Pestic. Phytomed. (Belgrade), 27(2), 2012, 117–129
DOI: 10.2298/PIF1202117M

UDC: 582.952.2:581.162.3
Scientific paper

Insects Associated with Sesame (*Sesamun indicum* L.) and the Impact of Insect Pollinators on Crop Production

Mahmoud Farag Mahmoud

Suez Canal University, Faculty of Agriculture, Plant Protection Department, 41522 Ismailia, Egypt
(mfaragm@hotmail.com)

Received: March 1, 2012
Accepted: March 27, 2012

SUMMARY

A survey of insects associated with sesame, *Sesamun indicum* L. (Pedaliaceae) was conducted at the Agriculture Research Farm of The Faculty of Agriculture, University of Suez Canal during the growing seasons 2010 and 2011. All different insect species found on the experimental site were collected for identification. Sampling was done once a week and three times a day. Three methods were used to collect insects from the sesame plants (a sweep net, pitfall traps, digital camera and eye observation). A total of 31 insect species were collected and properly identified during the survey. Insects recorded on the plants were divided into four groups, true pollinators (Hymenoptera), other pollinators (Diptera, Coleoptera and Lepidoptera), pests (Orthoptera, Odonata, Hemiptera and Homoptera) and natural enemies (Coleoptera, Hymenoptera, Neuroptera and Dictyoptera).

For studying the impact of insect pollination on sesame production, the experiment was divided in two: opened and non-opened pollination of sesame. 50 plants from non-opened pollination were covered with a perforated paper bag to allow the air to pass through and to prevent insects from approaching the plants. Quantitative and qualitative parameters were measured as follows: pod weight, number of seeds in each pod, weight of 1000 seeds, germination (%), seedlings vigour and oil content (%). Results clearly demonstrate that the opened pollination improved the crop production.

Keywords: Sesame; Pests; Pollination; Natural enemies; Crop production

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oilseed crop in tropics and subtropics. However, 99% of its production area is located in developing countries, where it is usually grown by small holders. In Egypt, sesame is considered a food crop rather than an oilseed crop because most of its produced seed is consumed directly. Also, it is an excellent source of nectar and pollen for insects.

A total area under sesame production in Egypt has increased from 11.264 ha in 1961 to 31.000 ha in 2009, and a quantity of sesame seed has also increased from 10.469 tons in 1960 to 41.000 tons in 2009 (Faostat, 2011). According to FAO estimates, Honduras and Egypt are the leading countries in sesame production achieving a yield of 1267 and 1063 kg/ha, respectively. It is clear that the increase in sesame production during the last ten years was mainly due to the increase in cultivated area especially in newly reclaimed sandy soils.

Any assessment of new regions potential for sesame production would be aided by the knowledge of insect fauna that is associated with this crop. Insect pests of sesame were broadly reviewed by several authors (Biswas et al., 2001; Rai et al., 2001; Thapa, 2006).

Co-evolution of flowering plants and their pollinators started about 225 million years ago (Price, 1975). Insufficient number of suitable pollinators causes a decline in fruit and seed production (Partap, 2001). Of the total pollination activities, over 80% is performed by insects and bees therefore, they are considered the best pollinators (Robinson and Morse, 1989). Sesame flower structure facilitates cross-pollination, even though the crop is usually considered as self-pollinating. The rate of cross-pollination is between 0.5% and 65% depending on insect activity, environmental conditions and availability of other vegetation (Rakesh Kumar and Lenin, 2000). Ashri (2007) cited Van Rheenen who achieved pollination rates between 2.7 and 51.7% in Nigeria. Both opened and bee pollination treatments were effective in increasing the seed yield of sesame from 22 to 33% compared to "pollination without insects" (Panda et al. 1988). In addition to increasing the yield, cross-pollination also helps raising the quality through a more unified ripening period and an earlier harvesting time.

The purpose of this research was to identify insects associated (i.e., herbivorous, pollinators, predacious, parasitic) with sesame crop during the critical period (flowering phase) in Ismailia Governorate. Also, the impact of pollinators on qualitative and quantitative parameters of sesame crop was assessed.

MATERIAL AND METHODS

Experimental design

The experiment was conducted at the Farm of Agriculture Faculty, University of Suez Canal, during two successive seasons of 2010 and 2011. The area used for the experiment (2800 m^2) was divided into 24 plots of 8×10 m^2 each and separated by a clean space of 0.5 m^2. *Sesamun indicum* L. seeds, cultivar Shandawil 3, were purchased from the Agriculture Research Center, Giza. Prior to planting seeds were treated with Rizolex-T (3 g/kg seeds) to prevent rot infection. Seeds were planted on previously prepared seed bed, on the flat surface at a distance of 0.3 m between the rows and drilled within the rows. Normal cultivation measures were applied before the harvest. The plants were grown insecticide-free during both seasons.

