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Effect of Weed Management on Growth, Yield and Quality of Ajwain (*Trachyspermum ammi* L.)

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ABSTRACT: A field experiment was conducted to investigate the effect of different weed management practices on growth, yield and quality of ajwain (*Trachyspermum ammi* L.). The study employed randomized block design with twelve treatments and three replications. Findings revealed that, after weed-free check, oxyfluorfen 0.080 kg/ha PE fb propaquizafop 0.050 kg/ha PoE at 30 DAS treatment exhibited the highest plant growth parameters such as plant height, fresh and dry weight of the plant. Yield parameters such as seed yield per hectare, number of umbels per plant, number of umbellates per umbel and number of seeds per umbellate. The seed yield was found significantly higher (781.67 kg ha^{-1}) in weed-free check (T_{11}), which was on par with oxyfluorfen 0.080 kg ha^{-1} PE fb propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS (T_6) (700.00 kg ha^{-1}).

Keywords: Ajwain, weed management, growth, yield, quality, pre-emergence.

INTRODUCTION

Spices, described as "any of the aromatic vegetable products used in cooking, seasoning, and preserving foods" by the International Standard Organization (ISO), are natural plant-based materials that flavor, taste, aromatize, and add pungency to food. Of the 109 spices recognized by ISO, India cultivates 63, including 20 seed spices, covering 48% of the area and contributing to 19% of spice production. The dry regions of Gujarat and Rajasthan, known as the "seed spice bowl," produce 80% of seed spice output, playing a significant role in India's economy through domestic use and export demand (Anon., 2017).

Ajwain, or bishops weed, is a small seed spice belonging to the Apiaceae family, with the botanical name *Trachyspermum ammi* L. Endemic to Egypt, it is a crucial rabi season crop with a diploid chromosome number of 2n = 18. The herbaceous erect annual plant grows to 60-120 cm, featuring a striped, erect stem and an umbel inflorescence with an average of 16 umbellates, each with 10-16 flowers. White and protandrous, the flowers are pollinated by insects like honey bees (Tiwari and Agarwal 2004).

Despite meeting nearly half of the world's demand, India exports only 14% of its annual spice production. Ajwain, in particular, faces challenges in productivity due to factors such as the absence of high-yielding varieties and agronomic issues like weed development during critical growth periods. Weeds lead to poor growth and delayed germination, resulting in a yield loss of 70-78% (Patel *et al.*, 2019).

While pre-emergence herbicides control early weed growth, they are ineffective in later stages. Hand weeding and post-emergence herbicides become necessary. To optimize weed control, farmers need to evaluate different herbicides and hand weeding at varied intervals. Hence investigating new combinations of hand weeding, pre-emergent, and post-emergent herbicides is crucial for enhancing ajwain cultivation outcomes.

MATERIAL AND METHODS

The experiment was carried out in the Department of Plantation, Spice, Medicinal, and Aromatic Crops, College of Horticulture Bagalkot, Karnataka, India, on black loamy soil. There are twelve treatments in total namely T_1: Pendimethalin 38.7% CS @ 1.0 kg ha^{-1} as PE alone, T_2: Pendimethalin 38.7% CS @ 1.0 kg ha^{-1} as PE followed by hand weeding at 30 DAS, T_3: Pendimethalin 38.7% CS @ 1.0kg ha^{-1} as PE followed by propaquizafop 10% EC @ 0.05 kg ha^{-1} as PoE at 30 DAS, T_4: Oxyfluorfen 23.5% EC @ 0.080 kg ha^{-1} as PE alone, T_5: Oxyfluorfen 23.5% EC @ 0.080 kg ha^{-1} as PE fb hand weeding at 30 DAS, T_6: Oxyfluorfen 23.5% EC @ 0.080 kg ha^{-1} as PE fb propaquizafop 10% EC @ 0.05 kg/ha as PoE at 30 DAS, T_7: Pretilachlor 50% EC @ 0. kg ha^{-1} as PE alone, T_8: Pretilachlor 50% EC @ 0.5 kg ha^{-1} as PE fb hand weeding at 30 DAS, T_9: Pretilachlor 50% EC @ 0.5 kg

