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The Role of Honeybee (*Apis mellifera*) Pollination in Enhancing Seed Yield and Yield Related Parameters of *Coriandrum sativum* L

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Abstract: Coriander (*Coriandrum sativum* L.) is one of the most important annual spice and medicinal herbplant. It is an open pollinated crop and honeybees are effective pollinators for open pollinated crops because of a lot of nectar and pollens are available on the flowers of *Coriandrum sativum*. An experiment was conducted to evaluate the effect of honeybees pollination on *Coriandrum sativum* seed yield and yield related parameters at Sinana Agricultural Research center at on-station. The study had three experiment; these includes plots caged with honeybees (T1), plots caged without honeybees (T2) and open pollinated plots (T3). All collected data were analyzed using One-way-Analysis of Variance (ANOVA). There were no significant different ($P>0.05$) on Date of blooming, Date of flowering,, Primary and secondary branches among the three treatments. Whereas, there were a significant difference ($P<0.05$) on Flowering period, shading time, Number of capsule, Thousand kernel weight and total seed yield per hector. The result also revealed that about 29.70% of seed yield advantage of *Coriandrum sativum* pollinated by honeybees over control/un pollinated by any insect. From this result it was concluded that visits of honeybees at flowering time of *Coriandrum sativum* have very helpful in increasing seed yield and yield related components of this crop.

Keywords: Honeybees, Pollination, *Coriandrum sativum* L, Yield

1. Introduction

Pollination is an essential biological process in higher plant reproduction that involves the transfer of pollen to the female sexual organs of flowers [1]. Pollination carried out by animals is considered an important ecosystem service with 35% of the plants cultivated in the world benefitting from this interaction [2]. Among the various pollinating agents, insects played a major role. The global annual economic value of insect pollination is estimated to be € 153 billion [3]. Of the total pollination activities, over 80 per cent is performed by insects and bees contribute nearly 80 per cent of the total insect pollination, and are considered the best pollinators due to their suitable body size, hairiness, thoroughness, steadfastness, floral constancy, and manageable populations [4]. It is also known that honeybees (*Apismellifera* L.) play an important role in pollination of some cultivated plants, notably allogamous species for which cross pollination is essential. Cross pollination of entomophilous crops by honeybees is considered as one of the effective and cheapest method for triggering the crop yield both qualitatively and quantitatively. Being the pollination service provider bees contribute handsomely in enhancing the productivity and production of cross pollinated crops through efficient pollination in an inconspicuous and ilentmanner [5, 6].

Coriander (*Coriandrum sativum L.*), which belongs to the family of umbelliferae (Apiaceae) is one of the most important annual spice and medicinal herb which is cross pollinated plant. It is grown in Ethiopia and throughout the world for its seeds as well as leaves and has immense uses [7, 8]. Coriander originated from the Mediterranean andWestern Asian regions [9]. There is a longstandingtradition of cultivation of coriander in Ethiopia [10].

The flowers are hermaphrodite and protandrous where pollen release precedes stigma receptivity, sopollen from a different flower is required for seed set [11, 12]. According to the observations by several authors, the flowers of coriander attract many groups of insects, in particular the Diptera, Coleoptera and Hymenoptera [13, 14]. But among all, it is the bees which are the potential pollinators of this crop.

Although, honeybees have great contribution in giving pollination service for ecosystem many people's do not understand it. Most of the time people only knows by their honey and bees wax, but the values of honeybees for pollination services had 10 folds times the values that they have for honey and beeswax. Moreover, the role of honeybees for pollination of local farming system is still poorly understandand till not sufficiently appreciated [15]. So far, there is no detailed information regarding the pollinators or foragers of coriander is available in Ethiopia. Therefore, the aim of thisstudy was to assess the role of honeybees in enhancing the yield and yield related components of *Coriandrum sativum*in the highland of Bale Zone of Oromia Regional state in Ethiopia.

2. Materials and Methods

The study was conducted at the high land of Bale in Sinana Agricultural Research Centre (SARC) at on-station during the 2017-2019 main cropping season. It is found at a distance of about 463 km from Addis Ababa in the south-easterly direction, and 33 km from the nearby town, Robe. Geographic location is 07^0 07' N latitude and 40^0 13' E longitude. The elevation is 2400 meters above sea level. The area is characterized by bimodal rainfall pattern. The amount of rainfall distribution of the last thirty year (from 1990 to 2020), during crop growing seasons, was 905.13 mm. The monthly mean maximum and minimum air temperatures were 20.19°C and 9.58°C, respectively [16].