Collection and identification of true pollinators, other pollinators, pests and natural enemies

Plants were examined weekly, three times a day (early morning – afternoon – before evening) during the flowering period (7 weeks) for the presence of insects, which were then collected and identified. Three methods were used to collect insect from the sesame plants: a sweep net measuring 40 cm in diameter was used to collect insects flying over the plots, pitfall traps containing 4% formalin solution were used to trap insects walking on the surface and digital camera and eye observation were used to clear and settle insects**.** Observations of insect associations feeding on sesame leaves, stems, flowers, and pods, as well as predacious and parasitic activity against insect herbivores were carried out whenever possible, prior to specimens collection and preservation for identification. Insects were identified to the level of species, when possible, using published systematic keys and direct comparison with museum specimens from the Department of Plant Protection, Ismailia.

Impact of insect pollination on sesame production

For assessing the impact of insect pollination on sesame production, experiment was divided in two: opened and non-opened pollination of sesame. 50 plants from non-opened pollination were covered with a perforated paper bag to allow the air but at the same time to prevent insects to pass through. Quantitative and qualitative parameters were measured as follows: pod weight,

number of seeds in each pod, weight of 1000 seeds, germination (%), seedlings vigour and oil content (%) (Dhurve, 2008).

a- Quantitative parameters

1- Pod weight:

Weight of 25 randomly selected pods from each treatment was measured before the harvest using an electronic balance.

2- Number of seeds per pod

The number of seeds in a pod was counted and expressed as seeds per pod. Observation was made on 10 randomly selected plants per treatment.

3- Weight of 1000 seeds

The observation was made by weighing 1000 dried seeds drawn randomly from each treatment using an electronic balance and replicated 4 times for each treatment.

4- Seed yield per plant

After maturation, the pods from ten plants from each treatment were removed and recorded. The seeds were separated and weight using an electronic balance and expressed in grams per plant.

b- Qualitative parameters

1- Germination (%)

A hundred seeds obtained from the different treatments were taken and placed on germination paper in germination chamber at 27°C and 80% RH. The germination was estimated after 5 days of incubation and expressed in percents based on the number of seedlings obtained in the test out of total number of placed seeds. This test was replicated 4 times.

2- Seedlings vigour

For evaluating seedlings vigour, shoot and root length of twenty five seedlings from each treatment were measured when the 1st set of true leaves were visible.

3- Oil content (%)

Dried seeds were ground in a Moulinex grinder. For solvent extraction (Soxlhet method), 50g of ground seeds from each treatment were placed into a cellulose paper cone and extracted using light petroleum ether in a Soxhlet extractor for 8 h (Pena et al., 1992). Each treatment was replicated 4 times. The oil was then recovered by evaporating the solvent using a rotary vacuum evaporator and afterwards the percentage of oil content was calculated.

Meteorological conditions during the experiment

The weather data including temperature, relative humidity and wind speed were also recorded during the flowering period of sesame in two growing seasons of this study.

Statistical analysis

The data on quantitative and qualitative parameters were statistically analyzed using ANOVA (SAS Institute 2002). When F-test was significant, means were separated using Tukey's Honestly Significant Difference (HSD) Test at the 0.05 level of significance.

RESULTS

4

7

5

8

6

9

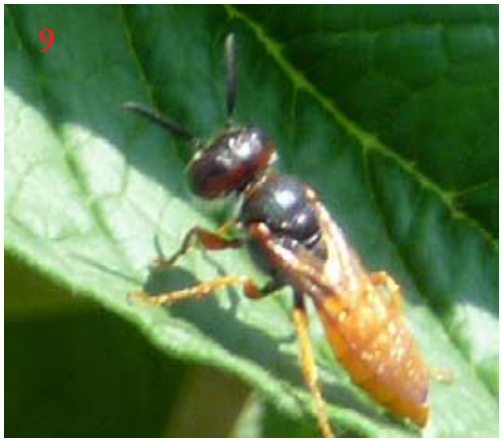


Figure 1. Some pollinators collected from sesame flowers, 1 – *Apis mellifera*, 2 – *Anthidium* sp., 3 – *Anthophora albigena*, 4 – *Megachile* sp., 5 – *Osmia* sp., 6 – *Xylocopa pubescens*, 7 – *Diellis collaris*, 8 – *Bembix priesneri*, 9 – *Philantus triangulum*, 10 – *Eumenes maxillosus*, 11 – *Musca domestica*, 12 – *Eristalis* sp., 13 – *Sarcophaga* sp., 14 – *Danaus chrysippus*, 15 – *Coccinella undecimpunctata*

Hymenopterous fauna of sesame (true pollinators)

Insects found in association with sesame plants during two successive seasons were divided in Hymenopterous fauna-true pollinators (Table 1), other pollinators (Table 2), pests (Table 3) and natural enemies (Table 4). Thirty-one species of pollinators, insect herbivores, predators and parasitoids were recorded feeding or captured on sesame leaves, stems, flowers, extra-floral nectarines or pods during the flowering period.

