	89.36	162.84	45.11
T ₅	<i>Cassia tora</i> ALE at 50% as PE fb 1 HW on 30 DAS	77.27	93.20	170.47	45.33
T ₆	<i>Datura metel</i> ALE at 50% as PE fb 1 HW on 30 DAS	81.40	96.79	178.19	45.68
T ₇	<i>Azadirachta indica</i> ALE at 50% as PE fb 1 HW on 30 DAS	78.43	94.36	172.79	45.39
T ₈	<i>Mangifera indica</i> ALE at 50% as PE fb 1 HW on 30 DAS	79.80	95.51	175.31	45.50
T ₉	Atrazine at 1.0 kg a.i. ha ⁻¹ as PE fb 1 HW on 30 DAS	88.00	100.17	188.17	46.76
T ₁₀	Weed free check (HW at 15, 30, 45, 60 DAS)	90.20	102.37	192.57	46.84
T ₁₁	Weedy check	54.43	71.73	126.16	43.06
	S.Em±	2.23	2.68	4.92	-
	C.D. at 5%	6.57	7.91	14.52	-
	General mean	76.44	91.65	168.09	45.36

3.3 Effect on Economics

The economic studies in terms of gross monetary returns, cost of cultivation, net monetary returns and B:C ratio of *kharif* maize are presented in Table 3 and graphically depicted in fig. 2 and 3.3.

The highest gross returns (₹ 2,20,130 ha⁻¹) were obtained under the weed-free check (T₁₀), followed closely by Atrazine 1.0 kg a.i. ha⁻¹ as pre-emergence followed by one hand weeding at 30 DAS (T₉) (214852 ₹ ha⁻¹) and it was followed by *Datura metel* ALE at 50% as PE fb 1 HW on 30 DAS (T₆) recorded (199986 ₹ ha⁻¹). However, the cost of cultivation was maximum in the weed-free check (94274 ₹ ha⁻¹) due to intensive labour, while a comparatively moderate cost (71993 ₹ ha⁻¹) was recorded in the Atrazine-based treatment. As a result, the Atrazine at 1.0 kg a.i.

ha⁻¹ as PE fb 1 HW on 30 DAS (T₉) obtained significantly higher net monetary return (142860 ₹ ha⁻¹) and B:C ratio (2.98). Comparable results have been reported by Sanodiya *et al.*, (2013)^[10]. Kolage (1999)^[6], Among the plant extract treatments (Parul Singh *et al.*, 2024)^[15], *Datura metel* ALE at 50% as PE fb 1 HW on 30 DAS (T₆) recorded the highest net monetary return (128905 ₹ ha⁻¹) and B:C ratio (2.81). These results indicate that effective weed control directly enhances crop productivity, leading to higher income per hectare. Weedy check (T₁₁) recorded the lowest gross monetary returns (135816 ₹ ha⁻¹), net monetary return (78406 ₹ ha⁻¹) and B:C ratio (2.37) due to poor crop yield resulting from heavy weed infestation and competition.

Table 3: Economics of *kharif* maize as influenced by weed management treatment

Tr. No.	Treatment	Gross monetary Returns (₹ ha ⁻¹)	Cost of cultivation (₹ ha ⁻¹)	Net monetary returns (₹ ha ⁻¹)	B:C ratio
T ₁	<i>Cassia tora</i> ALE at 25% as PE fb 1 HW on 30 DAS	172870	69559	103311	2.49
T ₂	<i>Datura metel</i> ALE at 25% as PE fb on 1 HW 30 DAS	185988	70143	115845	2.65
T ₃	<i>Azadirachta indica</i> ALE at 25% as PE fb 1 HW on 30 DAS	177971	69792	108179	2.55
T ₄	<i>Mangifera indica</i> ALE at 25% PE fb 1 HW on 30 DAS	181116	69924	111192	2.59
T ₅	<i>Cassia tora</i> ALE at 50% as PE fb 1 HW on 30 DAS	190227	70643	119583	2.69
T ₆	<i>Datura metel</i> ALE at 50% as PE fb 1 HW on 30 DAS	199986	71082	128905	2.81
T ₇	<i>Azadirachta indica</i> ALE at 50% as PE fb 1 HW on 30 DAS	193011	70766	122245	2.73
T ₈	<i>Mangifera indica</i> ALE at 50% as PE fb 1 HW on 30 DAS	196230	70911	125319	2.77
T ₉	Atrazine at 1.0 kg a.i. ha ⁻¹ as PE fb 1 HW on 30 DAS	214852	71993	142860	2.98
T ₁₀	Weed free check (HW at 15, 30, 45, 60 DAS)	220130	94274	125856	2.34
T ₁₁	Weedy check	135816	57410	78406	2.37
	S.Em±	5526	-	3604	-
	C.D. at 5%	16301	-	10633	-