2.1. Experimental Set up

The experiments were arranged in a randomized complete block design (RCBD) with five replications. For the experiment Waltahivariety of Coriander (*Coriandrum sativum*) was usedand all recommended agronomic practices were also followed. The plots were kept from any damaging condition throughout the cropping season. The treatments were: plots caged with honeybees (T1)- the plots were covered with an insect proof mesh cage and a honeybee colony with ten frames were placed inside the cage during the flowering peak (50% florets open) time, plots caged pollinator exclusion (T2) -the plots were covered with an insect proof mesh cage before the ray florets started openingand plots kept open to all pollinators (T3)-plots accessible to all flower visitors or left open for natural pollination as control. Insect proof mesh cages (4m x 3m and 2.5m high) were made of wood covered with 20% shade cloth. All insects were removed from all the caged before blooming, to exclude unwanted pollinators. Honeybee colonies used in this experiment received supplementary feeding (dissolved sugar) and water before and after theywere placed in the cages. At the time of maturity 10 mature pods were selected randomly from each replication and the number of seeds produced was counted manually. Harvesting was done from each plot after seeds were matured. The seeds was separated manually from the pods and yield had calculated per plot for all the treatments.

2.2. Flower Visitation Identifications

During the whole flowering period, flower visitor identifications were done in each of the plots accessible to all flower visitors, to assess which and how many insect species were visiting the *Coriandrum sativum* crop; and in the open plots accessible only to honeybees and other visitors to count the number of honeybee pollinators. The number of bees and other pollinators in the open treatment was observed in one m^2 area for five minutes seven days a week during the whole flowering period to identify other pollinators than honeybees and the data was recorded at 9.30am, 11.30am, 1.30 pm and 3.30pm hours a day. Visiting insects were collected and identified by the entomologist at Sinana Agricultural Research Center.

An increase in yield and quality of *Coriandrum sativum L* seeds due to managed honeybee pollination was calculated using the following formula.

$$\text{Yield increament}(\%) = \frac{(\text{Yield from honeybees pollinated} - \text{Yield from insect excluded})}{\text{Yield from from open pollinated}} \times 100 \quad (1)$$

2.3. Data Collection and Measurement

Flowering Period: The flowering period was determined by recording the flower starting and ending date of the plants. Ten plants were selected to study the effects of mode of pollination on flowering period of the plant.

Blooming date (50% flowering): The number of days elapsed between date of sowing and date of 50% flowering was computed and expressed as average number of days to flowering.

Number of primary branches per plant: Number of primary branches per stem was randomly counted from selected ten middle row plants at final harvest.

Number of Secondary branches per plant: Number of secondary branches per stem was randomly counted from selected ten middle row plants at final harvest.

Number ofCapsule: On individual plant basis, number of capsule in the tagged plantscounted manually. The mean capsule per plant taken for each treatment.

Shading Time: It is days to maturity when about the plants reached 50%physiological maturity and its flowers was totally shades.

Thousand kernel weight (TKW) (g): It was determined based on the weight of 1000 seeds sampled from the grain yields of each plot by counting using an electric seed counter and weighed with an electronic balance.

Seed yield per hector (Quintals): Grain yield was

determined by harvesting plants from the net middle plot area to avoid border effects. Seeds, which were obtained from the corresponding net plot were cleaned manually and weighed using sensitive balance and recorded as mean values of seed yield per hectare in Quintals.

2.4. Data Analysis

All collected data were checked for normality and subjected to analysis of variance using statistical software package (SAS 9.1.3). The data were statistically analyzed using one-way-analysis of variance (ANOVA) and the differences among treatment means were compared using Least Significance Difference (LSD) test at 5% level of significance.

3. Results and Discussions

Number of foraging honeybees and other pollinators/visitors of coriander.

