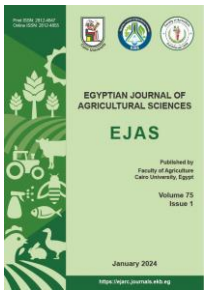
Egypt. J. Agric. Sci., 2024,75 (Special Issue):67-77.
***Doi:* 10.21608/ejarc.2024.347442**

Egyptian Journal of Agricultural Sciences

Journal homepage: www.ejarc.journals.ekb.eg

Published by: Faculty of Agriculture, Cairo University, Egypt

Print ISSN 2812-4847 Online ISSN 2812-4855



14th International Conference of Arab Beekeepers Union, 13-15 November, 2023, Cairo-Egypt

Effects of Honey Bee Pollination on Seed Yield and Chemical Composition of Two Sesame Varieties in Egypt

By

Mohammad A. Abd Alfattah and Mohamed S. El-Masarawy*

Department of Economic Entomology and Pesticides, Faculty of Agriculture, Cairo University, 12613 Giza, Egypt

ABSTRACT

The objective of this study was to evaluate the effect of open pollination by honey bee (*Apis mellifera* L.) on the seed yield of sesame (*Sesamum indicum* L.). Moreover, Germination Speed Index (GSI), Germination Percentage (GP), and chemical composition of seeds that produced from open and caged treatments were determined. The obtained results showed that the open pollination led to increase the number of pods/plant, weight of seeds/plant, mean yield/feddan, and seed index (weight of 1000 seeds) than those produced from caged treatment for both varieties of sesame. Also, the presence and visitation of honey bees had a good influence on the (GSI) of produced seeds. The values of this parameter were 23.42 and 23.84% in open pollinated areas compared with 17.08 and 17.09% in caged ones of both sesame varieties, Taka 1 and Taka 2, respectively. Nearly, the same effect was observed for the (GP) which was higher in seeds of open plots (95.0 and 96.0%) than those produced from caged ones (75.0 and 77.0%) for the both mentioned varieties of sesame, respectively. Furthermore, application of open pollination in plots was induced to improvement the chemical composition of seeds. Where total lipids, crude protein, and carbohydrates of open plot seeds increased in comparison with seeds produced from caged treatment for both varieties of sesame.

Keywords: *Honey bee; pollination; pollen; nectar; sesame, yield, germination*

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is considered one of the most important and oldest oil-seeds crops cultivated in many countries, e.g. India, Sudan, China, Nigeria and Egypt. Further, sesame ranked as the third important oil crops in the world after soybean and mustard (canola) (Rahman *et al.*, 2022). Sesame is an annual crop grown in the tropics and sub-tropics for the edible oil extracted from seeds, and the seeds are used after being hulled to manufacture several industrial commodities (Abou-Gharbia *et al.*, 2000). The cultivated area of sesame in Egypt reached 76,190 feddans with productivity up to 48000 ton (FAO, 2022). Furthermore, sesame seeds are characterized by their high nutritional and therapeutic values, as they are rich in a highly fat content of up to 44-58%, protein (18-25%), carbohydrates (13-14%), fiber (6-8%), and about 5% of ash (Mohamed and Awatif, 1998; Kahyaoglu and Kaya, 2006; Namiki, 2007; Borchani *et al*., 2010; Hegde, 2012 and Rao *et al*., 2022). Sesame is a self-pollinated crop, with both male and female structures within the same flower, and it belongs to the family Pedaliaceae. However, several reports indicated that cross-pollination led to improvement and increased the quality and quantity of sesame seed depending on activity of pollinators and environmental conditions (Khidir, 1973; Rashad *et al*., 1979; Crane and Walker, 1984 and Sarker, 2004). In the same context, study of Stein *et al*. (2017) referred

*Corresponding author E. mail: mohamedelmasarawy@gmail.com

Received: 06.01.2024 Accepted: 22.03.2024 Available online: 26.03.2024

to that shortage of pollinators led to obvious decrease of sesame yield with percentage about 60-70%. Furthermore, flowers of sesame are a good source of nectar and pollen for different insect species, especially honey bees and their peak activity from 9 am to 12 pm (McGregor, 1976; Mahfouz *et al*., 2012 and Rao, 2019). Meanwhile, honey bees (*A. mellifera* L.) are considered as one of the best insect pollinators as well as an important organism for maintaining environmental balance (El-Masarawy *et al*., 2021).

This study aims to study the foraging behavior of honey bee workers on sesame flowers, and to determine the role and impact of honey bee as an insect pollinator on certain yield components of sesame such as weight of seed/plant, Seed Index (weight of 1000 seed), and estimated yield/feddan. In addition, calculations of Germination Speed Index (GSI), Germination Percentage (GP) and chemical composition in open and caged treatments of sesame seeds were done.

2. MATERIALS AND METHODS

This study was conducted from May to September during two consecutive seasons throughout 2020 and 2021, in the apiary of Agricultural Experimental Station, Faculty of Agriculture, Cairo University, Giza governorate, Egypt. Two varieties of sesame "*Sesamum indicum* L." those Taka 1 and Taka 2 were cultivated in latest of spring (May), and were harvested in the latest of summer (September), and the flowering period was started from mid of July to mid of August. As well, all of the agricultural practices were carried out according to Weiss (1983). Sesame was cultivated in eight plots each (6m X 7m/plot) and the caged area was (3m X 3.5m X 2.25m high). The caged area was covered with mosquito net to exclude insect pollinators especially honey bee to visit the plants inside the cage, the cages were put on the chosen plots just before starting of the blooming period. The distance between the apiary and plants of sesame was about 70 meters, and all bee colonies were balanced in strength.

2.1. Bee visitation

The activities of honey bee workers on the mentioned varieties of sesame throughout the blooming period were studied.

2.1.1. Number of bees/m²/min. (mean of ten readings) was estimated by the aid of one square meter wooden frame. This estimation was measured five times per day at two hours intervals started from 8:00 am until 4:00 pm throughout the flowering period.