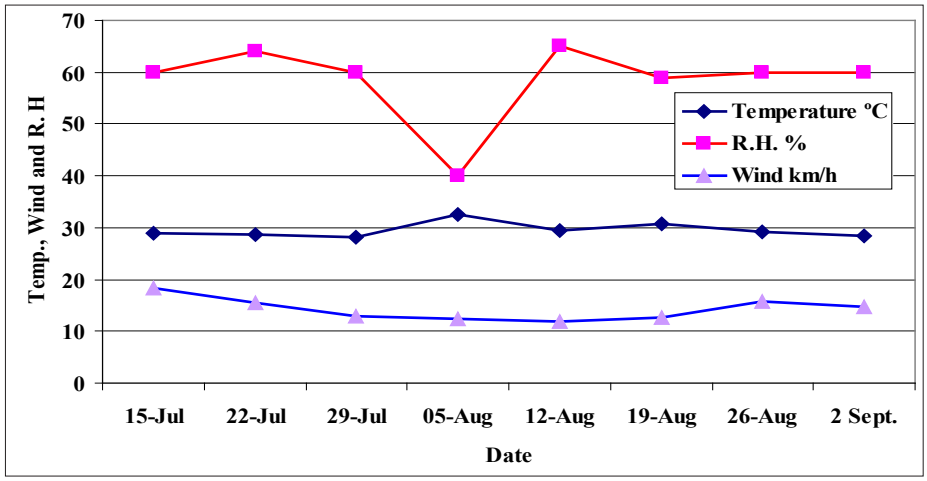
The list of true pollinators (Hymenopterous fauna) that visited sesame flowers is presented in Table 1. 11 species of true pollinators were recorded during the present study: three belonging to family Megachilidae, two to Apidae, one to Anthophoridae, one to Sphecidae, one to Crabronidae, one to Eumenidae, one to Scoliidae, and one to Formicidae. The ration (%) of true pollinator species in collections out of total number of sampled Hymnenoptera specimens in 2010 and 2011 is presented in Table 1. Honybee, *Apis mellifera* was the most dominant species constituting 36.02% and 37.01% of sampled true pollinators in two successive years, followed by Sand wasp, *Bembix priesneri* 14.81%, 20.48%, Digger wasp, *Dielis collaris* 13.81%, 12.31% and Wool-Carder bee, *Anthidium* spp. 9.06%, 12.66%, respectively. The rest of true pollinators (Hymenoptera) together constituted 26.13% in 2010 and 17.68% in 2011, which included Mining bee *Anthophora albigena*, Carpenter bee *Xylocopa pubescens*, Mason bee *Osmia* spp., Leafcutter bee *Megachile* spp., Beewolf wasp *Philanthus triangulum abdelkader*, Potter wasp *Eumenes maxillosus* and Desert dwelling ant *Cataglyphis bicolor*.

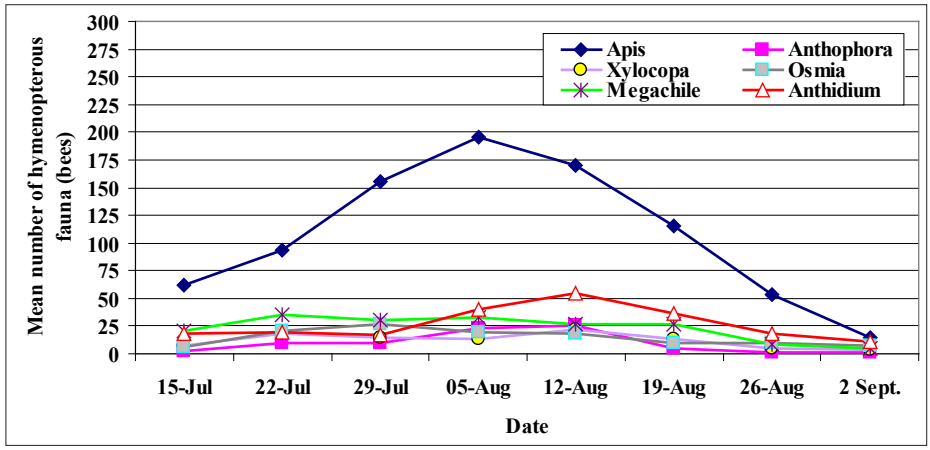
The phenology of true pollinators

The phenology of true pollinators (bees and wasps) on sesame crop during the flowering period in seasons of 2010 and 2011 is presented in Figures 2 and 3. It is noticed that all pollinators in both seasons reached the abundance peaks from 29th July to 12th August which represented about 50% of flowering period. The highest abundance peaks of Apis, Dielis and Bembix in season of 2010 were registered on the 5th of August when the average temperature, wind and relative humidity were 32.5°C , 12.4 km/h and 40% R.H., respectively. The peaks of Apis and Anthidium (bees) abundance in 2011 were recorded on the 5th of August when the average temperature, wind and relative humidity were 29.7°C , 14.4 km/h and 63% R.H., respectively. Regarding wasps, Bembix had two peaks of abundance on 29th of July with 29.7°C , 14.4 km/h and 63% R.H. and on 12th of August with 29.6°C , 22.6 km/h and 50% R.H., respectively. In addition, for Dielis wasp another peak was noticed on 5th of August with 28.8°C , 11.1 km/h and 63% R.H.

