The Pharma Innovation Journal 2022; SP-11(2): 366-369

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(2): 366-369

www.thepharmajournal.com
Received: 22-12-2021
Accepted: 25-01-2022

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Diversity of insect pollinators and impact of mode of pollination on yield parameters of Ajowain [*Trachyspermum ammi* (L.) Sprague] in India

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Abstract
Level of biodiversity, especially of insect pollinators on ajowain cv. HAJ-18 [*Trachyspermum ammi* (L.) Sprague], was studied at Research Farm, Department of Vegetable Science, Hisar,India. In present studes, seventeen insect of different species were recorded belonging to ten families of four orders from the ajowain flowers in which five belong to order Lepidoptera, four to Hymenoptera, six to Diptera and two related to Coleoptera. Among the insect pollinators *Musca domestica* L., *Chrysomya megacephala* F., *Sarcophaga* sp., *Eristalinus aeneus* Scopoli, *Eristalinus* sp. and *Eristalinus tabanoides* Jaennicke were the most frequent. The yield/plant (9.08 g), yield/m^2 (82.18 g), test weight (2.15 g) and per cent of germination (68.0) were significantly higher in open pollination as compared to without insect pollination (6.59 g, 60.58 g, 1.54 g and 40.0%, respectively). In open pollination, per cent increase in yield/plant, yield/m^2, test weight and per cent germination over without insect pollination was 37.76 g, 35.66 g, 39.48 g and 70.0 per cent, respectively. For seed production of ajowain insect pollinators are supposed to be indispensable to get good returns.

Keywords: insect pollinators, modes of pollination, yield and ajowain cv. HAJ-18

Introduction
Ajowain [*Trachyspermum ammi* (L.) Sprague], a member of Apiaceae family, is an erect, glabrous, or minutely pubescent, branched, up to 90 cm tall, aromatic annual herbaceous plant, bearing greyish brown fruits having importance both as a spice and medicine. Ajowain commonly known as Bishop's weed, ajowain caraway, carom seeds, or thymol seeds originated in the Middle East, possibly either in Egypt, Iran, Afghanistan and or Indian Subcontinent. Presently, it is mainly cultivated in Persia and India. In India, the major ajowain producing states are Rajasthan and Gujarat, whereas, Rajasthan produces about 90 per cent of the India's total production (Sharma and Singh, 2000) [10]. Although, ajowain is grown for the most part in plains, yet it also comes up well in Deccan plateau in India. Mainly it is a cross-pollinated crop (2n= 18), but some flowers are self-fertile (Malhotra and Vijay, 2004) [5]. Being short-long day plant, the crop grows well in cool season from October to March, both under dry and irrigated conditions. Some of the best quality small seeded varieties are usually cultivated in India, particularly in Ujjain and Gwalior in Madhya Pradesh state. Ajowain also being used as adjuncts in small quantities for flavouring numerous foodstuffs, as preservatives, as antioxidant, in medicines and for the extraction of essential oils used in perfumery, essence and medicine (Mehta *et al*., 1994) [6].

Pollination, which is essential for the process of fertilization and production of fruits and/or seeds, is one of the limiting factors for ajowain productivity that significantly contribute to the it's productivity. In nature, only about 5 per cent of the flowers are self-pollinated and 95 per cent needs other source as animal pollinated (Tewari and Singh, 1983) [14]. Insect pollination accounts to the tune of 90 per cent of total pollination of crop (Richards, 1986; Buchmann and Nabhan, 1996) [8, 2].

Since a very meagre information is available on the pollination requirements of ajowain, therefore the present study was carried out with the aim of to chalk out on the diversity of insect visitors/pollinators and effect of different modes of pollination on seed yield of ajowain in Hisar of Haryana state in India.

Material and Methods

Study sites and climate

Experiment were conducted in two set that comprised of ajowain crop cv. HAJ-18 with two modes of pollination, *viz.*, open-pollination (OP) and without insect pollination (WIP) at Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, India during the crop season 2013-14 year. The climate of Hisar region is semi-arid and characterized by hot and dry winds during summer months and dry and during winter prevails severe cold conditions. Hisar city also known as city of steel and geographically located in Indo-Gangetic plains of North-West India at 215.2 meter (705 ft MSL) coordinates at 29˚10'0" N, 75˚43'0" E on map, receives average precipitation 490.6 mm annually with average summer and winter temperature 32.5 ˚C and 17.6 ˚C, respectively.

The temperature shows wide range of fluctuations during summer, while the temperature below freezing point accompanied by frost may be observed during winter months (December-January), which is very common feature of this region. Rainfall confined mainly to the monsoon months from July to September, but light showers or cyclonic rains also occur sometimes during winter and spring months.

