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Role of Pollinators on Seed Yield and Oil for Some Canola (*Brassica napus* L.) Genotypes

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ABSTRACT

Canola plant is considered one of the important oil crops that has a great future in Egypt so that the current studies were conducted at the research farm of the Agricultural Research Center in Shandaweel, Sohag Governorate, for two consecutive agricultural seasons, winter 2021\2022 and 2022\2023 to study the role of pollinators on the productivity of three varieties of canola (Masr1, Serw4 and Pactol). The results revealed that canola flowers were visited by 10 species of arthropods belong to 8 families and 4 orders. The identified species were classified to insect gathering nectar or pollen, predator and phytophagous insects. During both seasons, Hymenoptera was the most abundant order followed by Diptera, Coleoptera and Lepidoptera with ratio 71, 15, 10, and 4%, respectively. Whereas, honeybees, (*Apis mellifera* L.) and hover fly, (*Syrphus corollae* F. and *Sphaerophoria scripta* L.) were the most abundant pollinators detected at the first week of February till the end of flowering season in the end of March**.** Also, data showed that all studied character was significantly difference among three studied genotypes at both season. Masr1 recorded the highest seed yield/feddan (1295.42, 1282.46 kg) and total protein content but recorded lowest oil content, while Pactol gave the highest oil content in uncaged plants at first and second season respectively. Pactol had the lowest values of tested parameters, in uncaged case, but the heights oil content (48.88, 49.03 %) at both seasons respectively.

Keywords: Canola, *Brassica napus* L. Pollinators, Honeybees, Production, Seed yield.

1. Introduction

Canola or oilseed rape (*Brassica napus*), is one of the most commonly grown oilseeds all over the world. It has<30 µmol glucosinolates per gram of rapeseed meal and <2% erucic acid in the oil. (Goyal *et al.,* 2020). The term "Canola" originates from the low acid rapeseed cultivar that was developed in the 1960s by Canadian plant experts.

Canola oil is distinguished by a high concentration of total unsaturated fatty acids and a relatively low concentration of saturated fatty acids contained the two essential fatty acids (linoleic acid) omega 6 and (linolenic acid) omega 3. Therefore, it is considered one of the most important oils for human health (Aboelkassem, 2014).

Nearly 75% of the world's most important plant species depend on pollinators for their fruits and seeds, Also, pollinators contribute 35% of the global food volume and play a key role in providing essential nutrients for human livelihoods (Klein *et al.,* 2007). Whereas, the pollination needs of plant species vary widely and consequently depend on insect pollinators (Morse and Calderone, 2000).

Entomophilous flowers on canola have the ability to self- and cross-pollinate. Although it is self-fertile and may yield well in the absence of pollinators, but it produced a higher seed output when pollinators were present, particularly honeybees. (Frieseand Stark, 1983; Williams, 1985).

The global production of canola oil increased from 25.69 million metric tons, in 2012 to 31.8m in 2023 (Statista, 2023a). Leading producing countries of canola in 2022/2023 were, European union (19.5m), Canada (19m), China (14.7m), India (11.4m), Japan (4m) and others (20.08m) (Statista, 2023b). Egypt annually imports 1.9 million tons of vegetable oils in general, and thus comes in seventh

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place among the countries importing vegetable oils. Therefore, the canola crop recommends raising overall oil production to fill the gap between edible oil production and consumption (Mazeed, 2006).

This study aimed to investigate the population dynamics of dominating pollinators over the flowering season and to survey pollinators of canola. Also, the effect of insect pollination and seed yield was investigated.

2. Materials and Methods

The current studies were conducted at the research farm of the Agricultural Research Center in Shandaweel, Sohag Governorate, three varieties of canola (Masr1, Serw4 and Pactol) were sown for two consecutive agricultural winter seasons, 2021\2022 and 2022\2023. In the current investigation, about half feddan was planted about the middle of November in both seasons. In a field trial, a randomized complete block design with three replications (RCBD) was used to plant three canola cultivars with three replicates/ cultivars. One plant per hill was thinned, and the spacing between seeds was 30 cm within the row and 50 cm between rows. Throughout the duration of the trial, standard agricultural procedures were followed and no insecticidal treatments were applied.

