# Pollinators' community of ajwain (*Trachyspermum ammi*) and their role in reproductive success of quality production

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#### ABSTRACT

To ascertain the pollinator community of ajwain (*Trachyspermum ammi* L.) and the potential pollinators for quality seed production, a field experiment was conducted at ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan for two years. The pollinator community of ajwain was composed with 34 insect species in 7 orders and 14 families. Most of insect pollinators started their foraging at 9.00 hr and reached their respective peak activity between 12.00 to 14.00 hr and ceased at 18.00 hr. Three honeybee species *Apis florea, A. mellifera* and *A. dorsata* foraged for nectar and pollen, whereas butterfly species foraged for nectar and all Dipteran flies foraged either for nectar collection or for both nectar and pollen. Ten floral visitors (Hymenoptera-5 species, Diptera-4 species and Coleoptera-1 species) were identified as most important and potential pollinators of ajwain crop for semi-arid region performed higher foraging rate and visitation frequency. The higher seed yield of ajwain (1364.13 kg/ha) was recorded in bee pollination (BP) plots with slightly lower than sugar attractant and open pollination mode, whereas lowest yield was obtained without insect pollination (WIP)-control (844.43 kg/ha seed yield) plots. Bee pollination services increased the seed yield of ajwain by 61.54% over control and also enhanced the seed test weight and essential oil of seed in term of quality.

Keywords: Ajwain, Insect pollinators, Pollination success, Population dynamics, Yield

Ajwain (Trachyspermum ammi L.) is an important seed spice crop belongs to Apiaceae family. It is growing worldwide but India is dominating country, produced 19620 tonnes seed from 35880 ha area with average productivity of 547 kg/ha in 2018–19 (Anonymous 2020). It is most widely used as spice; possessing nutritional as well as several medicinal properties. The crop is highly cross-pollinated in nature, wherein 70.05-77.83% cross pollination incurred through pollinators. Pollination is a most important ecosystem service carrying by animals for sustainability and continuity in majority of angiosperms in the world. Almost 75% of the main crop species of the world depend on pollinators for seed and fruit set (Klein et al. 2007). Non-availability of effective pollinators during flower anthesis cause massive loss in the food commodity. The annual value of this service is estimated at US\$112 billion worldwide and reaches the value of 153 billion in 2005, contributing 9.5% of agricultural food production

crops (Gallai et al. 2009). A little information is known about the diversity of pollinators in seed spices particularly on ajwain for semi-arid region. Meena et al. (2015) reported Apis florea as potential and most frequent pollinator of ajwain. It is evident from literature that the role of insect pollinators in cross pollinated crops is correlated with quantitative and qualitative yield attributes, i.e. number of higher seed set/umbel, more uniform seed maturation, higher yield, seed size and weight, oil content in seed, and increased seed germination. The higher (80.6%) fruit set percentage is reported in insect pollinated flowers instead of 46. 3% in natural open pollination (Verma and Dwivedi 2018). Ajwain is being a cross pollinated nature of seed spice; the scope of this study become more imperative for widespread research by scientific community. Our main objective behind this research was to study the diversity of floral visitors for finding out the potential pollinators of ajwain for future conservation and their ultimate role on quality yield in semi-arid region of India.

## MATERIALS AND METHODS

The field investigations were conducted at the Research Farm, ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan (a semi-arid region of India) during *rabi* 2016–17 and 2017–18. The experimental site is surrounded by Aravalli hill range, is lying between a latitude of 26° 27' 0" N and longitude of 74° 38' 0" E with 460 m msl altitude.

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The wild flora in surrounding was provided a habitat to natural pollinators. Apis mellifera were visiting from 10 colonies stationed 200 m from experimental field. In study area, summers are extreme hot and winters are cold; the mean daily temperature 37–48°C and 6–12°C, respectively. The area receives annual average rainfall of 300-550 mm (Meena et al. 2018), wherein relative humidity was ranged from 60-80% and medium to heavy fog was observed during study period. Field trials were conducted to ascertain the pollinators' status, diversity and their significance on yield and quality under existing conditions. Experiments were setup in RBD with four replications. Seeds of ajwain variety AA 1 were sown in well prepared field, splitted in plots sized of 20 m<sup>2</sup> under specified crop geometry, i.e. 45 cm row to row and 30 cm plant to plant spacing. Five treatments (mode of pollination), viz. without insect pollination (WIP)-caged, open pollination (OP), bee pollination (BP)-caged, sugar solution 10% and jaggery solution 10% as bee attractants were taken into study. Insect cages of insect proof nylon nets (16 mesh) measuring 5 m length, 4 m width and 2.17 m height were raised in 2 plots/replication with GI pipe frames before crop received flowering to avoid cross pollination. Two sprays of azadirachtin 0.03 EC @ 5 ml/l were applied inside insect cages of control plots to keep crop plants free from activities of any floral visitors. In BP, a four-framed colony of Apis mellifera was kept inside cage at 10-20% flowering stage to perform the pollination services. Plants were exposed to natural pollination in open pollination plots. All other required agricultural practices were followed in each treatment as per POP adopted by the Institute for ajwain crop.