ha^{-1} as PE fb propaquizafop 10% EC @ 0.05 kg ha^{-1} as PoE at 30 DAS, T_{10}: Hoeing at 30 and 60 days after sowing (DAS), T_{11}: Weed-free check, T_{12}: Un-weeded check. Each of the treatment was divided into three replications and experiment was carried out in randomized block design. Sowing was done on November 11th, 2022. Crop variety AA-2 (Ajmer Ajwain 2) was dibbled at a spacing of 45cm × 20cm in a 4 m square plot with soil chemical properties of alkaline pH (8.36), EC (0.26 dS m^{-1}) and organic matter (0.45%) with available N (178 kg ha^{-1}), P (53 kg ha^{-1}) and K (288 kg ha^{-1}). Throughout the crop time, a standard set of practices was used. The herbicide was applied using a Ganesh sprayer equipped with a flat fan nozzle and a 2l capacity. Manual weeding procedures such as interculturing (IC) and hand weeding (HW) were performed in accordance with the treatments. Growth parameters such as plant height, was recorded at 30, 60, 90, 120 and at harvest plant. Dry and fresh weight and days to 50% flowering was also calculated among growth parameter. Yield-related data, such as the number of number of seeds per umbellate, number of umbellate per umbel, number of umbels per plant and seed yield per hectare were collected. Under quality parameter essential oil and oleoresin percentage were calculated using Soxhlet method (Sontakke *et al.*, 2018).

RESULTS AND DISCUSSION

Growth parameters. The data on height of the plant revealed that (T_{11}) weed free check recorded higher results (25.53, 69.40, 88.77 and 89.77 cm) which was statically *on par* with (T_6) oxyfluorfen 0.080 kg/ha PE *fb* propaquizafop 0.050 kg/ha PoE at 30 DAS (23. 40, 64.20, 82.10, 82.87 cm) at 60, 90, 120 DAS and at harvest. The plant height in weed free check might be higher due to uprooting weeds during the growth period resulting in reduced weed competition, enhancing crop growth. Similarly in T_6 effective weed control reduced the hindrance caused by weeds in development of the main crop, which led to minimal competition between crop and weeds for water and nutrients increasing the plant height. Similar observation were found by Meena *et al.* (2009b) in ajwain crop, Meena *et al.* (2013) in fenugreek crop, Gohil *et al.* (2014) in fennel crop and Ahirwar *et al.* (2021) in garlic crop.

The fresh and dry weight of the plant was highest in (T_{11}) weed free check (413.17 g and 100.39 g, respectively). Among the various weed control strategies, (T6) oxyfluorfen 0.080 kg ha^{-1} PE *fb* propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS had the second highest value of plant fresh and dry weight on par with the weed free check (386.52 g and 94.51 g).

Table 1: Plant fresh weight, dry weight and days to 50% flowering as influenced by different weed management practices in ajwain.

Treatment	Treatment details	Plant (g)		Days to 50% flowering
		Fresh weight	Dry weight	
T_1	Pendimethalin 1.0 kg ha^{-1} * PE	320.31	83.79	100.00
T_2	Pendimethalin 1.0 kg ha^{-1} PE fb HW at 30 DAS.	351.87	89.45	101.67
T_3	Pendimethalin 1.0 kg ha^{-1} PE fb propaquizafop 0.050 Kg ha^{-1} PoE at 30 DAS	386.52	94.10	104.67
T_4	Oxyfluorfen 0.08 kg ha^{-1} PE	317.34	82.08	102.00
T_5	Oxyfluorfen 0.08 kg ha^{-1} PE fb HW at 30 DAS	350.64	89.46	104.33
T_6	Oxyfluorfen 0.08 kg ha^{-1} PE fb propaquizafop 0.050 Kg ha^{-1} PoE at 30 DAS	391.01	94.51	106.33
T_7	Petrilachlor 0.5 kg ha^{-1} PE	307.80	83.32	99.33
T_8	Petrilachlor 0.5 kg ha^{-1} PE fb HW at 30 DAS	335.32	79.33	104.00
T_9	Petrilachlor 0.5 kg ha^{-1} PE fb propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS	358.16	75.44	100.33
T_{10}	Hoeing at 30 and 60 DAS	366.76	92.53	105.00
T_{11}	Weed free check	413.17	100.39	106.67
T_{12}	Un-weeded check	277.01	62.35	95.00
	S.Em ±	**7.57**	**2.62**	**1.26**
	CD at 5 %	**22.20**	**7.70**	**3.71**

Note: *- kg a.i ha^{-1}; PE- Pre-emergence; PoE- Post emergence; DAS- Days after sowing; fb- Followed by; HW-Hand weeding