Table 1. Hymenopterous fauna of sesame during the flowering period in two successive seasons

No	Hymenoptera species	Systematic position	Species ratio %	
			2011	2010
1	*Apis mellifera* L.	Hymenoptera: Apidae	37.01	36.02
2	*Anthophora albigena* Priesner	Hymenoptera: Anthophoridae	2.64	3.27
3	*Xylocopa pubescens* Spinola	Hymenoptera: Apidae	5.56	4.07
4	*Osmia* spp.	Hymenoptera: Megachilidae	2.36	4.99
5	*Megachile* spp.	Hymenoptera: Megachilidae	1.42	7.85
6	*Anthidium* spp.	Hymenoptera: Megachilidae	12.66	9.06
7	*Bembix priesneri* Priesner	Hymenoptera: Sphecidae	20.48	14.81
8	*Philanthus triangulum abdelkader*	Hymenoptera: Crabronidae	0.71	2.18
9	*Eumenes maxillosus* (De Geer)	Hymenoptera: Eumenidae	3.35	1.88
10	*Dielis collaris* (Fabr.)	Hymenoptera: Scoliidae	12.31	13.81
11	*Cataglyphis bicolor* Fabricius	Hymenoptera: Formicidae	1.64	1.97





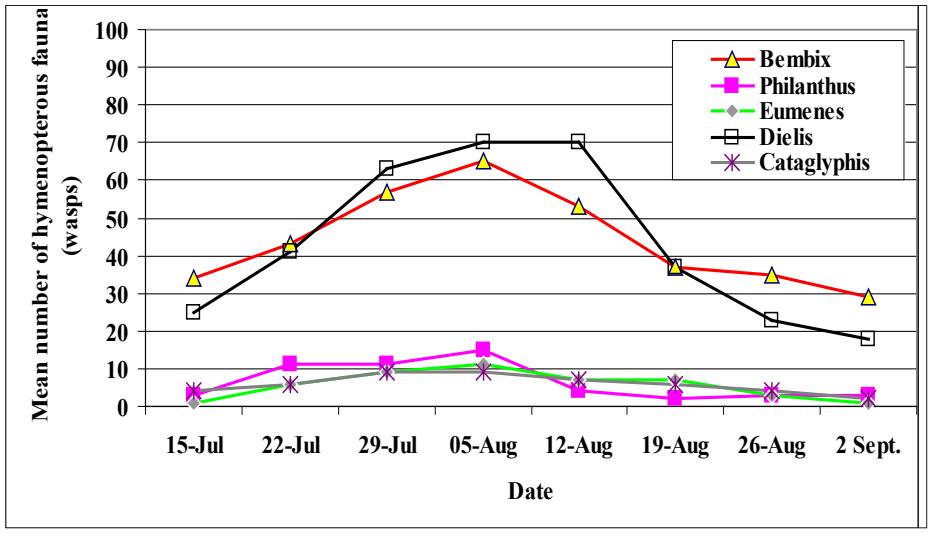


Figure 2. The phenology of true pollinators (bees and wasps) on sesame crop during the flowering period in 2010, with temperature, wind speed and R.H.