2.1. Survey of insects visited canola flowers

Weekly samples were collected from the canola field (Masr1) by using two sampling methods (i.e., direct count, sweep net). Samples were initiated from the first week of February and continued till the last week of March, during both canola growing seasons. After being collected, each sample was filled up in a muslin bag and brought into the laboratory for analysis. When necessary, specimens were examined under a stereomicroscope after being killed by chloroform in a closed chamber. Unknown insect specimens were identified by the Taxonomic Dept., Plant Protection Institute, Agricultural Research Center (Giza, Egypt). Also, abundance percentages of the collected insects were calculated utilizing the formula of Facylate (1971) as following:

$$A = \frac{n}{N} X\ 100$$

A = Abundance percentages.
n = Total number of each species appeared in samples.
N = Total number of all species taken all over the season.

2.2. Population dynamic of the dominant insects visit canola flowers during (2021\2022 and 2022\2023) growing seasons

During the flowering season, A wooden frame of 1 m^2 area was used, insects visiting canola, (Masr1) flowers in each square meter area for five minutes for each replicate were counted. The count started from the first to last opening of flowers once a week (Amor, 2021).

2.3. Effect of pollinators on seed production

In the beginning of flowering., 40 plants/ cultivars of canola were selected randomly and divided into two groups, each consists of 20 plants. The first group was covered with chiffon to avoid pollinating insects. However, the second group was left un-caged. Bags were taken out after seeding. The following characteristics were studied: number of racemes per plant, 1000-seed weight (g), seeds weight per plant (g), days to first flower (day), plant height (cm), first siliqua height (cm), and seeds oil content (%). The AOAC (1990) was used to determine the oil percentage. Total protein was determined in the seed using the AOAC (2000) method**.** and pods per plant were counted for each group. Pods of seed samples were randomly taken from inspected plants.25 pods were randomly selected from the selected plants in each sample. These samples were replicated 20 times in each inspection plant group/ cultivars.

The pods were subjected to a certain examination. The increase in seed weight as a result of insect pollination was calculated from the following equation:

$$Seed\ weight\text{-}increase\ (\%) = \frac{W.\ unbagged\ sample - W.\ bagged}{W.\ unbagged} X\ 100$$

2.4. Statistical analyses

Data were subjected to analysis of variance for statistical purposes. The means were divided into significant ranges using Duncan's multiple range test where the result (F) was significant (Snedecor, 1956).

3. Results and Discussions

3.1. A survey of the insects visits canola flowers

The primary objective of the current survey is to determine the insect species composition visit canola flowers, at Sohag Governorate. A partial taxonomic list of insects, pollinators and visitors collected by sweep net and direct count methods from canola flowers at the Research Farm of Agricultural Research Center at Shandaweel, Sohag Governorate during the flowering period of, 2021\2022 and 2022\2023 seasons is presented in Table (1). Results indicated that a presence of 10 species of arthropods that are a part of 8 families and 4 orders. The identified insect species were classified to insect gathering nectar or pollen, predator and phytophagous insects. Hymenoptera was the most prevalent order with 70.67% followed by Diptera, Coleoptera and Lepidoptera which recorded 14.33, 11.33, and 3.67%, respectively (Fig. 1). Whereas, (Fig.2) showed that honeybee, *Apis mellifera* L. was the most abundant specie (63.00%) followed by hover flies, *Syrphus corollae* F. and *Sphaerophoria scripta* L. (10.00%), carpenter bee, rose chafer, *Tropinota squalida* S. (8.00%), *Xylocopa pubescens* Spinola (6.67%), house fly, *Musca domestica* L. (4.33%), lady beetle, *Coccinella undecimpunctata* L.(3.33%), small cabbage white, *Pieris rapae* L. (2.00%), pea blue butterfly, *Lampides boeticus* L. (1.67%), and wild bee (*Andrena ovatula* Kirby (1.00%)

These data showed some consistency with those of Abdel-Rahman and Rateb (2014) who recorded, honeybee, carpenter bee, wild bee (*Andrena* spp), rose chafer, hover fly, house fly, and horse fly visited canola flowers in Assuit Governorate, Egypt.