2.1.2. During the blooming period, the honey bee visitation could be divided to nectar gathering and pollen collection throughout the day periods. Also, the required time for each bee to collect nectar or gather pollen from the flowers of both two varieties was calculated.

2.2. Productivity of the tested crops under different pollination conditions

2.2.1. Quantity of the crop

The following parameters were measured in the open and caged treatments to calculate the increase value of the open pollination on the produced crop: No. of capsules/plant, weight of seeds (g)/plant, weight of 1000 seeds (g) "Seed Index", weight of seeds (g)/m², estimated yield of one feddan (kg/feddan).

2.2.2. Quality of the produced seeds

The effect of open pollination on quality of the produced seeds was measured throughout the following parameters: germination speed index (GSI), germination percentage (GP), and chemical composition of seeds.

Seed germination was assessed by placing 100 seeds from each variety of sesame for both treatments (open and caged), in glass Petri dishes with single layer of Whatman filter paper ≠ **1.** The filter paper was saturated with distilled water and then kept moist in the incubator at 25°C for seeds of sesame, and then the first reading of germination was taken after 3 days while the last reading was taken after 3 days later for sesame seeds.

The GSI was calculated according to the A.O.S.A (1983) on seeds vigor as described below:

$$GSI = \frac{No.normal\ seedlings}{Days\ of\ first\ account} + \frac{No.normal\ seedlings}{Days\ of\ final\ account} \times 100$$

The GP was calculated as a formula below:

$$GP = \frac{Total\ No.\ Normal\ seedlings}{Total\ No.\ tested\ seeds} \times 100$$

Also, the chemical analysis of sesame seeds was done to compare between percentages of lipids, protein, carbohydrates, moisture, and ash of seeds of open and caged treatments, and this chemical analysis was carried out according to methods of Vogel (1975) and AOAC (2000). Furthermore, the layout of the experiment was in

Randomized Complete Block Design (RCBD), and the obtained data were analyzed according to Duncan Multiple Range Test (1955).

3. RESULTS AND DISCUSSIONS

3.1. Determination of visitation activity of honey bee (number of bees/ m²/min).

Honey bees "*Apis mellifera* L." plays an important role as an insect pollinator in sesame cultivars compared with other insect visitors; and were associated well with sesame during blooming periods. Honey bees had the dominant of other pollinators owing to nearby honey bees' colonies as far about (70m) from sesame plants. Data (Table 1) showed that the average number of honey bee foragers fluctuated through 5 intervals/day; ranging between 1-3 bee/m²/min. for both two varieties throughout two successive seasons. However, the visitation activity started in the early morning and reached the peak at 12:00 pm (3.33 and 3.04 bee/m²/min.) for Taka 2, and (3.15 and 2.92 bee/m²/min.) for Taka 1, in the first and second season, respectively. Then, foraging workers clearly decreased towards the end of the day to reach the lowest value with 1.25 bee/m²/min. at 4.00 pm for both varieties (Table 1).

3.2. Honey bees foraging activity for collecting nectar and gathering pollen

Data as shown in Table (1) appeared that the mean activity of honey bees in collecting nectar from both varieties, it was started with a small percentage about 14.0-16.0% at 8:00am for both seasons for Taka 1 and Taka 2, respectively. Then, the activity of workers for collecting nectar gradually increased to the midday and reached the maximum peak with 79.0-82.0% at 2:00 pm for both seasons for Taka 1 and Taka 2, respectively.

On the other hand, the activity of bees in gathering pollen took an opposite direction to that in collecting nectar, whereas the maximum peak of pollen gathering occurred at 8:00am and 10.00 am for both seasons with percentages ranged between 78.0 and 86.0 % for both varieties. Then, the activity of pollen gathering by workers fluctuated between high and low throughout the last intervals of the day (Table 1). Fig. (1) shows the surface structure and shape of sesame pollen

Table (1): Activities of honey bee for gathering pollen and nectar for two sesame varieties throughout the day during two successive seasons 2020 and 2021.

Parameter	Bee/m²/min		%Bee collects nectar		%Bee collects pollen		Required time (sec) for nectar		Required time (sec) for pollen	
Season / Time	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Taka 1										
8:00am	1.67 g	1.48 g	14.0 h	16.0 f	86.0 a	84.0 a	11.10 i	11.28 i	22.12 d	23.90 d
10:00am	2.11 e	1.95 e	18.0 g	17.0 f	82.0 c	83.0 a	13.49 h	14.11 h	22.88 c	24.85 b
12:00pm	3.15 b	2.92 b	66.0 e	62.0 d	34.0 e	38.0 c	24.20 d	25.50 d	12.50 g	13.66 g
2:00pm	2.39 c	2.18 c	79.0 b	82.0 a	21.0 h	18.0 f	32.10 b	34.20 b	16.02 e	18.54 e
4:00pm	1.32 h	1.25 h	70.0 d	72.0 b	30.0 f	28.0 e	18.18 e	19.29 e	12.22 h	13.40 h
Mean	2.13	1.96	49.4	49.8	50.6	50.2	19.81	20.88	17.15	18.87
Taka 2										
8:00am	1.85 f	1.64 f	15.0 h	16.0 f	85.0 b	84.0 a	10.80 j	11.20 j	23.60 b	24.20 c
10:00am	2.25 d	2.02 d	22.0 f	20.0 e	78.0 d	80.0 b	14.66 g	14.77 g	24.00 a	25.50 a
12:00pm	3.33 a	3.04 a	70.0 d	68.0 c	30.0 f	32.0 d	25.30 c	26.20 c	10.95 j	12.88 j
2:00pm	2.25 d	2.17 c	82.0 a	81.0 a	18.0 i	19.0 f	34.23 a	34.88 a	15.87 f	18.22 f
4:00pm	1.24 i	1.23 h	73.0 c	71.0 b	27.0 g	29.0 e	16.11 f	17.80 f	11.23 i	13.11 i
Mean	2.18	2.02	52.4	51.2	47.6	48.8	20.22	20.97	17.13	18.78

Means in the same column of same season for both two varieties followed by same letters are not significantly different at 5% level of significance.

grains which were collected from the sesame flowers (Magnification "X"= 40X30).