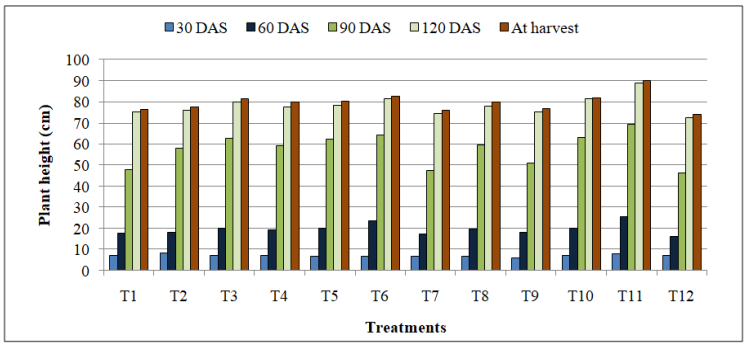

Fig. 1. Plant height at different growth stages and at harvest as influenced by different weed management practices in ajwain.

The increase in dry matter in T_{11} may be because continuous weeding causing reduction in weed population and increased availability of nutrients to the main crop, similarly effective suppression of weeds in T_6 also resulted in higher dry matter accumulation in the main crop. The findings were comparable to those of Nalini *et al.* (2017) in the ajwain crop.

The data on days to 50% flowering revealed that longest duration for flowering was recorded (T_{11}) weed free check (106.67). With respect to other treatments flowering longer duration on par to T_{11} was recorded with (T6) oxyfluorfen 0.080 kg ha^{-1} PE fb propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS (106.33), (T_{10}) Hoeing at 30 and 60 DAS (105.00), (T_3) Pendimethalin 1.0 kg ha^{-1} PE fb propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS (104.67) (T_5) Oxyfluorfen 0.08 kg/ha PE fb HW at 30 DAS (104.33), and (T_8) Petrilachlor 0.5 kg ha^{-1} PE fb HW at 30 DAS (104.00) which implied there was very less crop weed competition in these treatments which led to prolonging the vegetative stage of the main crop. The results were in accordance with studies of Dungarwal *et al.* (2002) in fenugreek crop and Mehta *et al.* (2010) in fenugreek crop.

Table 2: Yield parameters at harvest as influenced by different weed management practices in ajwain.

Treatments	Treatment details	Yield attributes			Seed yield
		Seeds per Umbellate	Umbellate per umbel	Umbels per plant	kg ha^{-1}
T_1	Pendimethalin 1.0 kg ha^{-1} * PE	10.80	10.73	83.80	365.00
T_2	Pendimethalin 1.0 kg ha^{-1} PE fb HW at 30 DAS.	11.33	11.20	100.53	405.00
T_3	Pendimethalin 1.0 kg ha^{-1} PE fb propaquizafop 0.050 Kg ha^{-1} PoE at 30 DAS	12.87	11.87	110.27	541.67
T_4	Oxyfluorfen 0.08 kg ha^{-1} PE	11.87	11.27	96.60	426.67
T_5	Oxyfluorfen 0.08 kg ha^{-1} PE fb HW at 30 DAS	12.40	11.60	106.93	495.00
T_6	Oxyfluorfen 0.08 kg ha^{-1} PE fb propaquizafop 0.050 Kg ha^{-1} PoE at 30 DAS	13.13	12.20	124.00	700.00
T_7	Petrilachlor 0.5 kg ha^{-1} PE	9.93	10.13	82.07	345.00
T_8	Petrilachlor 0.5 kg ha^{-1} PE fb HW at 30 DAS	11.93	11.40	96.80	468.33
T_9	Petrilachlor 0.5 kg ha^{-1} PE fb propaquizafop 0.050 Kg ha^{-1} PoE at 30 DAS	11.00	11.00	84.27	386.67
T_{10}	Hoeing at 30 and 60 DAS	13.00	11.70	117.13	618.33
T_{11}	Weed free check	15.13	13.60	135.13	781.67
T_{12}	Un-weeded check	9.33	9.93	82.00	149.17
	S.Em ±	**0.92**	**0.63**	**7.42**	**51.88**
	CD at 5 %	**2.70**	**1.85**	**21.76**	**152.16**

Note: *- kg a.i ha^{-1}; PE- Pre-emergence; PoE- Post emergence; DAS- Days after sowing; fb- Followed by; HW-Hand weeding