Table 1: Insects collected from canola plants during (2021\2022 and 2022\2023) flowering seasons.

Order	Family	Common name	Scientific name	Foraging Purpose
Hymenoptera	**Apidae**	Honeybees	*Apis mellifera* L.	N& P
		Carpenter bee	*Xylocopa pubescens* S.	N & P
	Andrenidae	Wild bee	*Andrena ovatula* K.	N & P
Coleoptera	**Scarabaeidae**	Rose chafer	*Tropinota squalida* S.	Phyto.
	Coccinellidae	The lady beetle	*Coccinella undecimpunctata* L.	Pre.
Diptera	**Syrphidae**	Hover fly	*Syrphus corollae* F.	N.& Pre.
			Sphaerophoria scripta L.	N. & Pre.
	Muscidae	House fly	*Musca domestica* L.	N.
Lepidoptera	**Pieridae**	Small cabbage white	*Pieris rapae* L.	N&Phyto.
	Lycaenidae	The pea blue butterfly	*Lampides boeticus* L.	N&Phyto.

N.: insects feed on a nectar
N & P: insects feed and gathering a nectar and pollen.
Pre: Predator, insect or one of their stages feed on other insects
Phyto: Phytophagous, Insects, feed on plants.
Nect. &Phyto: Insects, their adult feeds on the nectar, but their larvae feeds on the plant
Nect. & Pre: Insects, their adult is a phytophagous, while their larvae are a predator.

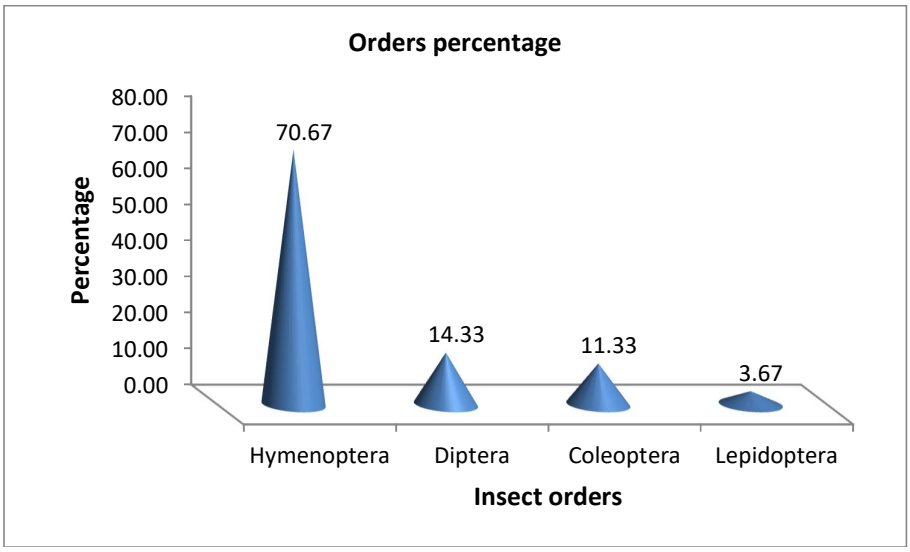

Fig. 1: Abundance percentage of different insect's order visited canola flowers during (2021\2022 and 2022\2023) growing seasons.