Diversity of floral visitors on ajwain was studied in open pollination plots, where no plant protection measures were applied. Usual observations on variety of floral visitors were recorded at weekly intervals throughout the flowering season. Sweep-netting of floral visitors was also performed at 30% flowering initiation and continued till end of flowering. The specimens of floral visitors were collected, preserved and identified with the help of literature available. The visitation frequency (number of visits/m<sup>2</sup> bloomed area for 60 sec) of important floral visitors were recorded at hourly interval from 06.00 to 10.00 hr and 2 hourly interval from 12.00 to 18.00 hr, for 10 calm and clear sunny days to perform the study of foraging behaviour and temporal abundance. Foraging rate of Apis pollinators was studied as visitation frequency by counting of number of umbels visited per min) on ajwain flower and also observed their stay time on a flower to find the pollination efficiency. The pollination effectiveness was measured in term of per unit area yield appreciation, test weight and essential oil contents by the visit of particular insect species. For that, five modes of pollination were applied, in which floral visitors allowed for pollination accordingly as described in experimental details. The data on yield and quality parameters, i.e. seed yield, test weight and essential oil contents were recorded and values were subjected to statistical analysis using analysis of variance (ANOVA). The statistical analysis was

performed using the computer software OPSTAT.

#### RESULTS AND DISCUSSION

Floral visitor diversity: The pollinator community of ajwain was composed of 34 insect species belong to 14 different families from 7 orders (Table 1). Among various floral visitors visited on ajwain flowers, the majority of pollinators were from Hymenoptera (13 species) followed by Diptera included 8 species and 4 species each of Lepidoptera and Hemiptera. The remaining species of floral visitor were from Coleoptera (3 species), Neuroptera (1 species) and Acarina (1 species), also played role in pollination of ajwain. Among total Hymenoptera, three honeybees, Apis dorsata, A. florea, A. mellifera; two solitary bees and one unidentified hymenoptera sp. were considered under systematic observation. Ajwain flowers were visited by seven bee species of which, three were honeybees. Highest per umbels/day mean population (28.2 bees) were recorded for A. florea followed by A. mellifera (20.5 bees), solitary bee sp. 1 (7.6 bees) and A. dorsata (5.5 bees). No research works of pollinators' diversity on ajwain were carried so far, so that present results could not be compared and discussed. However a little work on pollinators of other seed spices, i.e. coriander, fennel and cumin was carried out to support the present findings. A. dorsata, A. mellifera and A. florea reported as potential pollinators of coriander (Shivashankara et al. 2016), fennel (Meena et al. 2016) and cumin (Meena et al. 2018). Pollinator abundance and composition vary with varied geographical area, latitude and the time. In the study area, within honeybees, A. florea is usually regarded as most frequent and potential pollinator of ajwain then A. mellifera and A. dorsata. The similar observations were recorded by Sikdar et al. (2019) where A. florea executed prominent pollination services in seed spice crops including fennel, ajwain and cumin. A. florea and A. mellifera were more frequent, contributed 31.83 and 23.14% proportion of total hymenoptera and 19.48 and 14.16% proportion of total floral visitors, respectively (Table 1). The remainder of observed floral visitors were less frequent and contribute low pollination service to ajwain flowers. The second most dominant group of ajwain floral visitors were from Syrphidae family of order Diptera observed among the true flies, comprising eight species. Episyrphus balteatus, Episyrphus sp., Eristalis sp. and Musca sp. were most abundant with mean population of 5.8, 4.37, 5.7 and 5.5 flies/umbel/day, respectively. Syrphid flies are also efficient pollinators of oilseed rape (Jauker and Wolters 2008) and seed spices are accordance with present findings.