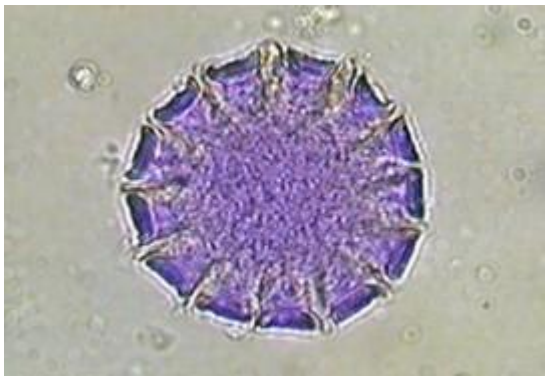


Fig. (1): Pollen grain of sesame, *Sesamum indicum* L.

3.3. Required time (seconds) for a bee to collect nectar and pollen from sesame flower

The obtained results in Table (1) showed that the nectar's collecting bees was spent less time on sesame flower at 8:00am with mean time reached to 10.95 and 11.24 sec. for both varieties in the 1st and 2nd season, respectively. While, honey bee foragers were spent long time (33.17 and 34.54 sec.) at 2:00pm for both varieties in the 1st and 2nd season, respectively. Quite the opposite, the pollen gathering bees were spent more time on the flowers throughout the morning hours with mean (22.86 and 24.05 sec.) at 8:00am and (23.44 and 25.18 sec.) at 10:00am for both varieties in the 1st and 2nd season, respectively. While, foragers workers were spent less time during midday (11.73 and 13.27 sec.) at 12:00 pm for both varieties in the 1st and 2nd seasons, respectively (Table 1).

Lack of movement of nectar-collecting bees on flowers, and their prolonged stay on flowers during midday may be due to the abundance of nectar secretion during this period. Thus, bee worker took its load from nectar from small number of flowers. On the other hand, the pollen-collecting bees were taking long time on the flower in the early morning than the other periods of the day because the anthers open and the pollen grains are dispersed with higher relative humidity during this time of the day (Table 1).

These observations are in an agreement with the findings of Guirguis, (1965), Khidir and Elawad (1972) and El-Rabie (1976). They reported that honey bee (*A. mellifera* L.) was considered the main visitors of sesame flowers and wild bees appeared as good pollinators, but their populations were badly affected through destroying their nesting places by different agricultural practices. Moreover, Abd Al-Fattah (1995) mentioned that the high activity of honey bees on sesame crop during the morning might be due to the opening of the major number of flowers during that time and that foragers were ready to collect the pollen. This collecting period ranged from 5:00 am to 10:00 am according to climatic conditions. He found a highly significant positive correlation between pollen gathers and relative humidity (+ 0.873), while this correlation was significant with both No. of flowers and plants/bee/min. Therefore, the high effectiveness of honey bee foragers as pollinators for sesame crop was concentrated in the morning where pollination was taking place by insects shortly after flower opening. These insects visited and carried pollen from one flower and enter another one prior to the time its own pollen became available for self-pollination. Also, he recorded a high estimation of pollen collectors' percentage (75.4-86.3%) at 8pm-11pm, while for nectar gathers percentage (63.2-97.8%) was between 12.00pm-3.00pm. He added the honey bee worker was collected nectar spent 38.4sec./flower and that was collected pollen spent 34.4sec/flower.

On the other hand, Kamel (1997) reported that most bees and wasps were active on the sesame flowers from 9:00 am till 5:00 pm, and reached their maximum activity around 11.00 am to 1.00 pm, with the highest number of visits and longest time spent on flowers during the third week of blooming (late August) and during the period from 11.00 am to 1.00 pm. Also, on the same context, Said *et al*. (2013) stated that the moderate foraging activity on sesame flowers was between 9:00 am to 11:00 am with 2.4 bees/m²/5min, where this activity increased gradually to reach its highest level with 9.8 bees/m²/5min at 1:00 pm to 3:00 pm. Furthermore, Rahman *et al*. (2022) mentioned that the visitation of insect pollinators on sesame flowers reached the peak between 9:00 am to 11:00 am, while, the lowest value of pollinators visitation was recorded in period from 2:00 pm to 3:00 pm. On the same trend, the results of Mahfouz *et al*. (2012) were consistent with our findings. Whilst, they found that highest foraging number of pollinators on sesame was at 9:00-11:00am, followed by 11:00-1:00pm, then 1:00-

3:00pm and finally from 3:00-5:00pm. On the other hand, Kambrekar *et al*. (2019) demonstrated that insects were belonged to order Hymenoptera was the predominant pollinators on sesame with percentage 71.05%, followed by orders of Diptera and Lepidoptera with values 18.42 and 10.53%, respectively.

3.4. Potential value of open pollination for sesame crop

3.4.1. Number of capsules and weight of seeds/plant

Data was tabulated in Table (2) showed that a significant increase in both mean No. of capsules/plant and weight of seeds (g)/plant in open treatment than those in caged ones during two seasons. The means No. of capsules/plant of open pollination treatment of Taka 1 were highly significant increasing with values 74.9 and 66.5 capsules/plant in 1st and 2nd season, respectively, compared with 66.4 and 52.6 capsules/plant in the same seasons. The same positive effect of open pollination was occurred in No. of capsules/plant of Taka 2 with values 88.7 and 74.8 faced 54.6 and 58.7 capsules/plant in 1st and 2nd season, respectively. Furthermore, the results of weight of seeds (g)/plant were took the same trend as similar to No. of capsules/plant. Therefore, weight of seed (g)/plant of open plots of Taka 1 reached up to 14.4 and 10.9 g compared to 10.6 and 6.0g only in caged plots for 1st and 2nd seasons, respectively. Also, in open plots of Taka 2, weight of open pollinated seeds was reached to 16.7 and 11.0g compared with 9.6 and 6.9g in caged plots for 1st and 2nd season, respectively.