Figure 1. *Coriander pollination experimental set up (cage with bees, caged without bees and open plots).*

(Coriandrum sativum) flowers were visited by 7 species of insects belonging to 4 orders (Table 1). *Apis mellifera* was found the most dominant species (64.62%) with highfrequent visitor at maximum activity at 11:30 am time andminimum activityat 3: 30 pm. This is probably due to the bee's activity being limited by environmental factorslike daily temperatures. Counts were made on one meter (1 m^2) squire for 5 minutes, when the flowers were open. *Apis mellifera*as the most dominant floral visitor of coriander has also been reported earlier from India [17]. It is generally thought that the more visits made, the more efficient is the pollinator, though this also depends on the per visit pollen contribution to the pistil late flower part [18].

Table 1. *Coriander (Coriandrum sativum L) visitors number andpercentages.*

No	Insect order	CommonName	Scientific Name	Counted No.	Percentage
1	Hymenoptera	Honeybees	*Apismellifera*	42	64.62
		Carpenter bee	*Xylocopa*	2	3.08
2	Orthoptera	Grass hopper	*Orthoptera*	3	4.62
		Wasp	*Colletessuccinctus L*	6	9.23
3	Diptera	Housefly	*Musca* sp.	5	7.69
4	Lepidoptera	Butterfly	*DanauxplexippusL*	3	4.62
		Spider	*Achaearaneatrpidariorum*	4	6.15
	Total insect count			65	100

The mean data of blooming date (Table 2) showed no significant differences among the treatment. This might due to blooming date is not affected by mode of pollinations, however it depends on environmental factors like daily temperate and relative humidity and also on soil type.

In the current study shading time of *Coriandrum sativum* had significantly affected by pollinators agents. The early shading time were observed in treatment caged with honeybees (107.2 days) and followed by open pollination (111 days). This showed that shading time highly depends on mode of pollinations.

The flowering period of *Coriandrum sativum L* were significantly affected by mode of pollination. Plots caged without honeybees had the longest flowering period (41.4 days), followed by open pollination, while caged with honeybees had the smallest flowering period (32.47 days).

Similar idea reported flowering period had affect by mode of pollination and the longest flowering period was observed in Canola crops caged without bees followed by open pollinated crops [19]. This may indicated that mode of pollination had great contribution for early maturation of *Coriandrum sativum.*

Table 2. *Mean comparison of three years data collected on Date of flowering date of blooming, Shading time and Flowering period.*

Treatments	DF	DB	ST	FP
Caged with honeybees (T1)	74.73±2.06	95.6±3.706	107.2±2.297^{b}	32.47±0.703^{c}
Caged without honeybees (T2)	74.8±2.031	94.27±3.316	116.2±2.46^{a}	41.4±0.515^{a}
Open Pollination (T3)	74.8±2.041	94.33±3.424	111±2.332^{ab}	36.2±0.518^{b}
Over all mean	74.78±1.153	94.73±1.968	111.5±1.445	36.69±0.643
LSD	NS	NS	6.75	1.67
CV (%)	10.59	14.25	8.21	6.18

abc= means with different superscripts within a column are significantly different (P<0.05), NS= none Significant
Notice: DF = Date of Flowering, DB = Date of Blooming, ST= Shading Time, FP= Flowering period.

The number of primary and secondary branches were not significantly different (p>0.05) among treatments of *Coriandrum sativum*. This may probably because of the primary and secondary branches were not affected by mode of pollination, but it is affected by environmental factors and soil type.

Significant different (P<0.05) was observed in capsule setting among treatments (Table 3). Plots caged with honeybees had the highest number of capsule setting per plant (184.93), while plots caged without honeybees had the lowest number of capsule setting per plant (108.67). Similarly, in Sunflower crops caged with honeybees increased significantly the percentage of seed setting, number of filling seed per head compared with crops caged without honeybees [19].

Table 3. *Mean comparison of three years data collected on Primary branch, secondary branch and Number of Capsule.*

Treatments	PB	SB	NCP
Caged with honeybees (T1)	23.87±5.09	59.73±8.87	184.93±20.02^{a}
Caged without honeybees (T2)	24.33±4.87	55.8±7.76	108.67±12.04^{b}
Open Pollination (T3)	26.33±6.02	63.33±9.88	149.8±17.16^{ab}
Over all mean	24.84±3.02	59.62±5.03	147.8±10.54
LSD	NS	NS	3.4434
CV (%)	43.85	83.40	57.66

abc= means with different superscripts within a column are significantly different (P<0.05), NS= none Significant
Notice: PB= Primary branches, SB= secondary branches and NCP= Number of capsule

The present result revealed that there wasa significant different ((P<0.05) among treatments regarding thousand seed weight (TKW). Plots caged with honeybees the highest TKW (3.05 g), whereas plots caged without honeybees had the lowest TKW (2.16 g). Similar result found from Pakistan on the Coriander crop caged with honeybees [20].