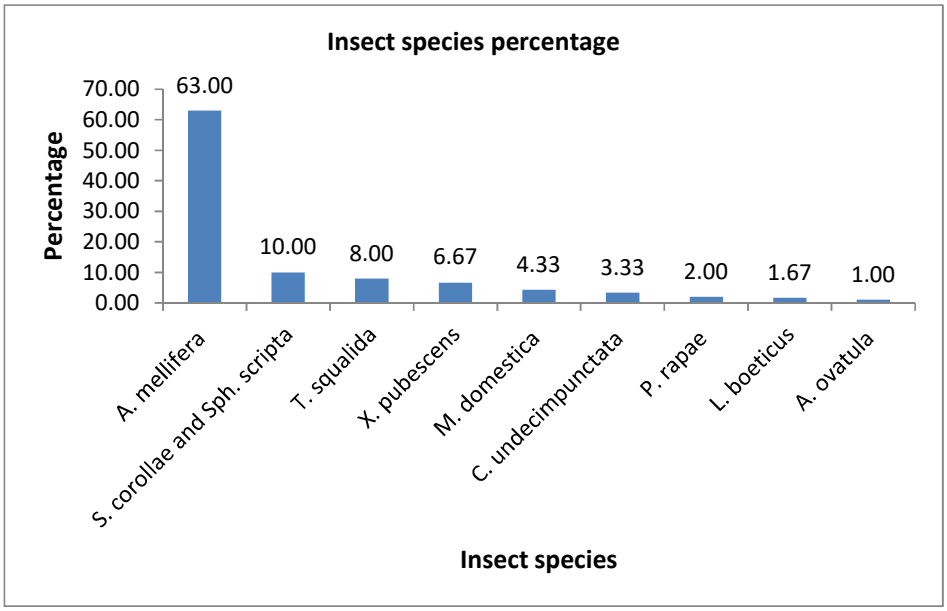

Fig. 2: Abundance percentage of different insect species visited canola flowers during (2021\2022 and 2022\2023) growing seasons.

Also, was partially agree with those of Kamel *et al.* (2015) in Ismailia, Egypt who stated that with canola flower the abundance percentage of the order Hymenoptera was 66.39 and 65.41% in the 2013–14 and 2014–15 growing seasons, Followed, by Diptera 16.83 and 18.07%, Coleoptera 14.30 and 12.17%, and Lepidoptera 3.02 and 4.23% respectively. Suman *et al.* (2015) in India who recorded 18 insects visited the rape flowers. It belongs to 4 orders, including Hymenoptera (8 species), Lepidoptera (5 species), Coleoptera (3 species) and Diptera (2 species). Order Hymenoptera constituted 83.6% of total insect visitors followed by Lepidoptera (8.2%), Diptera (5.4%) and Coleoptera (2.8%). Among all the insect visitors, *Apis mellifera* was the most abundant with (26.7%) followed by *Apis cerana* with (23.1%), *Apis dorsata* with (14.2%) and *Apis florea* with (9.2%) and Amro (2021) in Assuit Governorate, Egypt who found that the relative percentage of the abundance of insect orders visited canola flowers were Hymenoptera 83%, Diptera 12% Lepidoptera 3% Coleoptera 2% and the relative percentage of insect species abundance were, honeybee 58%, carpenter bee 15%, wild bee (*Andrena*

ovatula Kirby) 10%, hover fly 6%, horse fly 4%, small cabbage white 3%, house fly 2%, Rose chafer 1% and lady beetle 1%.

3.2. Population dynamic of the dominant insects visit canola flowers during (2021\2022 and 2022\2023) growing seasons.

Data graphically in Fig. 3 illustrated the population densities of *A. mellifera* during the two successive canola growing seasons, (2021\2022 and 2022\2023).

In both seasons, *A. mellifera* was detected during the 1st week of February, the population increased gradually and reached its peak which recorded 83.00 and 94.00 individuals/m^2/5min., respectively, on the 1st week of March and then decreased gradually to the end of the flowering season.