3.4.2. Average weight of 1000 seed (Seed Index), seeds/m² and estimated mean yield/feddan

Data presented in Table (2) illustrated that the mean weight of Seed Index of Taka 2 was the heaviest, with 4.2 g weight compared to 3.1 g in caged seeds in both seasons. Whilst, the corresponding values of Taka 1 were 3.3 and 2.7g for open and caged seeds, respectively. On the same context, the yield of seeds (g)/m² was showed also significant increasing between open and caged plots. So, open plots values of Taka 1 reached 235.0 and 210 g/m² compared with 167.5 and 140.1 g/m² for caged plots in 1st and 2nd seasons, respectively. Moreover, the same trend occurred for open plots of Taka 2, where the yield of seeds/m² reached up to 270.8 and 217.6 g compared to 157.1 and 134.3 g for caged plots in 1st and 2nd seasons, respectively. According to four previous mentioned parameters, the estimated mean yield/feddan showed supremacy of open pollinated plots than caged (without any pollinators) ones, values of open pollination treatment for Taka 1 reached up to 986.9 and 888.2kg/feddan faced 703.6 and 588.4 kg/feddan for caged treatment. In addition, the obtained data exhibited the same vigor of open treatment for Taka 2, with values reaching up to 1,137.1 and 913.8 kg/feddan compared with 659.8 and 563.9 kg/feddan for caged ones **(**Table 2).

It could be concluded that the cross-pollination played an important role in sesame cultivars vigor than self-pollination (in cages). Also, sesame crop productivity improved with cross-pollination, with the abundance of forager honey bees in sesame cultivars. Moreover, from the previous data, it appeared that yield of *S. indicum* var. Taka 2 was the best with cross-pollination, and therefore it could be recommended with increasing cultivated area from *S. indicum* var. Taka 2 cultivars, especially with abundantly of honey bee workers.

In spite of some authors reporting that sesame is a self-pollinated crop (Kinman and Martin, 1954), variable amounts of cross-pollination occur, depending on variety, (Rheenen, 1968 and Khidir, 1972). However, type of pollination was also, confirmed in the present study and beside the benefit of the two cultivars from open crossing, the response of Taka 2 variety to cross-pollination was higher than that of Taka 1 cultivar. Srivastava and Singh (1968) recorded 43.66% increased of yield over the best parent when they crossed between two different cultivars. Also, Rashad *et al*. (1979) in their study on insect pollinators of sesame appeared that plots caged with honey bees had significantly higher yield than plots caged to exclude insects; however, open plots had the highest yield. They added that the average yield in open plots was 552kg/feddan. However, Mishra (1994) stated that the highest yield of sesame was in open-pollinated areas with value 820kg/hectare, followed by *A. mellifera* pollinated areas with value was 744kg/hectare, and finally the lowest yield for areas without insect pollinators with value was 497kg/hectare. It worth note, our results are in agreement with the findings of Abd Al-Fattah (1995) who studied the behavior of honey bees, *Apis mellifera* L. workers on two cultivars of sesame crop, *Sesamum indicum* L., and their relative role in pollination. He found that the yield of exposed plants for M-

Table (2): Impact of honey bee on sesame yield of two sesame varieties under open and caged conditions during two successive seasons 2020 and 2021.

Parameter	No. capsules/plant		Weight of seed /plant (g)		Weight of seed/m^2 (g)		Seed Index (g)		Yield/fed (kg)	
Season / Treatment	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Taka 1										
Open field	74.9**	66.5**	14.35**	10.89**	235.0**	210.0**	3.34**	3.31**	986.9**	888.2**
Caged	66.4	52.6	10.64	5.97	167.5	140.1	2.72	2.72	703.6	588.4
Taka 2										
Open field	88.7**	74.8**	16.67**	11.04**	270.8**	217.6**	4.22**	4.18**	1137.1**	913.8**
Caged	54.6	58.7	9.58	6.92	157.1	134.3	3.17	3.12	659.8	563.9

**Means highly significant at 5% level of significance.

48 sesame variety was significantly higher than those for the variety of 301 3BO throughout the two seasons.

Also, Kamel (1997) found that the open pollination of sesame flowers improves the quality and quantity of the crop. However, Baydar and Gürel (1999) in their study on the effect of honey bees on cross-pollination and hybrid seed production in sesame, *S. indicum* L., reported that seed yield increased in the varieties "Golmarmara, Margo and Yousung", which were up to 9.52, 39.65 and 21.49 %, respectively. Also, Caliskan *et al*. (2004) found that the highest sesame seed yield was obtained from 510,000 plant/ha in 2002 and 2003, with 1,633 and 1,783 kg/ha, respectively.

Our findings also confirmed the results of Blal *et al*. (2013), they showed that higher of number of capsule/plants, capsule weight, number of seed/capsules, seed index and seed yield/plant in open plots of sesame compared with caged ones. On another study, Pasthe and Shylesha (2013) found that there was an increase in the number of capsules by almost double from 27.93 to 51.90 when repeated visits of *A. cerana* foragers occurred for sesame flowers. Also, Rahman (2014) documented the percentages of capsule setting were 80.0%, 73.6 and 65.6% for bee pollinated, open pollination and caged plots, respectively. Moreover, the same positive effect of bee pollination was determined by Sajjanar and Eswarappa (2015), their data showed that number of capsules/plants improved from 29.14 in caged plots (without insect pollinators) to 40.43 in caged plots with honey bees' colonies. However, Das and Jha (2019) reported that the fully open pollinated plots of sesame presented higher seed yield than plots that were supplied with honey bee colonies only. Meanwhile, findings of Das and Jha. (2019) revealed that open pollination exceeded, slightly, then honey bees' pollination, but both treatments excelled by a significant increase compared with the treatment without any pollinators. Therefore, values of number of capsules/plants, seed index (g) and yield (kg/ha) were (41.57, 3.10 and 835.14), (38.85, 2.89 and 784.71) and (28.71, 2.56 and 580.28) for treatments of open pollination, honey bees' pollination and without any pollinators, respectively.