Mode of pollination had a significant effect on the total yields per hector. From the current study, the total yield of plots under different treatments were compared and significant (P<0.05) differences were found. The yield from all treatments were differ and the highest yield per hector was obtained in treatments plots caged with honeybees (19.38Qt/ha) and followed by open pollinated crop (16.80Qt/ha). The lowest yield per hector was gained from caged without honeybees (14.39Qt/ha) (Table4). The higher yield of crops caged with honeybees might be because of the higher pollination efficiency of honeybees inside the cage. These results are in agreement with the already recorded observations by researchers on the effect of pollinators in increasing seed yield of *C. sativum* [21, 22]. The results are also in Similar with previous result of on *Guizotia abyssinica* at Tigria Region of Ethiopia [23].

Table 4. *Mean comparison of three years data collected on Thousand Kernel weight and Total Seed Yield.*

Treatments	TKW (g)	TSY (Qt/ha)
Caged with honeybees (T1)	3.05±0.09^{a}	19.38±0.46^{a}
Caged without honeybees (T2)	2.16±0.11^{c}	14.39±0.28^{c}
Open Pollination (T3)	2.55±0.09^{b}	16.80±0.75^{b}
Over all mean	2.57±0.08	16.88±0.43
LSD	0.27	1.52
CV (%)	14.42	12.25

abc= means with different superscripts within a column are significantly different (P<0.05), NS= none Significant
Notice: TKW= thousand Kernel weight, and TSY= Total seed yields

In the present investigation conducted at Sinana Agricultural Research center at on-station, the result revealed that plots caged with honeybees had yield advantage of 29.70% in Coriander crop over control / caged without honeybees. Insect pollination enhanced average crop yield between 18 and 71% depending on the crop [24]. This might be because of Coriander pollination was highly affected by mode of insect pollination.

4. Conclusion

Visitations of honeybees in *Coriandrum sativum* L were increased total seeds yield and seed yield related components produced. From the present study, the result revealed that mode of pollination and pollinators had a significant effect on the total seed yield of *Coriandrum sativum* L per hector. The highest seed yield (19.38Qt/ha) was observed in plot caged with honeybees, followed by open pollinated plot (16.80Qt/ha) and the least seed yield was gained from plot caged without honeybees (14.39Qt/ha). It was also observed that plots caged with honeybees had a yield advantage of 29.70% over control or plots caged without honeybees. Thus, strategies to promote pollination by honeybee may be helpful

in enhancing seed yield of *Coriandrum sativum* L*,* therefore it is recommended that to use honeybees as an input to increase the productivity of *coriandrum sativum* L.

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References

[1] Leland J. Cseke, Peter B. Kaufman and Ara Kirakosyan, 2007. The Biology of Essential Oils in the Pollination of Flowers, *Natural Product Communications* Vol. 2 (12) PP, 1317-1336.

[2] Klein AM, Vaissière B, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C, Tscharntke T (2007). Importance of crop pollinators in changing landscapes for world crops. Proceeding Royal Society London B, Biological Sciences 274, 303-313.

[3] Gallai, N., Salles, J. M., Settele, J. and Bernard, E. V. 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics*, 68: 810-821.

[4] Robinson, W. E. and Morse, R. A. 1989. The value of honeybees as pollinators of US crops. *American Bee Journal*, 129 (1): 477-487.

[5] Singh, R., Chaudhary, B. K., Bhowmick and Singh, R. P. 2005. Honeybee flora of Bihar, Uttar Pradesh and Madhy Pradesh. *International Beekeeping Congress*, Nov. 13th -18th 2005, Bangalore, India. pp. 53.

[6] Mohapatra, L. N. Sontakke, B. K. and Rana singh, N. 2010. Enhancement of crop production through bee pollination. Orissa review, September, 2010. pp 44-47.