Data graphically presented in Fig. 4 illustrate the population density of hover flies, (*S. corollae* and *S. scripta*) visited canola flowers during (2021\2022 and 2022\2023) growing seasons. In the first season 2021/2022. However, flies were detected during the 1st week of February with means 3.00 individuals/ /m^2/5min then the population increased gradually and reach its first peak, 5.20 individuals/ /m^2/5min. on 9 Feb. and the second peak was 8.00 individuals /m^2/5min on 23 Feb. then increased gradually to the end of the flowering season with 11.80 individuals /m^2/5min. In the second season 2022/2023 hover flies had two peaks on the 9th and 23rd Feb with 8.00 and 9.00 individuals /m^2/5min respectively. Then increased gradually to the end of the flowering season with 11.60 individuals/m^2/5min.

These data were in partial agreement with those of Kamel *et al.* (2015) in Ismailia, Egypt who said that canola inflorescences were blooming for 55 to 65 days, and the flowering peak occurred after 25-45 days of flowering, and the number of *A. mellifera* increased with the increasing number of flowering plants. Rosa *et al.* (2011) who stated that the correlation between the number of *B. napus* flowers in the crop and the number of recorded honey bees during the blooming period was positive

Colley and Luna (2000) showed that syrphid flies have a short-tongued so that it prefers to forage on canola flowers which have a short corolla and many flowers.

Bhowmik *et al.* (2014); Roy *et al.* (2014) and Akhtar *et al.* (2018) recorded six species from Syrphidae, *Eupeodescorollae*, *Eristalistenax*, *Ischniodonscutellaris*, *Melanostoma* sp., *Eristalissmilis* and *Episyrphusbalteatus* on canola flowers.

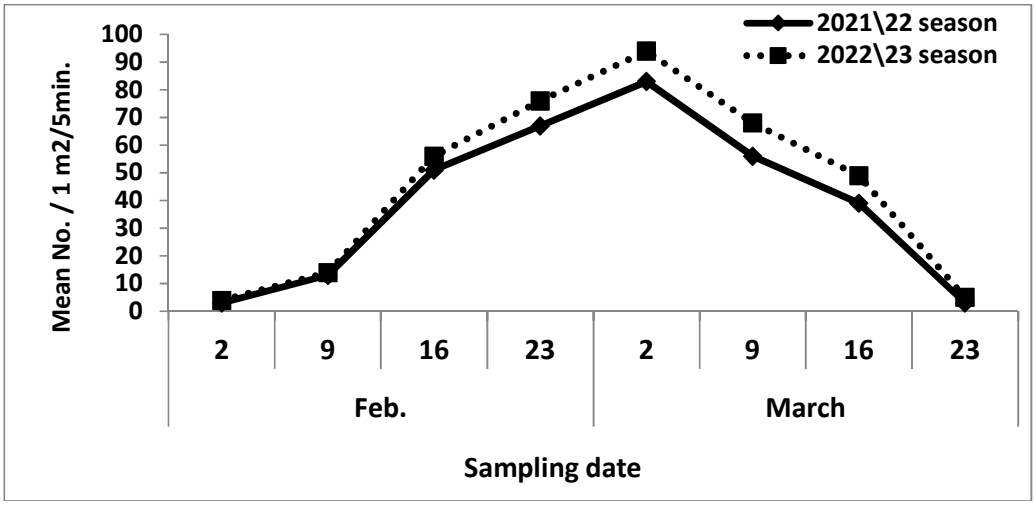

Fig. 3: Population dynamic of honeybees, *Apis mellifera* L. visited canola flowers during (2021\2022 and 2022\2023) growing seasons.