Soils status and fertilization

Sandy-loam soil with moderate fertility and pH 8.0 indicating slightly alkaline nature of the soil in the experimental field. Based on soil analysis, the soil of the experimental field was low in nitrogen, medium in organic carbon (0.33%), available phosphorus (8 kg/ha) and rich in potassium (480 kg/ha). Well-decomposed two years old farmyard manure was incorporated into the soil @ 10 t/ha at the time of field preparation. The field was prepared up to fine tilth by giving repeated ploughings with disc harrow followed by planking.

Crop husbandry

For raising a healthy crop 50 kg nitrogen, 25 kg phosphorus and 25 kg potash fertilizers were applied per hectare at the time of last ploughing. The crop was raised by following the practices of recommendations per Package of Practices of CCS Haryana Agricultural University, Hisar. Flowering period of *Ajwain* extend from 15 March to 30 April.

Diversity of insect visitors/pollinators

Insect visitors/pollinators of ajowain flowers were collected by using a cone type hand net throughout flowering periods of the crop at different hours of the day after 10 per cent flowering in the crops. All the collected insects were killed and preserved as dry specimen and were got them identified.

Effect of different modes of pollination on seed set

The effect of different modes of pollination on ajowain crops like yield and quality was investigated using two modes of pollination *viz.*, open pollination (OP) and without insect pollination (WIP). In WIP, a selected crop area of 1x1 m was enclosed with nylon net before initiation of flowering in the crop to restrain the entry of flower visitors. In OP, rest of the field (1x1 m) was exposed to the natural open pollination. Experiment was replicated seven times.

Following parameters were compared in OP and WIP conditions:

a) **Seed yield:** The seed yield in caged and uncaged plants was compared at harvest.

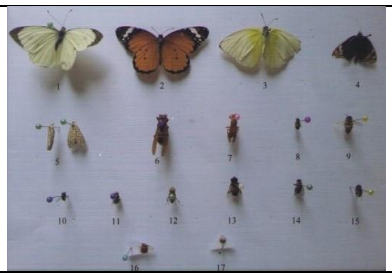
b) **Test weight:** The weight of 1000 seeds obtained from different modes of pollination was recorded to compare the modes of pollination.

c) **Seed viability:** Total 100 seeds obtained from two modes of pollination were sown in Petri plates to know the effect of modes of pollination on seed germination/viability.

Statistical analysis

The data pertaining to seed yield, test weight, and seed germination were statistically analysed by using standard analysis of variance (ANOVA) procedures (Sheoran *et al.*, 1998) [12].

Flowers of *ajowain*



Insect visitors/pollinators of ajowain flowers

Pollen grains of ajowain flower

Results

Diversity of insect visitors/pollinators on ajowain flowers

The data on diversity of insect visitors/pollinators on ajowain flowers have been presented in Table 1. Seventeen insect species belonging to ten families of four orders were recorded during the course of investigations. Out of which; five belong to order Lepidoptera, four to Hymenoptera, six to Diptera and two to Coleoptera. Dipteran were the major floral visitors that fall into four families namely, Muscidae (*Musca domestica* L.), Calliphoridae (*Chrysomya megacephala* F.), Sarcophagidae (*Sarcophaga* sp.) and Syrphidae (*Eristalinus aeneus* Scopoli, *Eristalinus* sp. and *Eristalinus tabanoides* Jaennicke) followed by hymenopteran *viz.*, Apidae (*Apis florea* F. and *A. mellifera* L.), and Vespidae (*Vespa orientalis* L. and *Polistes olivaceus* F.) and lepidopterans from three families *viz.*, Nymphalidae (*Danaus chrysippus* L. and *Junonia orithya* L.), Pieridae (*Pieris brassicae* L. and *Catospilia pomana* F.), and Arctiidae (*Utethesia pulchella* L.) and coleopteran from one family *viz.*, Coccinellidae (*Coccinella septempunctata* L. and *Cheilomenes sexmaculata* Chevrolat).