[7] Parthasarathy V. A., Chempakam B., Zachariah T. J., 2008 - *Chemistry of Spices*. - CABI Publishing, Wallingford, Oxfordshire, uk, pp. 445.

[8] Nowak J., Szemplinski W., 2014 - *Influence of sowing date on yield and fruit quality of coriander (*Coriandrum sativum L.*)*. - Acta Sci. Pol., HortorumCultus, 13 (2): 83- 96.

[9] Burdock G. A., Carabin I. G., 2009 - Safety assessment of coriander (*Coriandrum sativum L.*) essential oil as a food ingredient. - *Food Chem. Toxico*l., 47: 22-34.

[10] Geremew A., Firew M., Amsalu A., 2014 - Correlation and path coefficient analysis studymong seed yield and oil content in Ethiopian coriander (*Coriandrum sativumL.*) genotypes. - *Int. J. lant Breed. Genet*., 8: 224-240.

[11] Wierdak R N 2013. Essential oil composition of the coriander (*Coriandrum sativum* L.) herb depending on the development stage. *Acta Agrobotanica* 66: 53-60.

[12] Mandal S and Mandal M 2015. Coriander (*Coriandrum sativum* L.) essential oil: Chemistry and biological activity. *Asian Pacific J Trop Biomed* 5: 421-28.

[13] Sinacori A, Sinacori M, Oliveri E and Carrubba A 2009. Apiepronubiselvaticinella produzione di *Coriandrum sativum* L. *Apoidea* 6: 155-61.

[14] Bendifallah L, Louadi K and Doumandji S 2013. Bee fauna potential visitors of coriander lowers *Coriandrum sativum* L. (Apiaceae) in the Mitidja area (Algeria). *J ApiSci* 57: 59-70.

[15] Jacobs J, Simoens C, Graaf DC, Deckers J (2006). Scope for non wood forest products income generation from rehabilitation area. J. Dry lands 1 (2) 171-185.

[16] SARC (Sinana Agricultural Research Center), 2020. Annual report. pp. 1-90.

[17] Chaudhary O P abdJage Singh, 2006. Diversity, temporal abundance, foraging behaviour of floral visitors and effect of different modes of pollination on coriander (*Coriandrum sativum L.*), Journal of Spices and Aromatic Crops Vol. 16 (1): 8–14.

[18] Herrera, C. M., 1989. Pollinator abundance, morphology and flower visitation rate: Analysis of the "quantity' component in a plant pollinator system. *Oecologia*, 80: 241–248.

[19] Oz M, Karasu A, Carkrnak I, Goksoy AT, Turan ZM, 2009. Effect of honeybee (*Apismellifera*) pollination on seed set in hybrid Sunflower (*Helianthus annuus* L.). Afr. J. Biotechnol. 8 (6): 1037-1043.

[20] Munawar, M. S., G. Sarwar, S. Raja, E. S. Waghchoure, F. Iftikhar and R. Mahmood, 2009. Pollination by honeybee (*Apismellifera*) increases seed setting and yield in black seed (*Nigella sativa*). *Int. J. Agric. Biol.*, 11: 611–615.

[21] Dhore M M 2009. Insect pollination and seed production in *Coriandrum sativum*L. (Apiaceae). UGC Minor Research Project, 2009-11, Sanction Letter No. F. 47-612/08.

[22] Kumar M and Jaiswal B K 2012. Effect of honeybee (*Apismellifera* L.) pollination on yield and quality in coriander. *Indian J Ento* 74: 281-84.

[23] Haftom Gebremedhn and Alemayehu Tadesse, 2014. effect of honeybees (Apis mellifera) pollination on seed of Guizotiaabyssinica (L. f.). Afr. J.Agric. Res. Vol. 9 (51), pp 3637-3691.

[24] Ignasi Bartomeus, Simon G. Potts, IngolfSteffan-Dewenter, Bernard E. Vaissi`ere, MichalWoyciechowski, Kristin M. Krewenka, Thomas Tscheulin, Stuart P. M. Roberts, HajnalkaSzentgy¨orgyi, CatrinWestphaland Riccardo Bommarco (2014), Contribution of insect pollinators to crop yield and quality varies with agricultural intensification. Peer J 2: e328; DOI 10.7717/peerj.328.