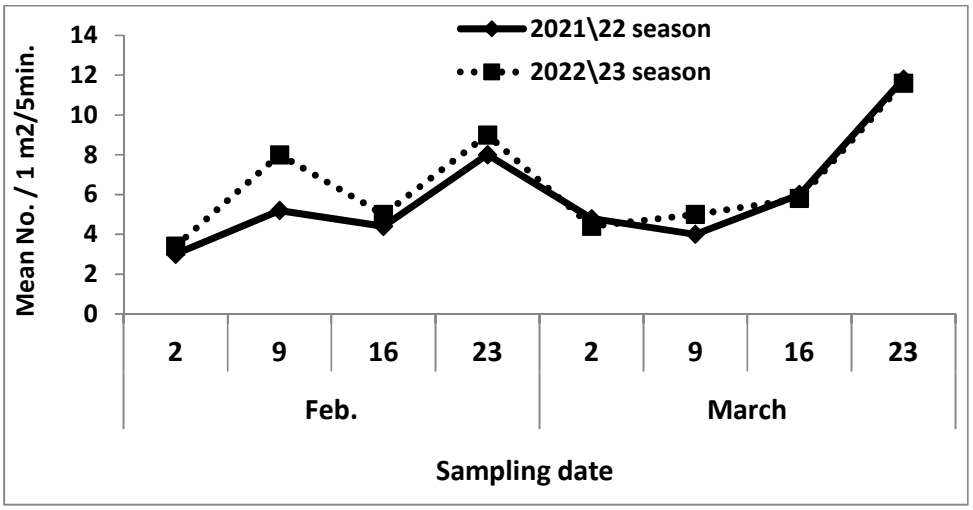

Fig. 4: Population dynamic of hover flies, *Syrphus corollae* F. and *Sphaerophoria scripta* L. visited canola flowers during (2021\2022 and 2022\2023) growing seasons.

3.3. Effect of pollinators on seed production

Data in Table 2 revealed that all studied character was significantly difference among three studied genotypes at both season. Data show that Masr1 recorded the highest Plant height (147.51 and 147.91cm), Fruiting zone (94.00 and 92.84 cm), number of racemes/ plan (5.92 and 5.74), number of siliqua/ plant (169.21 and 162.72), seed yield/plant (13.09 and 12.96 g), seed yield/feddan (1146.44 and 1134.98 kg) and total protein content (23.63 and 23.58 %) but recorded lowest oil content (45.22 and 45.52 %) at both seasons respectively, followed by Serw4 which recorded plant height (140.22 and 139.22 cm), Fruiting zone (87.20 and 85.66 cm), number of racemes/ plan (4.98 and 5.03), number of siliqua/ plant (160.30 and 156.95), Seed yield/plant (11.54 and 11.42 g), Seed yield/feddan (1015.07 and 1004.9 kg), oil content (46.24 and 46.39 %) and total protein content (22.17 and 22.12 %) in both seasons growth. Pactol had recorded the lowest Plant height (126.10 and 124.17 cm), Fruiting zone (84.93 and 84.32 cm), number of racemes/ plan (4.22 and 4.43 /plant), number of siliqua/ plant (136.55 and 133.80 /plant), Seed yield/plant (10.37 and 10.21 g), Seed yield/feddan (917.56 and 908.39 kg) and total protein content (20.36 and 20.31 %) but gave the highest oil content (48.47 and 48.62 %), the variation among three tested genotypes may be due to genetic variation and their adaptation and interaction with environmental condition. These results are agreement with Aboelkassem (2014); Mekki, (2013) and Hozayn and EL-Mahdy (2017). This wide range of variations is available in current materials which can assist the Egyptian breeder in any early selection breeding programmer.

Table 2: Effect of canola cultivars on yield and its attributes in 2021\2022 and 2022\2023 seasons.