Regarding of insect pollination effectiveness on sesame, Rahman *et al*. (2022) determined significantly impact of honey bees as pollinators on sesame. They designed three treatments to evaluate the effect of pollinators on sesame as following, T_1 (caged with honey bees), T_2 (caged without honey bees) and T_3 (open), all if items of both No. capsules/plant, seed Index (g) and total estimated yield (t/ha) were significantly higher between T_1 and T_2. No. capsules/plant was 86.5, 58.8 and 83.5 for T_1, T_2 and T_3, respectively. Moreover, results of seed Index (g) and total estimated yield (t/ha) were (3.5 & 1.2), (2.9 & 0.8) and (3.2 & 1.0) for T_1, T_2 and T_3, respectively. Furthermore, Rao *et al*. (2022) revealed that the bee-pollinated treatments showed a significant improvement for qualitative and quantitative parameters of sesame. so, they stated that the highest percentage of capsule setting was current in the treatment of bee pollination with value 88.3%, followed by open pollination with value 79.6%, then the lowest value for without insect pollinators was 75.8%. Moreover, they found significant increasing value for bee pollination treatment about No. capsules/plant compared with treatments of open pollination and plots without

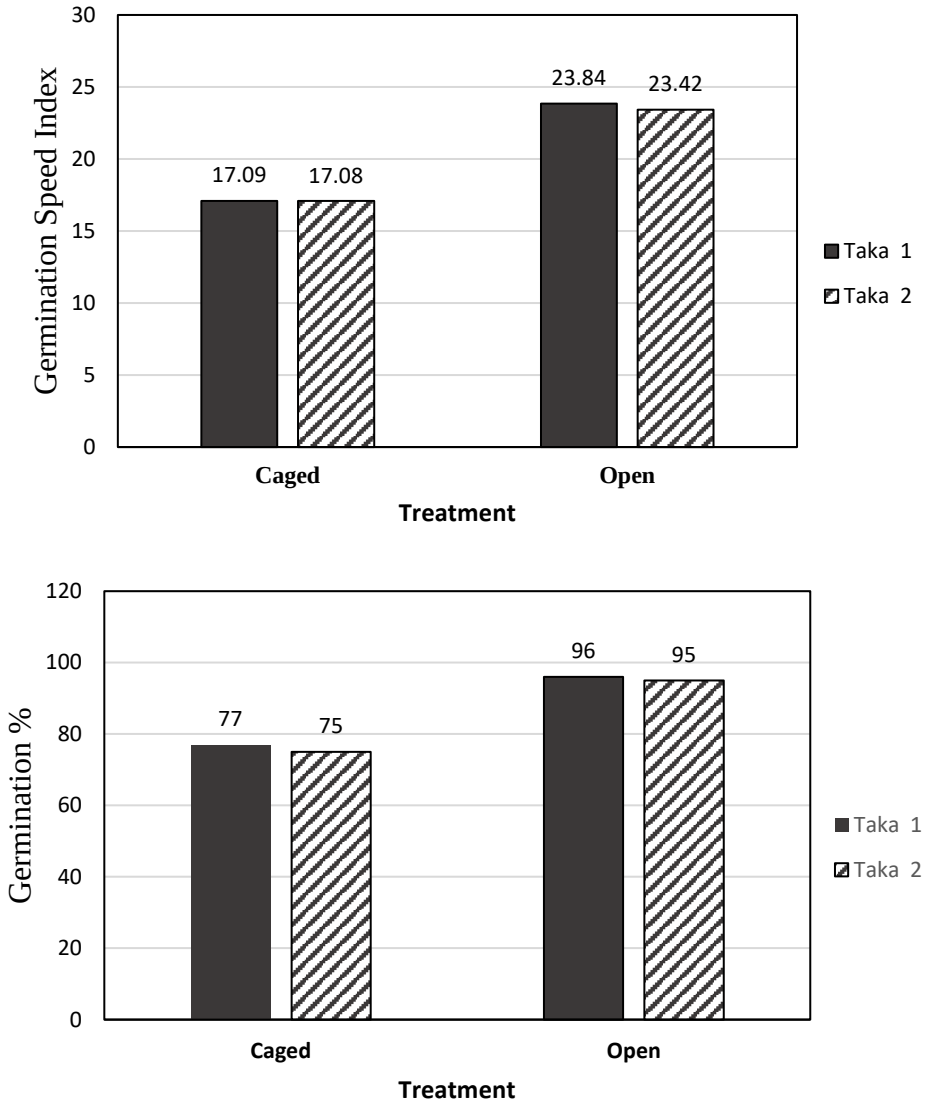


Fig. (2): Germination test of seeds for two varieties of sesame under open and caged treatments.

insect pollinators with values reached to 77.7, 66.9 and 52.9 capsules/plant for three treatments, respectively. (Rao *et al*., 2022). Also, on the same context of high efficacy of honey bees as an excellent pollinator; findings of Rao *et al*. (2022) referred to that parameters of seed Index (g), weight of yield (g)/m^2 and yield (kg)/hectare came in the interest of the areas that were vulnerable to pollination by bees with significant high values reaching 3.02 g, 8.86 g and 787.6 kg, respectively. Whereas, the corresponding results of same previous parameters for open pollination were 2.70 g, 7.22 g and 641.3 kg, and were 2.45 g, 5.35 g and 475.1 kg, respectively, for the treatment without insect pollinators.

3.5. Effect of pollination on germination of sesame seeds

The values of GSI were 23.42 and 23.84% in open Taka 1 and Taka 2, respectively. Contrary, values of caged treatment were 17.08 and 17.09%. While, GP values were 95.0 and 96.0% in open seeds of Taka 1 and Taka 2, respectively. Whilst, values were 75.0 and 77.0% in caged seeds. Therefore, open-pollination was considered the best agent for hybrid vigor in sesame cultivars (Fig. 2).

These results go in line with the findings of Baydar and Gurel (1999) they found that the ratios of sesame cultivars on cross-pollination values were significantly different for the varieties in the

caged experiments. However, the ratio cross-pollination was 4.29, 18.69 and 11.72% in progenies from non-caged plots, and 2.40, 4.61 and 4.29% in progenies from caged plots of Golmarmara, Margo, and Yousung, respectively.