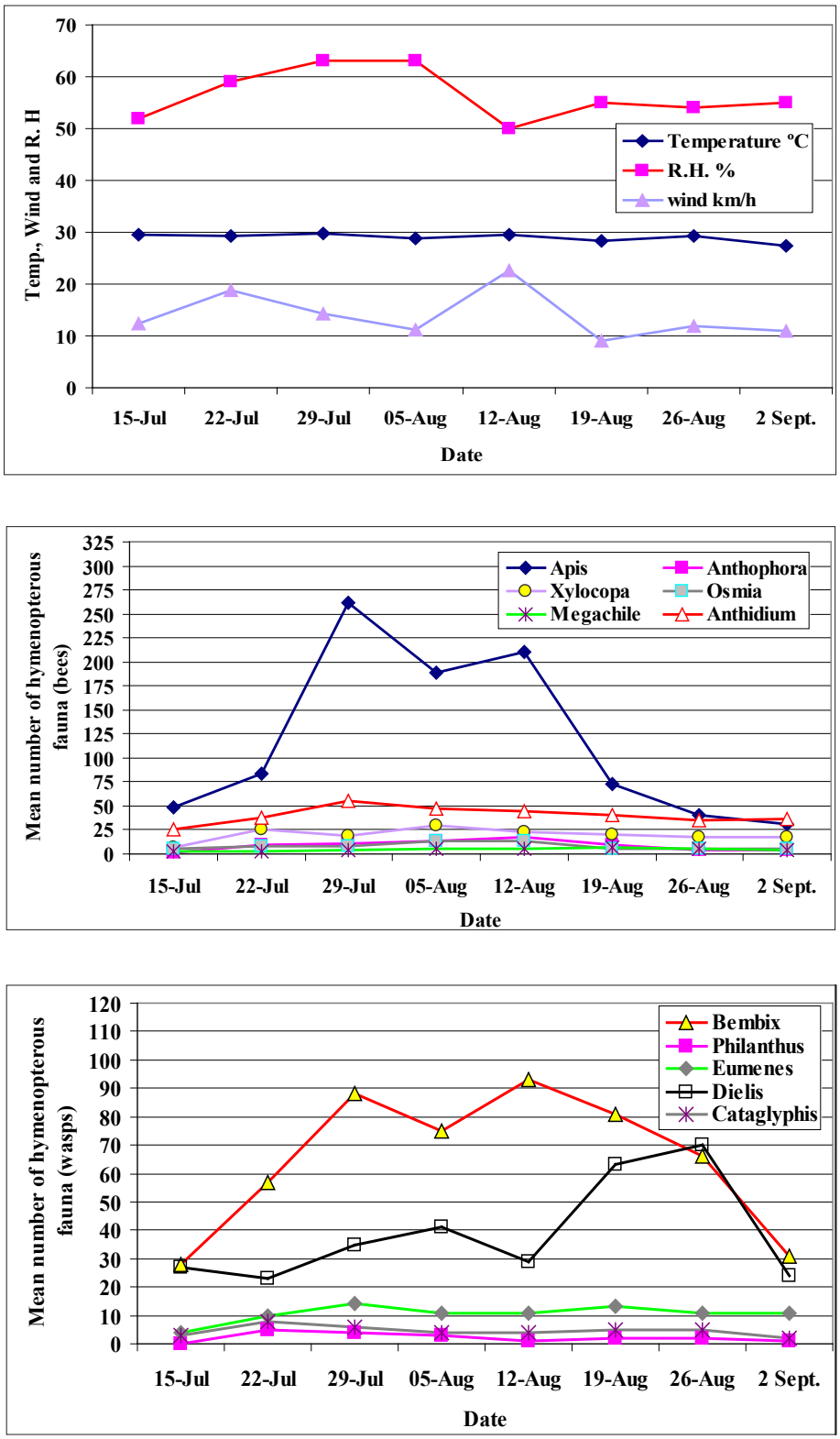


Figure 3. The phenology of true pollinators (bees and wasps) on sesame crop during the flowering period in 2011, with temperature, wind speed and R.H.

The other pollinator fauna of sesame

The other pollinator fauna of sesame included as many as 7 species (Table 2). African monarch butterfly *Danaus chrysippus* was the dominant one in both seasons (2010 and 2011). It was recorded in ration of 31.19%, 34.45% of collected other pollinator species, respectively. While Cabbage butterfly *Pieris rapae* was the second dominant species only in 2011 (20.97%), followed by Lady beetle *Coccinella undecimpunctata* (20.51%) and House fly *Musca domestica* (17.09%) in 2010 and Bean butterfly *Cosmolyce baeticus* (16.47%) in 2011. The rest of other pollinators together constituted 11.53% in 2010 and 6.36% in 2011 including Flesh fly *Sarcophaga* sp. and Drone fly *Eristalis* sp. from order Diptera.

Pest fauna of sesame

There were 10 species of defoliators registered during the study which belong to orders Orthoptera, Hemiptera, Odonata and Homoptera. Two species of insects belonging to order Orthoptera were associated only with the leaf. Three species from order Hemiptera were associated with the leaf and flower, while three species from order Homoptera were associated with the leaf and pod (Table 3).

The insect pests attacking the leaves and flowers are grouped into one order, namely Hemiptera with three species as visitors to leaves and flowers. The Hemipterous pest Green stink bug *Nezara viridula* (whose nymphs and adults are associated with flowers and leaves) comprised 13.22% in 2010 and 9.58% in 2011 of collected pest species, respectively.

The main piercing-sucking insect associated with leaves and pods, a leafhopper- *Empoasca lybica,* was the most dominant (26.59%, 29.94%) in 2010 and 2011, respectively. The second dominant species was Tobaco whitefly *Bemesia tabaci* (20.21%, 18.96%) followed by Green peach aphid *Myzus persicae* (18.99%, 15.36%) in 2010 and 2011, respectively.

Table 2. Other pollinator fauna of sesame during the flowering period in two successive seasons

No	Other pollinator species	Systematic position	Species ratio %	
			2011	2010
1	*Pieris rapae* L.	Lepidoptera: Peridae	20.97	13.24
2	*Danaus chrysippus* L.	Lepidoptera: Nymphalidae	34.45	31.19
3	*Cosmolyce baeticus* L.	Lepidoptera: Lycaenidae	16.47	6.41
4	*Musca domestica* L.	Diptera: Muscidae	9.36	17.09
5	*Sarcophaga* sp.	Diptera: Sarcophagidae	2.62	4.27
6	*Eristalis* sp.	Diptera: Syrphidae	3.74	7.26
7	*Coccinella undecimpunctata* L.	Coleoptera: Coccinellidae	12.35	20.51