Traits / Genotypes	Plant height (cm)	Fruiting zone (cm)	No. of racemes/ plant	No. of Siliqua/ plant	Seed yield/plant (g)	Seed yield/feddan (kg)	Oil (%)	Total Protein (%)
				2021/2022				
Masr 1	147.51a	94.00aT	5.92a	169.21a	13.09a	1146.44a	45.22 a	23.63a
Serw4	140.22a	87.20b	4.98b	160.30b	11.54b	1015.07b	46.24b	22.17b
Pactol	126.10b	84.93b	4.22c	136.55c	10.37c	917.56c	48.47a	20.36c
				2022/2023				
Masr 1	147.91a	92.84a	5.74a	162.72a	12.96a	1134.98a	45.52c	23.58a
Serw4	139.22b	85.66b	5.03b	156.95a	11.42b	1004.92b	46.39b	22.12b
Pactol	124.17c	84.32c	4.43c	133.80b	10.21c	908.39c	48.62a	20.31c

The investigated data at Table (3) recorded that a highly significant effect between caged and uncaged on all studied traits. However, there are no significant differences between the two growing seasons in caged and uncaged cases on all studied traits. Uncaged plants recorded higher indicators than

caged plants for yield, its components, and total oil content, except for total protein content at two growing seasons.

Uncaged plants had the highest of Plant height (145.20 and 144.33 cm), Fruiting zone (93.38 and 92.21 cm), number of racemes/ plant (4.90 and 5.07), number of siliqua/ plant (158.52 and 154.24), seed yield/plant (13.18 and 13.03 g), seed yield/ feddan (1159.72 and 1148.13 kg) and oil content (46.92 and 47.17 %), but recorded lowest total protein content (21.79 and 21.74 %),whereas caged case had lower index of plant height (130.68 and 129.86 cm), Fruiting zone (84.04 and 82.99 cm), number of siliqua/ plant (5.13 and 5.06 /plant), number of siliqua/ plant (152.18 and 148.06 /plant), seed yield/plant (10.15 and 10.03 g), seed yield/ feddan (892.99 and 884.06 kg) and oil content (46.38 and 46.53 %). While the highest percentage of total protein (22.32 and 22.27 %) at both seasons respectively.

These results concur with those of Amor (2021), which found statistically significant variations in all quantitative and qualitative yield characteristics across the studied canola cultivars, whether they were caged or not. Compared to non-pollinated plants, high numbers of pollinators increase the quantity and quality of canola output, as numerous studies have demonstrated. Even so, canola is a self-pollinating crop; without insect pollination, it does not yield a significant number of mature siliques.

Table 3: Effect of pollinators on canola yield and its attributes in 2021\2022 and 2022\2023 seasons.

Traits / Treatment	Plant height (cm)	Fruiting zone (cm)	No. of racemes/ plant	No. of Siliqua/ plant	Seed yield/plant (g)	Seed yield/feddan (kg)	Oil (%)	Total Protein (%)
				2021/2022				
Uncaged	145.20a	93.38a	5.13b	158.52a	13.18a	1159.72a	46.92a	21.79b
Caged	130.68b	84.04b	4.95a	152.18b	10.15b	892.99b	46.38b	22.32a
				2022/2023				
Uncaged	144.33a	92.21a	5.07a	154.24a	13.03a	1148.13a	47.17a	21.74b
Caged	129.86a	82.99b	5.06a	148.06b	10.03b	884.06 b	46.53b	22.27a

The impact of insect pollinators on three canola varieties' various yield characteristics in the first growing season (2021\2022 and 2022\2023) are presented in Table (4).

Data showed that Masr 1 the tallest Plant height (155.27 and 155.69 cm), Fruiting zone (98.95 and 97.72 cm), number of racemes/ plan (5.93 and 5.92), number of siliqua/ plant (172.66 and 166.05), seed yield/plant (14.79 and 14.64 g), Seed yield/ feddan (1295.42 and 1282.46 kg) and total protein content (23.44 and 23.99 %) but lowest oil content (45.43 and 45.88 %) in uncaged case at both seasons respectively, flowed by Serw 4, the Plant height recorded (147.60 and 146.60 cm), Fruiting zone (91.78 and 90.30 cm), number of racemes/ plan (4.95 and 5.05), number of siliqua/ plant (163.57 and 160.16), Seed yield/plant (13.03 and 12.91 g), seed yield/ feddan (1146.97 and 1135.50 kg), oil content (46.43 and 46.58%) and total protein content (21.88 and 21.38%). However, Pactol had the lowest values of tested parameters, in uncaged case at both seasons respectively, but the heights oil content (48.88, 49.03 %).