Yield parameter. The number of seeds per umbellate was found significantly higher in (T_{11}) weed free check (15.13). Among the different weed management practices statistically *on par* values were seen with (T_6) oxyfluorfen 0.080 kg a.i ha^{-1} PE fb propaquizafop 0.050 kg a.i ha^{-1} PoE at 30 DAS (13.13), (T_{10}) hoeing at 30 and 60 DAS (13.00) and (T_3) pendimethalin 1.0 kg a.i ha^{-1} PE fb propaquizafop 0.050 kg a.i ha^{-1} PoE at 30 DAS (12.87). With respect to number of umbellates per umbel the Observations revealed that, (T_{11}) weed free check recorded significantly higher number of umbellate per umbel (13.60). Among the different weed management practices, (T_6) oxyfluorfen 0.080 kg a.i ha^{-1} PE fb propaquizafop 0.050 kg a.i ha^{-1} PoE at 30 DAS and (T_3) pendimethalin 1.0 kg a.i ha^{-1} PE fb propaquizafop 0.050 kg a.i ha^{-1} PoE at 30 DAS showed *on par* results (12.20 and 11.87 respectively) to weed free check.

Similarly Significantly highest number of umbel per plant was found in (T_{11}) weed free check (135.13) which was *on par* with (T_6) oxyfluorfen 0.080 kg a.i ha^{-1} PE fb propaquizafop 0.050 kg a.i ha^{-1} PoE at 30 DAS (124.00) and (T_{10}) hoeing at 30 and 60 DAS (117.13) The maximum seed yield per hectare was seen in (T_{11}) weed free check (781.67 kg) which showed *on par* results with (T_6) oxyfluorfen 0.08 kg a.i ha^{-1} PE fb propaquizafop 0.050 kg a.i ha^{-1} PoE at 30 DAS (700.00 kg). Higher results in yield parameter may be due to effective weed control by the treatments which led to increase in dry matter accumulation in the plant, which intern increased the number of seeds per umbellate, umbellates per umbel and umbels per plant which intern increased the seed yield. The observations were in agreement to findings of Nagar *et al.* (2009) in coriander crop, Nalini *et al.* (2017) in ajwain crop and Ahirwar *et al.* (2021) in garlic crop.

Table 3: Quality parameters as influenced by different weed management practices in ajwain.

Treatment	Treatment details	Quality parameters	
		Essential oil (%)	Oleoresin (%)
T_1	Pendimethalin 1.0 kg ha^{-1} * PE	3.40	3.80
T_2	Pendimethalin 1.0 kg ha^{-1} PE fb HW at 30 DAS.	4.07	3.40
T_3	Pendimethalin 1.0 kg ha^{-1} PE fb propaquizafop 0.050 kg ha^{-1}PoE at 30 DAS	5.00	3.40
T_4	Oxyfluorfen 0.08 kg ha^{-1} PE	3.87	3.80
T_5	Oxyfluorfen 0.08 kg ha^{-1} PE fb HW at 30 DAS	4.27	3.80
T_6	Oxyfluorfen 0.08 kg ha^{-1} PE fb propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS	5.07	3.60
T_7	Pretilachlor 0.5 kg ha^{-1} PE	3.47	3.60
T_8	Pretilachlor 0.5 kg ha^{-1} PE fb HW at 30 DAS	3.53	4.40
T_9	Pretilachlor 0.5 kg ha^{-1}PE fb propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS	3.80	4.40
T_{10}	Hoeing at 30 and 60 DAS	4.60	4.20
T_{11}	Weed free check	5.20	4.20
T_{12}	Un-weeded check	2.93	3.60
	S.Em±	**0.72**	**0.23**
	CD at 5 %	**NS**	**NS**

Note: *kg a.i ha^{-1}; PE- Pre-emergence; PoE- Post emergence; DAS- Days after sowing; fb- Followed by; HW-Hand weeding; NS-Non significant

Quality parameter. There was no significant difference observed with respect to essential oil percentage, and oleoresin percentage as they didn't affect the metabolism within the ajwain plant. The results were in accordance to research conducted by Khaliq *et al.* (2007) in fennel crop, Patel *et al.* (2017) in fennel crop, Patel *et al.* (2019) in ajwain crop and Rathod *et al.* (2021) in coriander crop.

CONCLUSIONS

Based on the current study's findings, it is possible to conclude that oxyfluorfen 0.08 kg ha^{-1} PE fb propaquizafop 0.050 kg ha^{-1} PoE at 30 DAS can provide good weed management resulting in increased plant growth and lucrative seed yield in ajwain during the rabi season.

FUTURE SCOPE

Based on the results obtained, aspects which need further investigation in ajwain are as follows:
— Studies should be carried out to know the effect of different herbicides on soil different classes of weeds.
— Studies on various concentration of oxyfluorfen for an effective management of weeds in ajwain.
— A detailed study can be planned application time of post emergent herbicide propaquizafop.

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Conflict of Interest. None.

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