Table 3. Pest fauna of sesame during flowering period in two successive seasons

No	Pest species	Systematic position	Life stage [1]	Plant part	Species ratio %	
					2011	2010
1	*Heteracris littoralis* (Ramb.)	Orthoptera: Acrididae	N, A	Leaf	8.38	1.97
2	*Acrotylus insubricus* (Scopoli)	Orthoptera: Acrididae	N, A	Leaf	7.38	4.10
3	*Nezara viridula* L.	Hemiptera: Pentatomidae	N, A	Leaf/flower	9.58	13.22
4	*Pyrrhocoris* sp.	Hemiptera: *Pyrrhocoridae*	N, A	Leaf/flower	1.99	2.27
5	*Creontiades* sp.	Hemiptera: *Miridae*	N, A	Leaf/flower	4.99	6.53
6	*Isochnura senegalensis* (Ramb.)	Odonata: Agrionidae	A	-	3.19	3.34
7	*Crocothemis erythraea* (Brulle)	Odonata: Libellulidae	A	-	2.19	2.73
8	*Empoasca lybica* (De Berg.)	Homoptera: Jassidae	N, A	Leaf/pod	29.94	26.59
9	*Bemesia tabaci* (Gennadius)	Homoptera: Aleyrodidae	A	Leaf/pod	18.96	20.21
10	(Sulzer) *Myzus persicae*	Homoptera: Aphididae	A	Leaf/pod	15.36	18.99

[1]Life stage: L, larva; N, nymph; A, adult.

Natural enemy fauna of sesame

Three species of predator insects were collected during this study. The Lady beetle *Coccinella undecimpunctata* was the dominant one either in season 2010 or in 2011. Its ration in collections was 51.06% and 38.82%, followed by Green Lacewing *Chrysoperla carnea* (26.59%, 35.29%) and Small praying mantis *Calidomantis savignyi* (10.63%, 5.88%) in 2010 and 2011, respectively. One parasitoid species was collected during both seasons. It was a parasitoid wasp *Diadegma* sp. registered in ration of 11.70% and 20.00% of collected natural enemy species respectively.

Impact of insect pollination on crop production (quantitative parameters)

The results in Table 5 present the quantitative parameters measured in both parts of the study: opened and non-opened pollination. The data indicate at significant differences in all quantitative parameters either in 2010 or 2011. Pod weight of sesame in opened pollination was significantly higher compared to the weight after non-opened pollination especially in 2010 ($F = 13.175$; $P \leq 0.0067$) while in 2011 the difference was not significant ($F = 2.826$; $P \leq 0.1312$). The number of seeds per pod was significantly higher in opened pollination compared to non-opened pollination in 2010 ($F = 9.574$; $P \leq 0.0063$) and in 2011 ($F = 16.361$; $P \leq 0.0008$). The weight of thousand seeds was significantly higher in opened pollination compared to non-opened pollination in 2010, ($F = 24.681$; $P \leq 0.0035$), while in 2011 the difference was not significant ($F = 0.7117$; $P \leq 0.4312$). The seed yield per plant (seed yield (g)/plant) was significantly higher in opened pollination compared to non-opened pollination in 2010 ($F = 17.562$; $P \leq 0.0005$) and also in 2011 ($F = 45.730$; $P \leq 0.0000$).

Impact of insect pollination on crop production (qualitative parameters)

The results in Table 6 present the qualitative parameters measured in both opened and non-opened pollination. Germination was significantly higher in opened pollination compared to non-opened pollination in 2010 ($F = 34.714$; $P \leq 0.0011$) and in 2011 ($F = 36.764$; $P \leq 0.0009$). Seedlings vigour (shoot and root length) was also significantly increased in opened pollination (shoot length in 2010 ($F = 5.844$; $P \leq 0.0265$) and in 2011 ($F = 21.797$; $P \leq 0.0002$), root length in 2010 ($F = 12.355$; $P \leq 0.0025$) and in 2011 ($F = 59.40$; $P \leq 0.0000$)). Also, the oil content was higher in opened pollination and the difference compared to the content in non-opened pollination was significant both in 2010 ($F = 4.179$; $P \leq 0.0588$) and in 2011 ($F = 6.818$; $P \leq 0.0401$).

Table 4. Natural enemy fauna of sesame during the flowering period in two successive seasons

No	Natural enemy species	Systematic position	Species ratio %	
			2011	2010
1	*Coccinella undecimpunctata* l.	Coleoptera: Coccinellidae	38.82	51.06
2	*Diadegma* sp.	Hymenoptera: Ichneumonidae	20.00	11.70
3	*Chrysoperla carnea* (Stephens)	Neuroptera: Chrysopidae	35.29	26.59
4	*Calidomantis savignyi* (Saussure)	Dictyoptera: Mantidae	5.88	10.63

Table 5. Influence of opened and non-opened pollination on pod weight, number of seeds/pod, weight of 1000 seeds and seed yield/plant of sesame

Treatments	Pod weight (g)		Number of seeds/pod		Weight of 1000 seeds (g)		Seed yield (g)/plant	
	2010	2011	2010	2011	2010	2011	2010	2011
Opened pollination	2.05 a	2.14 a	63.6 a	61.0 a	4.78 a	4.47 a	22.05 a	20.93 a
Non-opened pollination	1.73 b	1.80 a	51.0 b	50.2 b	4.28 b	4.36 a	14.21 b	13.94 b

Means followed by the same letter in a column are not statistically different by Tukey's HSD (P=0.05)

Table 6. Influence of opened and non-opened pollination on germination, seedlings vigour and oil content of sesame