	General mean	188018	71500	116518	2.63
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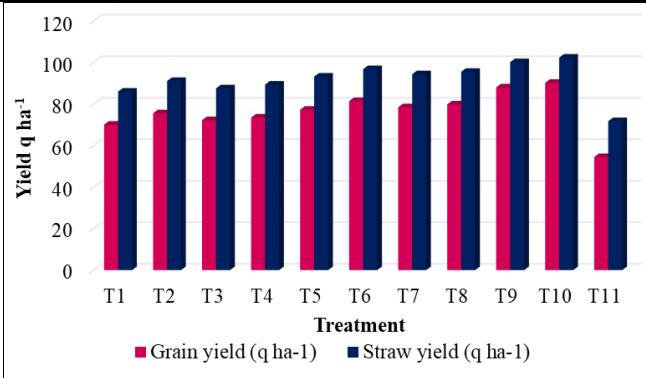


Fig 1: Grain yield and straw yield of maize as influenced by weed management treatment

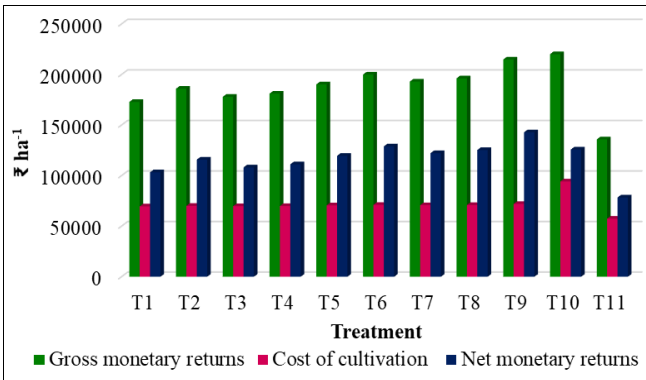


Fig 2: Economics of kharif maize as influenced by weed management treatment

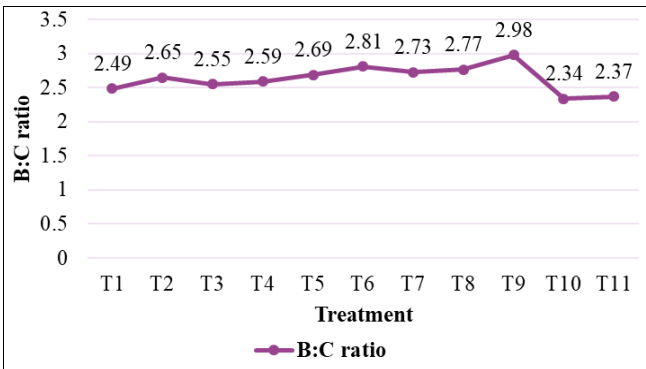


Fig 3: Benefits Cost ratio of kharif maize as influenced by weed management treatment

4. Conclusion

1. Weed management had a significant impact on maize yield attributes and yield. Atrazine at 1.0 kg a.i. ha⁻¹ as pre-emergence fb one hand weeding on 30 DAS treatments resulted in higher yield contributing characters and yield of maize. This was closely followed by *Datura metel* aqueous leaf extract at 50% as pre-emergence fb one hand weeding on 30 DAS which also showed notable improvement in crop yield contributing characters and yield of maize.
2. The economic analysis of different treatments revealed that Atrazine at 1.0 kg a.i. ha⁻¹ as pre-emergence fb one hand weeding on 30 DAS produced the highest net returns 142860 ₹ ha⁻¹ and B:C ratio 2.98. This was followed by *Datura metel* aqueous leaf extract at 50% as pre-emergence fb one hand weeding on 30 DAS gave net returns of 129541 ₹ ha⁻¹ and a B:C ratio of 2.84.

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