4. Effect of pollination on chemical analysis of sesame seeds

carbohydrates were higher in open seeds of Taka 1 with percentages 22.1 and 12.5% compared with 21.32 and 10.1% for caged seeds.

Moreover, similar on Taka 2 with percentages 26.5 and 10.4% compared with 22.8 and 8.7% for crude protein and carbohydrates, respectively. (Fig. 3).

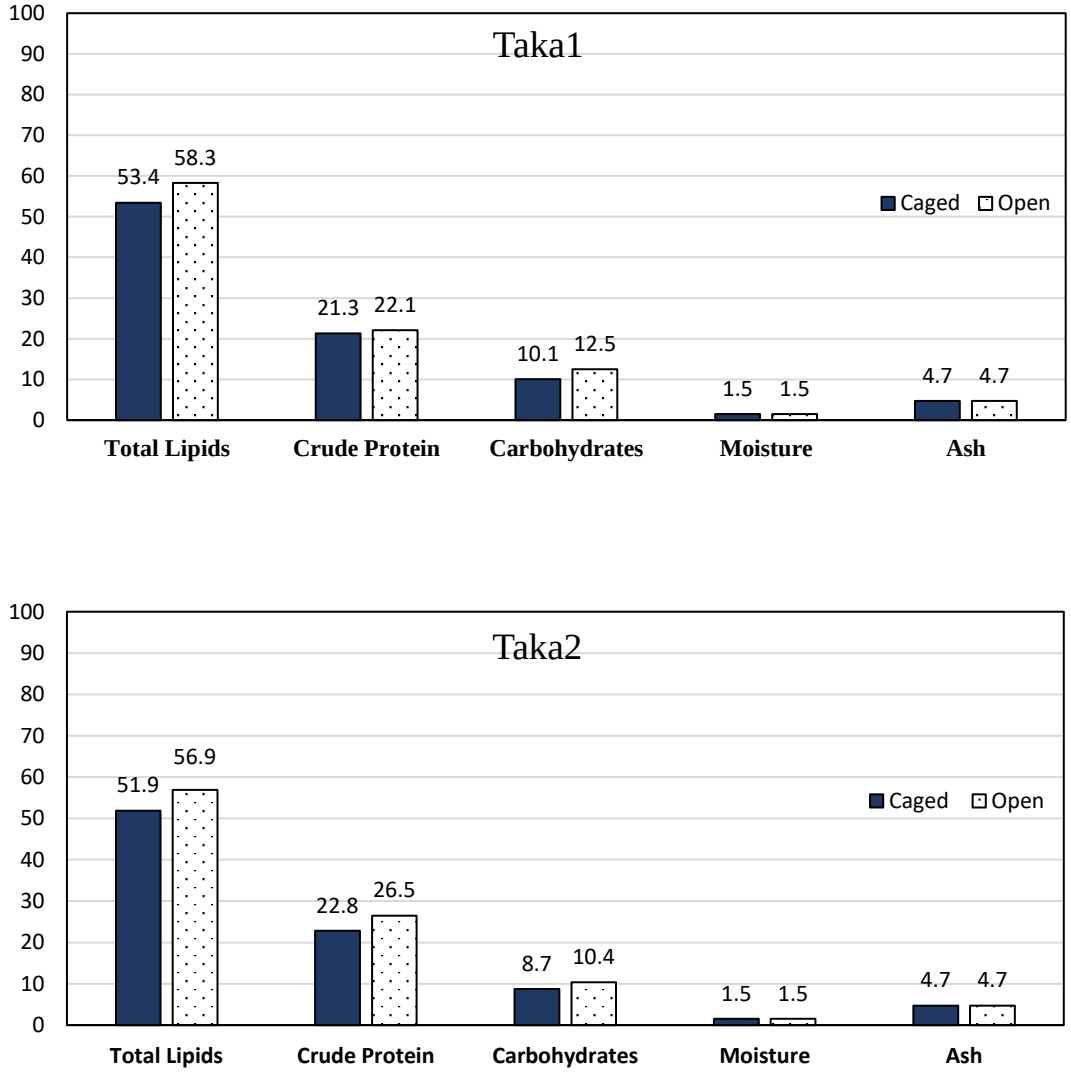


Fig. (3): Chemical analysis (%) of seeds of two sesame varieties (Taka 1 and Taka 2) under open and caged treatments.

Chemical analysis of sesame seeds clarified that, the seeds of sesame were rich source of lipid with percentages 58.23 and 56.87% in case of open treatment, compared with 53.39 and 51.94% of lipid in caged ones, for Taka 1 and Taka 2, respectively. In addition, crude protein and

Dashak and Fali (1993) found that seeds of 4 sesame cultivars contained high amounts of protein, oil and essential amino acids, the ash, moisture and carbohydrate contents were low. The iodine values and saponification values of the oils were high, indicated that they contained

unsaturated fatty acids. The seeds of 28 sesame strains were contained 46.5-55.3% oil, 18-26% protein, 2.85-3.85g methionine / 16g N, 0.156-0.288% S, 1.12-1.51% reducing sugars, 5.6-7.25% total sugar, 0.8-1.4% Ca, 0.41- 0.71% P, 0.4-0.95% K and 40.4 – 52.7% protein on oil-free basis.

These results are in agreement with the findings of Su *et al*. (2006). They reported that sesame, *Sesamum indicum* L.; seeds were contained abundant oil and antioxidant lignans related to the seed quality. In addition, Mazzani and Layrisse (1998) analyzed the chemical composition of seeds of 19 sesame's cultivars were from the germplasm bank in Venezuela. They found that the average oil content was >55% in 4 cultivars, whilst protein content was from 17.8 % to 28.1 %. Principal fatty acids were oleic and linoleic acids. Moreover, these findings and our results of chemical composition of sesame were consisted with findings of Sajjanar and Eswarappa (2015), they found the highest oil content was found in honey bee-pollinated plots with value 52.84 %, followed by open pollination with value 49.46 %, and finally the lowest value was 42.96 % for caged plots. Also, Rao *et al*. (2022) demonstrated that the sesame seeds from bee pollination treatment have supremacy in germination percentage and oil content with values 72.1 and 45.86, respectively. Whereas, the corresponding values were 61.4 and 45.03 % for open pollination, and 50.0 and 42.8 % for the treatment without insect pollinators, respectively.