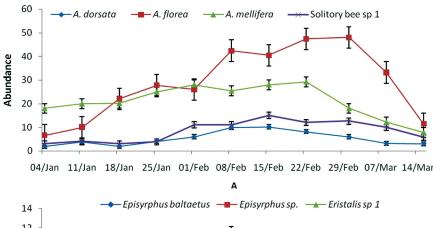
Population dynamics: The diurnal dynamic pattern of important and potential floral visitors revealed that honeybee species Apis florea and A. mellifera started their activity at 08.00 hr and A. dorsata at 09.00 hr with very less population (0.30-1.20 bees/m² bloom area) and frequency, which gradually increased their number with the advancement of temperature and sun light and reached to its maximum between 12.00-14.00 hr with average population of A. florea (25.55 bees/m² bloom area), A. mellifera (15.56 bees/

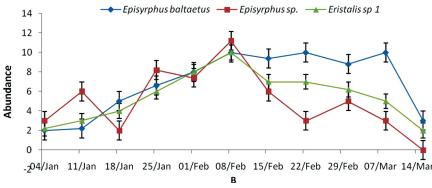
Table 1 Diversity of floral visitors on ajwain during rabi in semi-arid region

Name of species	Order	Family	Mean population day <sup>-1</sup>	Proportion (%) of total visitors
Apis dorsata Fab.	Hymenoptera	Apidiae	5.5	3.8
A. florea F.		Apidiae	28.2	19.48
A. mellifera L.		Apidiae	20.5	14.16
Solitory bee sp-1			7.6	5.25
Solitory bee sp-2			5.1	3.52
Ceratina sexmaculata Smith		Apidiae	2.3	1.59
Polistes hebraeus (F.)		Vespidae	0.3	0.21
Camponotus sp 1		Formicidae	3.7	2.56
Camponotus sp 2		Formicidae	1.8	1.2
Xylocopa sp.		Apidae	2.1	1.4
Unidentified hym sp. 1			7.3	5.0
Unidentified hym sp. 2			3.3	2.28
Unidentified hym sp. 3			0.9	0.62
Total Hymenoptera			88.6	62.85
Episyrphus balteatus (De Geer)	Diptera	Syrphidae	5.8	4.0
Episyrphus sp.		Syrphidae	4.37	3.0
Eristalis sp 1		Syrphidae	5.7	3.94
Eristalis sp 2		Syrphidae	3.2	2.21
Musca sp 1		Muscidae	5.5	3.80
Musca sp 2		Muscidae	2.8	1.93
Musca sp 3		Muscidae	1.2	0.83
Musca sp 4		Muscidae	0.4	0.28
Total Diptera			29.9	21.25
Dysdercus koenighii F.	Hemiptera	Pyrrhocoridae	2.3	1.59
Oxycaranus laetus (Kirby)		Lygaeidae	1.3	0.90
Bagrada hilaris (Burmeister)		Pentatomidae	0.7	0.48
Green bug			0.8	0.55
Coccinella septempunctata L.	Coleoptera	Coccinellidae	10.2	7.05
Menochilus sexmaculatus Fab.		Coccinellidae	5.1	3.52
Yellow beetle (Unidentified)			2.1	1.45
Chrysoperla zastrovi sillemi	Neuroptera	Chrysopidae	0.2	0.14
Plutella xylostella Linn.	Lepidoptera	Plutellidae	0.7	0.48
Lampiedis boeticus Linn.		Lycaenidae	1.1	0.76
Pieris brassicae L.		Pieridae	0.9	0.62
Lepidoptera sp (Unidentified)			1	0.69
Spider	Acarina		0.8	0.55
Grand total			144.77	

m² bloom area) and *A. dorsata* (4.20 bees/m² bloom area) and then decreased and reached to negligible at 18.00 hr. Ali *et al.* (2011) observed the peak activity of pollinators between 12.00 and 14.00 hr on *Brassica napus* in Oriental region of Pakistan. The other hymenopterans had highest foraging activities during 12.00 to 13.00 hr on coriander, fennel and black cumin (Sikdar *et al.* 2019) get support to the present results. Syrphid species were recorded on ajwain flowers throughout the day, sitting or flying on

flower umbels and exhibited in their population fluctuation pattern. The activity of *Musca* sp. 1 on ajwain flowers was recorded all over the day with scanty population (0.15 flies/m² bloom area) at 06.00 hr, highest (1.90 flies/m² bloom area) at 12.00 and spotted negligible at 18.00 hr. Flower visitation frequency of floral visitors depend on a number of factors like pollinator's foraging behaviour, quantity of floral rewards, nectar concentration in flowers (Abrol 2007) and several abiotic factors, viz. ambient temperature, relative





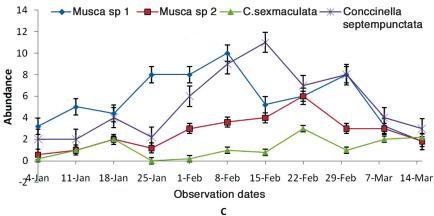


Fig 1 Fluctuation in populations of A. bees; B. Syrphidae, and C. other pollinators in ajwain field in semi-arid region of Rajasthan, India during flowering season.

humidity, light intensity and wind velocity.