Treatments	Germination (%)		Seedlings vigour				Oil content (%)	
			Shoot length (cm)		Root length (cm)			
	2010	2011	2010	2011	2010	2011	2010	2011
Opened pollination	96.25 a	97.25 a	7.65 a	7.75 a	9.40 a	9.30 a	58.00 a	58.00 a
Non-opened pollination	89.50 b	91.00 b	6.8 b	6.40 b	8.50 b	7.65 b	55.25 a	54.25 b

Means followed by the same letter in a column are not statistically different by Tukey's HSD (P=0.05)

DISCUSSION

The study carried out on the pollinator fauna (Hymenoptera and other) presented in Table 1 and 2 reveal that pollinators visiting sesame plants during the flowering period belong to four orders of class Insecta: Hymenoptera, Diptera, Lepidoptera and Coleoptera. The registered pollinators belong to different insect families and species, out of which the Hymenopterans (11 species) were the most abundant (Table 1), followed by Dipterans and Lepidopterans (3 species) and Coleopteran (1 species). These findings are in close agreement with Viraktmath et al. (2001) who also studied the relative abundance of pollinator fauna of sesame during two successive seasons. This author recorded 29 insect species, and 15 belonged to Hymenoptera, 8 to Diptera and 6 to Lepidoptera. Also, Kamel (1997) reported nine species of Hymenopterans as predominant visitors of sesame flowers.

The results obtained in the present study show that Honybee *Apis mellifera*, Sand wasp, *Bembix priesneri* and Digger wasp, *Dielis collaris* were the most dominant species on sesame crop. These results are in agreement with Kamel (1997), who stated that sand wasps and digger wasps were the most abundant insects visiting sesame flowers. *A. mellifera* comprised 30 and 32% of the foraging population on sesame crops in Egypt where species of *Megachile, Polistes,* and *Eristalis* are also important.

The results of this survey clearly indicate that although various insects are associated with *S. indicum*, some of them are major pests mostly damaging leaf/flower or leaf/pod with only three Homopteran pests (Leafhopper *Empoasca lybica*, Tobaco whitefly *Bemesia tabaci* and Green peach aphid *Myzus persicae*) and one Hemipteran pest (Green stink bug *Nezara viridula*). Pests that directly or indirectly reduce the quantity and/or quality of *S. indicum* are very important to farmers as sesame is a seed crop. Also, the results of this survey show the presence of some predators like Lady beetle (*Coccinella undecimpunctata*, Green Lacewing (*Chrysoperla carnea)* and Small praying mantis (*Calidomantis savignyi*) and parasitoids (a wasp parasitoid *Diadegma* sp). Lady beetle and Green lacewing are very important as natural enemies contributing to natural balance, and were recorded in high abundance in two successive seasons of this study. These findings are in close agreement with Sintim et al. (2010) who recorded some of these insects (*Myzus persicae*, *Nezara viridula*, Mantidae and *Apis* sp.) on sesame cultivar during the growing seasons (2005-2006) in Japan.

Sesame is considered a self-pollinated crop mainly because pollinating insects prefer flowers of other species if available (Ashri, 2007). Where insect activity is high, out-crossing can reach high level, but when sesame is surrounded by other flowering crops cross-pollination is under 1%. In Moreno, California, a high percent of out-crossing (68%) was registered in fields where sesame was the only flowering plant in a semi arid area and with minimal other vegetation.

The results in Tables 5 and 6 reveal that sesame plants exposed to insect visits had significantly higher quantity and quality yield compared to plants from which insects were excluded during two successive seasons of the study. Although some crops can produce without bee pollination, the presence of pollinators is important for increasing a yield, hence food security and income. Similarly, bee pollination is essential for reproduction of other crops. In the present study, there was a significant increase in the values of quantity and quality parameters in opened pollination in field during 2010 and 2011 (e.g. 35.55% and 33.39% seed yield (g)/plant; 4.74% and 6.46% sesame seed oil content). Also, pollination improved the germination and seedlings vigour, which is very important since germination is one of the most essential stages because if there is a poor stand, no subsequent farmer actions or weather conditions can help produce a high yield. The seedling stage is the most vulnerable to damage. At the beginning of this stage, leaf eating insects can destroy plants, but with plant growth, they can usually overcome the damage (Langham, 2007).

Crop pollination studies are rare compared to those of non-crop plants, especially in Africa in comparison to developed countries. In Egypt, for example, only a few studies have been done on crop pollination requirements and for a very small number of crops. One of the earliest is of El Rabie (1976) on the pollination of ground nut and sesame in Egypt. Hence, there is a need to improve the knowledge about pollination requirements of crops and not only to rely on information from studies done elsewhere in the world, as they may not be applicable in Egypt.

REFERENCES

Ashri, A.: Sesame (*Sesamun indicum* L.). In: Genetic Resources, Chromosome Engineering, and Crop Improvement (Singh R.J., ed.), Vol 4: Oilseed crops, CRC Press, Boca Raton, FL, USA, 2007, pp. 231-289.