Table 1: List of insect visitors/pollinators of ajowain cv. HAJ-18 flowers

S. No.	Scientific name	Family	Order	Working behaviour
1.	*Danaus chrysippus* L.	Nymphalidae	Lepidoptera	Top and Side
2.	*Pieris brassicae* L.	Pieridae	Lepidoptera	Top and Side
3.	*Junonia orithya* L.	Nymphalidae	Lepidoptera	Top and Side
4.	*Utethesia pulchella* L.	Arctiidae	Lepidoptera	Top and Side
5.	*Catospilia pomana* F.	Pieridae	Lepidoptera	Top and Side
6.	*Apis florea* F.	Apidae	Hymenoptera	Top
7.	*Apis mellifera* L.	Apidae	Hymenoptera	Top
8.	*Vespa orientalis* L.	Vespidae	Hymenoptera	Top
9.	*Polistes olivaceus* F.	Vespidae	Hymenoptera	Top
10.	*Musca domestica* L.	Muscidae	Diptera	Top
11.	*Sarcophaga* sp.	Sarcophagidae	Diptera	Top
12.	*Chrysomya megacephala* F.	Calliphoridae	Diptera	Top
13.	*Eristalinus aeneus* Scopoli	Syrphidae	Diptera	Top
14.	*Eristalinus tabanoides* Jaennicke	Syrphidae	Diptera	Top
15.	*Eristalinus* sp.	Syrphidae	Diptera	Top
16.	*Coccinella septempunctata* L.	Coccinellidae	Coleoptera	Top
17.	*Cheilomenes sexmaculata* Chevrolat	Coccinellidae	Coleoptera	Top

Effects of different modes of pollination on yield parameter of ajowain

The yield per plant (9.08 g), yield per m^2 area (82.18 g), test weight (2.15 g) and per cent germination (68.0) were significantly higher in case of open pollinated flowers as compared to without insect pollination (6.59 g yield/plant, 60.58 g yield/m^2 area, 1.54 g test weight and 40.0% germination). In open pollination, per cent increase in yield per plant, yield per m^2 area, test weight and per cent germination over without insect pollination was 37.76, 35.66, 39.48 and 70.0, respectively (Table 2).

Table 2: Effects of different modes of pollination on yield parameter of ajowain cv. HAJ-18

S. No.	Character	Mode of pollination		Per cent increase over WIP	t-value
		Open pollination	Without insect pollination		
1.	Yield/plant (g)	9.08	6.59	37.76	8.89**
2.	Yield/m^2 area (g)	82.18	60.58	35.66	5.83**
3.	Test weight (g)	2.15	1.54	39.48	4.70**
4.	Germination (%)	68.0	40.0	70.0	6.31**

**Treatments are significantly different at 1% level of significance.

Discussion

In present studies, a total of seventeen insect species belonging to ten families comprised of four orders were recorded, out of which five belong to order Lepidoptera, four to Hymenoptera, six to Diptera and two to Coleoptera. In other umbelliferae crops, the most cited species are *Hylaeus* spp., *Andrena* spp., and *Apis mellifera*, which are the main pollinators of coriander crop in Italy (Ricciardelli *et al*., 1979) [7]. In Haryana state of India, Chaudhary and Singh (2007) [4] illustrated that coriander flowers were visited by 34 species of insects belonging to 18 families and 8 orders. Chaudhary (2006) [3] reported that the floral visitors on fennel included 39 species belonging to 20 families and 7 orders. Studies done earlier indicated that *A. florea* (Sagar, 1981; Baswana, 1984) [9, 1] and *A. mellifera* were the chief floral visitors of fennel (Youngken, 1950) [15]. The yield per plant (9.08 g), yield per m^2 area (82.18 g), test weight (2.15 g) and per cent germination (68.0) were significantly higher in case of open pollinated flowers as compared to without insect pollination (6.59 g, 60.58 g, 1.54 g and 40.0%, respectively). In open pollination, per cent increase in yield per plant, yield per m^2 area, test weight and per cent germination over without insect pollination was 37.76, 35.66, 39.48 and 70.0, respectively. It is to be noteworthy that very meagre information is available on the pollination requirements of ajowain crop. Apart ajoiwain crop, Chaudhary and Singh (2007) [4] also reported that the lowest yield of coriander 6.3 g/plant was recorded in without insect pollination plots. Shelar and Suryanarayana (1981) [11] and Sihag (1986) [13] in their different studies delineated increase of yield in open pollination and bee pollination over without insect pollination in coriander, whereas, Sihag (1986) [13] reported heavier seed in caged plots (15.8 g) compared to open pollination (12.8 g).

Conclusion

It is inferred from the present studies in context of seed production of ajowain crop, insect pollinators are supposed to be indispensable to get good returns ajowain crop when compare to open as well as bee pollinated crop over the without insect pollinated crop in the field. Moreover, insect pollinators fetched yield/plant (9.08 g), yield/m^2 (82.18 g), test weight (2.15 g) and per cent of germination (68.0) significantly higher in open pollination as compared to without insect pollination (6.59 g, 60.58 g, 1.54 g and 40.0 per cent, respectively).

Acknowledgement

The senior author is highly thankful to the Professor and Head, Department of Entomology, CCS Haryana Agricultural University, Hisar, India for providing necessary facilities for conducting this piece of research.

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