Authors' contributions

All authors contributed in conceptualization, methodology, software, validation, formal analysis investigation, resources, data curtain, writing the original draft preparation, writing, review, editing, supervision and funding acquisition. All authors have read and agreed to the published version of the manuscript.

Competing interests

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

4. REFERENCES

AOAC (2000). Official methods of analysis of the association of official analytical chemist. 14th cd Washington, DC., USA.

AOSA (1983). Seed vigor testing handbook. Contribution No.32 to the Handbook on seed testing. 93p.

Abd Al-Fattah, M.A. (1995). The behavior of honey bee (*Apis mellifera* L.) workers on two cultivars of sesame crop, (*Sesamum indicum* L.) and their relative role in the pollination. Bull. Ent. Soc. Egypt. 73: 143-158.

Abou-Gharbia, H. A., Shehata A. A. Y. and Shahidi F. (2000). Effect of processing on oxidative stability and lipid classes of sesame oil. Food Res. Int. 33: 331-340.

Baydar, H. and Gurel F. (1999). The effects of honey bees on cross-pollination and hybrid seed production in sesame, *Sesamum indicum* L. Turk. J. Field Crops. 4(1): 21-24.

Blal, A. E. H., Kamel S. M., Mahfouz H. M., and Said M. (2013). Impact of opened, non-opened pollination and nitrogen fertilizer on sesame production in the reclaimed lands. Ismailia Governorate, Egypt. Pp:57-68

Borchani, C., Besbes S., Blecker C.H. and Attia H. (2010). Chemical characteristics and oxidative stability of sesame seed, sesame paste, and olive oils. J. Agric. Sci. Tech. 12(5): 585-596.

Caliskan, S., Arslan M., Arioglu M. and Isler N. (2004). Effect of planting method and plant population on growth and yield of sesame, *Sesamum indicum* L., in a Mediterranean of environment. Asian J. Plant Sci. 3(5): 610-613.

Crane, E. and Walker P. (1984). Pollination directory for world crops. Int. Bee Res. Assoc. England. Pp 184.

Das, R. and Jha S. (2019). Insect Pollinators of Sesame and the effect of entomophilous pollination on seed production in New Alluvial Zone of West Bengal. Int. J. Curr. Microbiol. Appl. Sci. 8(3): 1400-1409.

Dashak, D. A. and Fali C.N. (1993). Chemical composition of four varieties of Nigerian benniseed (*Sesamum indicum* L.). Food Chem. 47(3): 253-255.

Duncan, D. B. (1955). Multiple range and multiple F test. Biometrics. 11:1-24.

El-Masarawy, M. S., El-Bendary H.M., and El-Helaly A.M.A. (2021). The effect of using imidacloprid and chlorpyrifos and their nanoforms on certain characteristics of honey bee *Apis mellifera* L. Int. J. Trop. Insect Sci. 41:1037-1042.

El-Rabie, H. G. (1976). Pollination of groundnut (*Arachis hypogea* L.) and sesame (*Sesamum*

indicum L.) with special reference to the role of honey bees. M.Sc. Thesis, Fac. Agric. Al-Azhar Univ. Egypt. 92 Pp.

FAO (2022). Food and Agriculture Organization Statistics (FAOSTAT) for crops. https://www.fao.org/faostat/en/#data/QCL.

Guirguis, N. G. (1965). Survey and ecological studies of the insect pollinators of some crops in Qalyubia and Delta region. M.Sc. Thesis, Fac. Agric. Cairo Univ. 141p.

Hegde, D. M. (2012). Sesame. (Eds. Peter K.V.) Hand book of herbs and spices. 449-486.

Kahyaoglu, T., and Kaya S. (2006). Modeling of moisture, color and texture changes in sesame seeds during the conventional roasting. J. Food Eng. 75: 167-177.

Kambrekar, D. N., Kulkarni S., Jahagirdar S., and Natikar P.K. (2019). Pollinator diversity of sesame, *Sesamum indicum L.* and their abundance in Dharwad district of Karnataka. J. Exp. Zool. India. 22(1): 167-169.

Kamel, S. M. (1997). Occurrence and activity of Hymenopterous insects on sesame flowers with special reference to their effect on crop production. Ann. Agric. Sci. Moshtohor. 35(3): 1713-1725.

Khidir, M. O. (1972). Natural cross-fertilization in sesame under Sudan conditions. Exp. Agric. 8(1): 55-59.

Khidir, M. O. (1973). Genetic studies in sesame. II. Inheritance of flower colour and number of locules per pod. Exp. Agric. 9(4): 361-364.

Khidir, M.O. and Elawad S.H. (1972). Studies on floral biology in sesame. Fac. Agric. Univ. Khartoum, Sudan. Agric. J. 17(4): 55-62.

Kinman, M. L. and Martin J.A. (1954). Present status of sesame breeding in the United States. Agron. J. 46(1): 24-27.

Mahfouz, H. M., Kamel S., Belal M. A. H. and Said M. (2012). Pollinators visiting sesame (*Sesamum indicum* L.) seed crop with reference to foraging activity of some bee species. Cercet. Agron. Mold. 45(2): 49-55.

Mazzani, E. and Layrisse A. (1998). Chemical characteristics of seeds of sesame cultivars selected from the Venezuelan germplasm collection. Agron. Trop. Maracay, 48(1): 5-18.

McGregor, S. E. (1976). Insect pollination of cultivated crop plants. Agric. Handbook USDA. No. 496. 411p.

Mishra, R. M. (1994). Effect of honey bee (Apis mellifera L.) pollination on the yield of sesamum and its oil Content (Doctoral dissertation, M. Sc. Thesis, Orissa University of Agriculture and Technology, Bhubaneswar.