Biswas, G.C., Kabir, S.M.H. and Das, G.P.: Insect pest of sesamum (*Sesamum indicum* Linn.) in Bangladesh, their succession and natural enemies. Indian Journal of Entomology, 63: 117-124, 2001.

Dhurve, S.S.: Impact of honey bee population on seed production of niger. M. Sc. Thesis. University of Agriculture Sciences, Dharwad, India, 2008, pp. 1-79.

El-Rabie, H.G.: Pollination of ground nut *Araches hypogaea* L. and sesame, *Sesamum indicum* L. with special reference to the role of honey bees. M. Sc. Thesis, Fac. Agri., Al Azhar Univ., Egypt, 1976.

FAOSTAT database: (Food and Agriculture Organization of the United Nations), 2011.

Kamel, S.M.: Occurrence and activity of hymenopterous insects on sesame flowers with special reference to their effect on crop production. Annals of Agricultural Science, Moshtohor, 35(3): 1713-1725, 1997.

Langham, D.R.: Phenology of sesame. Reprinted from: Issues in new crops and new uses. J. Janick and A. Whipkey (eds.) ASHS Press, Alexandria, VA pp 144-182, 2007.

Panda, P., Sontakke, B.K. and Sarangi, P.K.: Preliminary studies on the effect of bee (*Apis cerana indica indica* Fab.) pollination on yield of sesamum and niger. Indian Bee Journal, 50: 63-64, 1988.

Partap, T.: Mountain agriculture, marginal land and sustainable livelihoods: Challenges and opportunities. International Symposium on Mountain Agriculture in HKH Region, ICIMOD, Kathmandu, Nepal, 2001.

Pena, D.G., Anguiano R.G.L. and Arredondo, J.J.M.: Modification of the method 1 AOAC (CB-method) for the detection of aflatoxins. Bulletin of Environmental Contamination and Toxicology, 49: 485-489, 1992.

Price, P.: Insect Ecology. John Wiley and Sons, New York, USA, 1975.

Rai, H.S., Gupta, M.P. and Verma, M.L.: Insect pests of sesame and their integrated management. Indian Farming, 2001, pp. 30-32.

Rakesh K. and Lenin, L.K.: Insect pollinators and effects of cross pollination on yield attributes of sesame (*Sesame indicum*). Indian Bee Journal, 62(1-2): 75-80, 2000.

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

SAS Institute Inc.: SAS/STAT User's guide, version 9.1. SAS Institute Inc. Cary, North Carolina, USA, 2002.

Sintim, H.O., Tashiro, T. and Motoyama, N.: Insect spectrum of a mixed cultivar sesame field. Agricultura Tropica Et Subtrobica, 43(4): 325-332, 2010.

Thapa, R.B.: Honeybees and other insect pollinators of cultivated plant: a review. Journal of the Institute of Agriculture and Animal Science, 27: 1-23, 2006.

Viraktmath, S.A., Patil, B., Murasing, S. and Guruprasad, G.S.: Relative abundance of pollinator fauna of cross-pollinated oilseed crops at Dharwad in Karnataka (India). Indian Bee Journal, 63(3-4): 64-67, 2001.

Insekti u usevu susama (*Sesamun indicum* L.) i uticaj insekata oprašivača na njegovu proizvodnju

Istraživanje faune insekata u proizvodnji susama, *Sesamun indicum* L. (Pedaliaceae) sprovedeno je na Istraživačkom poljoprivrednom dobru Poljoprivrednog fakulteta, Univerziteta Suecki kanal, tokom dve vegetacione sezone (2010 i 211). Sve primećene vrste sa eksperimentalnog lokaliteta su sakupljene za identifikaciju. Sakupljanje insekata sa biljaka susama je obavljano jednom nedeljno, tri puta dnevno, pomoću tri metode (kečer, lovne jame, observacija digitalnom kamerom i vizuelno praćenje). Ukupno je sakupljena i pravilno identifikovana 31 vrsta tokom ogleda. Insekti koji su registovani i sakupljeni sa biljaka su podeljeni u četiri grupe, i to: pravi polinatiori (Hymenoptera), ostali polinatori (Diptera, Coleoptera i Lepidoptera), štetočine (Orthoptera, Odonata, Hemiptera i Homoptera) i prirodni neprijatelji (Coleoptera, Hymenoptera, Neuroptera i Dictyoptera).

Za ispitivanje uticaja načina oprašivanja na proizvodnju susama, ogled je podeljen u dve celine: prirodno „otvoreno" oprašivanje i „ometano" oprašivanje. Pedeset biljaka u delu ogleda sa „ometanim" oprašivanjem su pokrivene perforiranom papirnom vrećicom kako bi se omogućio protok vazduha, a sprečilo doletanje insekata. Kvantitativni i kvalitativni parametri su mereni, i to: težina mahune, broj semena u mahuni, masa 1000 semena, klijavost (%), vitalnost klijanaca, sadržaj ulja (%). Rezultati rada ukazuju da je „otvoreno" oprašivanje poboljšalo prozivodnju susama.

Ključne reči: Susam; štetočine; oprašivanje; prirodni neprijatelji; biljna proizvodnja