Masr 1 cultivars was also the best value in the caged case in two seasons growth, where registered (139.74 and 140.13 cm) at plant height, (89.06 and 87.95 cm) at fruiting zone, (5.91 and 5.57/plant) at number of racemes/plant, (165.75 and 159.41/plant) at number of siliqua/ plant, (11.39 and 11.28 g) at seed yield/plant and (997.47 and 987.50kg) at seed yield/feddan in both seasons respectively, next Serw4 recorded that (132.80 and 131.84 cm) at plant height, (82.61 and 81.01 cm) at fruiting zone, (5.01 and 500 /plant) at number of racemes/plant, (157.03 and 153.75 /plant) at number of siliqua/ plant, (10.04 and 9.94 g) at seed yield/plant, (883.16 and 874.33 kg) at seed yield/feddan. However, the lowest indicators were recorded for Pactol cultivar.

These results are agreement with Amor (2021); Hozayn and EL-Mahdy (2017); Mekki, (2013) and Kamel *et al.* (2015).

Table 4: Effect of the interaction between insect pollinators, three canola cultivars and seasons growth on canola yield attributes.

Genotypes	Traits	Plant height (cm)	Fruiting zone (cm)	No. of racemes/ plant	No. of Siliqua/ plant	Seed yield/plant (g)	Seed yield/feddan (kg)	Oil (%)	Total Protein (%)
					2021/2022				
Masr 1	Uncaged	155.27 a	98.95a	5.93 a	172.66 a	14.79 a	1295.42 a	45.43d	23.44a
	caged	139.74 c	89.06 c	5.91 a	165.75 b	11.39 d	997.47 d	45.01d	23.82a
Serw4	Uncaged	147.60 b	91.78 b	4.95 b	163.57 c	13.03 b	1146.97 b	46.43c	21.88c
	caged	132.80 d	82.61 d	5.01 b	157.03 d	10.04 e	883.16 e	46.05c	22.46b
Pactol	Uncaged	132.74 d	89.40 c	3.98 d	139.33 e	11.72 c	1036.79 c	48.88a	20.06e
	caged	119.50 e	80.46 e	4.47 c	133.76 f	9.02 f	798.33 f	48.06b	20.67d
					2022/2023				
Masr 1	Uncaged	155.69a	97.72a	5.92a	166.05a	14.64a	1282.46a	45.88d	23.39a
	Caged	140.13c	87.95d	5.57b	159.41c	11.28d	987.50d	45.16e	23.77a
Serw4	Uncaged	146.60b	90.30b	5.05c	160.16b	12.91b	1135.50b	46.58c	21.83c
	Caged	131.84d	81.01e	5.00c	153.75d	9.94e	874.33e	46.20cd	22.41b
Pactol	Uncaged	130.7e	88.62c	4.25e	136.50e	11.54c	1026.40c	49.03a	20.01e
	Caged	117.63f	80.02f	4.61d	131.04f	8.89f	790.35f	48.21b	20.62d

4. Conclusion

Canola plant is considered one of the important oil crops that has a great future in Egypt. The presence of insect pollinators, especially honey bees, works to enhance the productivity of the canola crop in Sohag Governorate in Upper Egypt. Misr 1 is a promising variety for producing edible canola oil on a large scale and for increasing canola productivity in this region. Hence, the expansion of the cultivated areas of this variety ensures maximizing the production of edible oil to meet the increasing demand.

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