Mohamed, H.M.A. and Awatif I.I. (1998). The use of sesame oil unsaponifiable matter as a natural antioxidant. Food chem. 62(3): 269-276.

Namiki, M. (2007). Nutraceutical functions of sesame: a review. Crit. Rev. Food Sci. Nutr. 47(7): 651-673.

Pashte, V. V. and Shylesha A. N. (2013). Effect of number of honey bee visits on yield of sesamum. Bioinfolet-A Quart. J. Life Sci. 10(4c): 1591-1592.

Rahman, M. Z. (2014). Effect of bee pollination on the yield of sesame, *Sesamum indicum L.* Ph. D. Thesis, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Rahman, M. Z., Reza M. E., Hossain M. S., Ali M. R. and Hossain M. S. (2022). Effect of bee pollination on yield of sesame. Ecol. J. 4(1): 1-7.

Rao, K. S. (2019). Role of insect pollinators towards yield attributing parameters of Sesame (*Sesamum indicum* Linnaeus), Doctoral dissertation, Ph.D. Thesis. Chaudhary Charan Singh Haryana Agric. Univ., Hisar, Haryana, India, 121 pp.

Rao, K. S., Kumar Y., Yadav S., Poonia R., and Nayak S. B. (2022). Effect of different Modes of Pollination on Sesame yield parameters. In Biol. Forum-An Inter. J. 14(1): 238-242.

Rashad, S. E., Ewies M. A. and El-Rabie H. G. (1979). Insect pollinators of sesame, *Sesamum indicum* L., with special reference to the role of honey bees. Proceedings 4th International Symposium on Pollination, Maryland, Agric. Exp. Sta. Spec. Misc. Publ. 1:231-234.

Rheenen, H. A. V. (1968). Natural cross-fertilization in sesame (*Sesamum indicum* L.). Trop. Agr. 45(2): 147-153.

Said, M., Kamel S.A. and Mahfouz A.B.H. (2013). Impact of insect pollinators on sesame production. Lap Lambert Academic Publishing, Saarbrucken, Germany. P. 92.

Sajjanar, M. S. and Eshwarappa G. (2015). Bee pollination in crop production of sesame (*Sesamum indicum* L.). Mysore J. Agric. Sci. 49(4): 703-707.

Sarker, A. M. (2004). Effect of honey bee pollination on the yield of rapeseed, mustard and sesame. Geobros. 31:49-51.

Srivastava, D. P., and Singh S.N. (1968). Heterosis in sesame. J. India. Bot. Soc. 47(1-2): 79-88.

Stein, K., Coulibaly D., Stenchly K., Goetze D., Porembski S., Lindner A., Konaté S. and Linsenmair E. K. (2017). Bee pollination increases yield quantity and quality of cash crops in Burkina Faso, West Africa. Scient. Rep. 7:1-10.

Su, K. K., Noh R. S. and Gon C H. (2006). Influence of drought stress on chemical composition of sesame seed. Korean J. Crop Sci. 51(1): 73-80.

Vogel, A. J. (1975). A text book of practical organic chemistry. 3rd Ed. English Language Book Society and Longman Group Ltd. London. UK. 969-971

Weiss, E. A. (1983). Tropical oilseed crops. – (Tropical agricultural series). 1st Ed. Longman Inc., New York, USA., Pp. 161-215.

تأثير التلقيح بنحل العسل على محصول البذور والتركيب الكيميائي لصنفين من السمسم في مصر

محمد عبد الوهاب عبد الفتاح و محمد صلاح المعصراوى

قسم الحشرات الاقتصادية والمبيدات, كلية الزراعة, جامعة القاهرة, 12613- الجيزة - مصر

ملخص

تهدف هذه الدراسة إلى تقييم تأثير وكفاءة التلقيح الخلطي بواسطة نحل العسل *Apis mellifera* L. على محصول السمسم *Sesamum indicum* L. بالإضافة إلى تحديد مؤشر سرعة الإنبات (GSI)، ونسبة الإنبات (GP)، والتركيب الكيميائي لبذور السمسم المُنتجة من المعاملة المفتوحة للتلقيح والمعاملة بدون نحل العسل. ولقد أظهرت النتائج المتحصل عليها أن التلقيح المكشوف أدى إلى زيادة كلاً من عدد القرون/نبات، ووزن البذور/نبات، ومتوسط المحصول/فدان، ومعامل البذور Seed Index (وزن 1000 بذرة) بزيادة معنويةه عن تلك االناتجة من المعامله بدون حشرات ملقحه لكلا الصنفين من السمسم (طاقة1 و طاقة 2). كما أن وجود وزيارة شغالات نحل العسل لأزهار السمسم كان له تأثير جيد على مؤشر سرعة الإنبات التلقيح (GSI) للبذور المنتجة، وكانت قيم هذا المعامل 23.42 و 23.84% في البذور الناتجة من معاملة التلقيح المكشوف مقارنة بـ 17.08 و 17.09% في معاملة الأقفاص لكلا صنفي السمسم طاقه 1 و طاقه 2 على التوالي. ولوحظ نفس التأثير تقريباً عند قياس نسبة الإنبات (GP)، حيث كانت أعلى البذور الناتجة من معاملة التلقيح المكشوف بنسبة (95.0 و 96.0%) مقارنة بتلك المنتجة في معاملة الأقفاص (75.0 و77.0%) لكلا صنفي السمسم تحت الدراسة على التوالي. علاوة على ذلك، أدى التلقيح الخلطي إلى تحسين التركيب الكيميائي لبذور السمسم، حيث ارتفعت نسبة الدهون الكلية والبروتين الخام والكربوهيدرات في البذور الناتجة من معاملة التلقيح الخلطي مقارنة بنسبها في البذور المنتجة من معاملة النباتات غير المُعرضة للنحل والتلقيح الخلطي لصنفي السمسم.

المؤتمر الرابع عشر لإتحاد النحالين العرب (13-15 نوفمبر)2023 (القاهرة- مصر).
المجلة المصرية للعلوم الزراعية 2024 (المجلد 75) اصدار خاص: 67-77.