The population dynamic pattern of bee species on T. ammi during entire flowering season (Fig 1A) revealed that A. florea, A. mellifera, A. dorsata and solitary bee sp. 1 were recorded as most dominant and regular pollinators for ajwain crop in the region. The peak activities of these pollinators varied between species due to their foraging nature and availability of nectar and pollen in the flowers. The highest activities of A. florea (48 bees/m<sup>2</sup> bloom area/ day) was noticed in last week of February, followed by A. mellifera, solitary bee sp. 1 and A. dorsata (29.2, 15.0 and 10.2 bees/m<sup>2</sup> bloom area/day) in third and second week of February, respectively. Among syrphid pollinators, Episyrphus balteatus, Episyrphus sp. and Eristalis sp. were also recorded as comparatively less populated regular floral visitors of ajwain with unevenly distribution across the observation dates during flowering season (Fig 1B).

The population dynamic pattern of other pollinators such as *Musca* sp. 1, *Musca* sp. 2, *M. sexmaculata* and *C. septempunctata* was observed throughout the flowering period with unevenly fluctuation pattern with peak activity of *Musca* sp. 1 during first week of February. The remaining floral visitors were also observed in their highest activity between second and fourth week of February (Fig 1C).

Foraging rate of honeybee pollinators were also studied and found that honeybees started the foraging on ajwain flowers between 8.00 to 9.00 h in uniformly less in number and continued over the day. The highest number (6.58) of floral umbels visited per 60 second by A. mellifera which was followed by A. dorsata and A. florea visited 4.96 and 3.73 floral umbels/60 second at 14.00 h, respectively then after, flower visiting frequency of Apis pollinators reduced. The higher foraging rate of pollinators enhanced the pollen robbing of flowers simultaneously increased the seed set and seed maturity rate in ajwain.

Pollination effectiveness: The irresistible input of floral visitors on seed yield and seed yield attributes of ajwain was studied under statistically laid out field experimentation (Table 2) revealed that, insect pollinators significantly affect the seed yield. The minimum seed yield of ajwain (844.43 kg/ha) was obtained in control (WIP) caged plots with no input of insect pollinators, which was significantly inferior to all adopted mode of

pollination. The seed yield 1364.13 kg/ha of ajwain was recorded in bee pollination plots, while slightly higher seed yield 1366.26 kg/ha was obtained in plots exposed for natural pollination of open pollination plots, although the yield of both mode of pollination was statistically at par. Among four mode of pollination, significantly lowest yield 1195.44 kg/ ha was recorded in sugar solution 10% treated plots used as bee attractant, whereas, maximum seed yield of ajwain (1455.65 kg/ha) was recorded in Jaggery solution 10% treated plots used as another bee attractant and was found significantly superior over all mode of pollination. Percent increase in yield due to pollinator's input showed 61.54% and 61.80% yield enhanced in bee pollination and open pollination, respectively over control. A similar observation recorded by Meena et al. (2018) in their earlier study found that bee pollination increased the yield of cumin by 40.03%. Highest test weight 3.47 g of ajwain seed was recorded in

Treatment	Seed yield (kg/ha)	Per cent change over				Test weight	Essential oil
		WIP	OP	BP	SS	(g)	(%)
Control (WIP- caged)	844.43		61.80	38.09	29.36	3.02	1.49
OP	1366.29	61.80		0.16	14.29	3.47	2.26
BP-caged	1364.13	61.54	0.16		14.11	3.47	2.32
Sugar solution 10%	1195.44	41.57	12.50	12.37		3.23	2.13
Jaggery solution 10%	1455.65	72.38	6.54	6.71	21.77	3.47	2.31
CD (P=0.05)	112.98					NS	0.22

Table 2 Effect of different mode of pollinations on yield and quality of ajwain in semi-arid region in rabi

#Values are average of 4 replications, WIP, Without insect pollination; OP, Open pollination; BP, Bee pollination.

bee pollination and open pollination plots in comparison to control plots (3.02 g). Insect pollination also increased the essential oil (thymol content) in ajwain seed, which is main constituent of quality attribute in ajwain.

Study data revealed that bee pollination also increased 0.83 and 0.77% essential oil of ajwain seed in bee pollination and open pollination plots, respectively over control (Table 2) wherein highest essential oil 2.32% was recorded in bee pollination plots. Because of managed pollination through *A. florea, A. dorsata, A. mellifera* and true flies of Syrphidae and Muscidae, resulted the higher fruit set, seed setting, test weight and oil content in many cross pollinated crops (Sihag 1986, Singh 2002, Choudhary and Singh 2007). Study indicates the conservation and enhancement of these important native pollinators through reducing pesticidal load on crops during flowering and improve's local wild vegetation may boost the ajwain production in semi-arid region of Rajasthan.

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