Research Article

# Effectiveness of Native Solitary Bees in Seed Production of Sesame (*Sesamum indicum* L.)

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**Abstract** | Sesame is ranked among the top ten traditional oil seed crops of Pakistan. The present study is aimed to compare the effectiveness of native honey bees and solitary bees for better seed production of sesame and future conservation of effective insect pollinators. The sesame crop was grown during two years (2019 & 2020) at the research farm of MNS- University of Agriculture Multan, Pakistan. Abundance and diversity of native insect pollinators, their foraging behavior in terms of visit duration and visitation rate (number of flowers visited per minute) along with their pollination effectiveness in terms of single visit seed set efficacy were assessed. Pollinator community was composed of seven solitary bees species (*Nomia oxybeloides, Amegilla* sp., *Lasioglossum* sp., *Megachile* sp., *Xylocopa sp.*), two honeybee species (*Apis dorsata, A. florea*) and two syrphid fly species (*Eristalinus aeneus, Ischiodon scutellaris*). In both the years, honey bees were more abundant than the solitary bees while the syrphid flies were least abundant. However, visitation rate of solitary bee, *Amegilla* sp. was the highest (6.4 ± 0.41) followed by *N. oxybeloides* (3.4 ± 0.32) and *A. dorsata* (3.1 ± 0.90). Based on single visit seed set parameters *i.e.*, capsule length (cm), capsule weight (gm), number of seed per capsule and seed weight per capsule (gm), solitary bee *Amegilla* sp. was the most efficient followed by *A. dorsata* and *N. oxybeloides.* Conserving the most efficient native solitary bee (*Amegilla* sp.) and honey bee (*A. dorsata*) can lead to higher seed production. Moreover, the effectiveness of *Amegilla* sp. should also be evaluated for other oil seed crops in Punjab, Pakistan.

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## Introduction

Sesame (*Sesamum indicum* L.) is a member of *Pedaliacea* family (Ranjithkumar and Kumar, 2020) and is among the top ten traditional oil seed crops grown in Pakistan (Hameed and Azeem, 2017). Pakistan is facing extreme deficit in edible oil (Hussain *et al*., 2017) and is importing 88% of edible oil (3.13 million ton) annually (Mustafa, 2019). Oil extracted from sesame contains high nutritional value and stability against oxidative rancidity (Borchani *et al*., 2010). Moreover, sesame seeds contain 50% oil content, which is the main reason behind its cultivation (Kurt, 2018). Furthermore, it is valuable in food, chemical industries and in the field of medicine (Blal, 2013; Elleuch *et al*., 2007). Nutritionally, sesame seeds contain 44–57% oil, 13–14% carbohydrates, and 18–25% protein (Borchani *et al*., 2010). Sesame covers about 7.8 million hectare of the total world crop area (FAOSTAT, 2012). According to Pakistan Bureau of Statistic during 2017-18, almost thirty thousand tons of sesame seeds were produced in an area of 176 thousand acres in Pakistan. Pollinators play a great role in global food security. About 75% of commonly grown crops all over the world depend on the pollinators for their reproduction (Klein *et al*., 2007). Animal pollination, especially by insects contributes about 35% of global food production and about 22.6% pollination of crops depend on bees (Aizen *et al*., 2009). Moreover, pollinators also contribute in improving quality of fruit in term of increasing nutritional value of the crops used for human diet (Wietzke *et al*., 2018; van der Sluijs and Vaage, 2016). Wild bees are significant pollinators of crops and substantially contribute to food production (Kleijn *et al*., 2015; Mallinger and Gratton, 2015). The increasing attention towards wild bees as alternative pollinators shows wild bees are more efficient pollinators as compare to honeybees. Wild bees contribute significantly in crop pollination by providing 150 billion dollars worth pollination services all over the globe (Gallai *et al*., 2009).

Sesame crop consider to be auto-pollinated but flower encourages cross-pollination (Stein *et al*., 2017; Andrade *et al*., 2014). Qualitative and quantitative characters of sesame enhance with open-pollination as compared to control one (Blal *et al*., 2013). However, pollination by wild bees and the honey bees increase the yield up to 59% in sesame crop (Stein *et al*., 2017). Honeybees also play a significant role in the cross pollination of sesame (Parmar *et al*., 2017). Some previous studies have been reported that non-Apis bees (*Xylocopa* sp. and *Ceratina tarsata*) and honey bees (*A. mellifera, A. cerana*) were the most abundant pollinators in sesame crop (Kamel *et al*., 2013).

The purpose of our study is to identify local pollinators of sesame, their abundance and diversity as well as their pollination efficiency. This study evaluates the individual pollinator efficiency in terms of single visits, visit duration and visitation rate. By identifying the effective native insect, we can increase the seed yield and quality of sesame by conserving these native insect pollinators.

## Materials and Methods

*Study area*

Study was conducted at the research farm of MNS-University of Agriculture Multan, Pakistan. The experimental crop was sesame (*Sesamum indicum* L.) branched stem variety that was sown for 2 growing seasons 2019-2020, on an area of 0.5 acres. The experimental plot and sowing of sesame were homogeneously designed to avoid any variation that could affect the analytical comparisons of experiment. After sowing, manual removing of weed, management of pest and soil management (fertiliser and irrigation application) were done by standard means. Sesame field was surrounded by sunflower and cotton in south during both the years. The study area has subtropical climate with harsh conditions in hot summers and cold winters with the average monthly temperature of 35°C to 40°C.

*Pollinator abundance and diversity*

To check the abundance and diversity of different insect pollinators, we selected 15 plants randomly. The insect visitors were recorded by observing each plant for 1 minutes and number of pollinators visiting flowers were observed and counted. Observations were made at 0700, 1000, 1300 and 1600 hours. Insects' samples were collected for later taxonomic identification (Vockeroth, 1969; Michener, 2000).

*Foraging behavior*

Foraging behavior of different insect pollinators were recorded in terms of visit duration (time spent during contact with reproductive parts of the flower) and visitation rate (number of flower visited per minute). Weekly observation was done.

*Pollination Effectiveness*

To check the effectiveness of insects in sesame crop in terms of pod formation and seed formation, we selected 20 plants each for no insect visit (caged treatment) and free insect visits (open pollination treatment). Thereafter, pods were harvested and their different parameters (*i.e.*, capsule length, capsule weight, number of seed per capsule and seed weight per capsule) were recorded for comparison (Mahmoud, 2012).

*Single Visits*

To confirm the insect efficacy in relation to single visit, we caged the flower buds with muslin cloth before these opened. These buds were un-caged during the

**Table 1:** *Insect species visiting Sesame indicum along with their abundance.*

| Order | Family | Genus/Species | Total Abundance in 2019 | Total Abundance in 2020 | Foraging Task N/P |
|---|---|---|---|---|---|
| Hymenoptera | Apidae | *Apis dorsata* | 397 | 354 | N |
| | | *Amegilla* sp. | 289 | 317 | N/P |
| | Halectidae | *A. florea* | 207 | 157 | N |
| | | *Nomia oxybeloides* | 112 | 192 | N |
| | | *Lasioglossum* sp. | 103 | 77 | N/P |
| | Megachilidae | *Nomia* sp. | 22 | 41 | N |
| | | *Xylocopa* sp. | 33 | 24 | N |
| | | *Megachile* sp. | 29 | 47 | N |
| Diptera | Syrphidae | *Eristalinus aeneus* | 79 | 56 | P |
| | | *Ischiodon scutellaris* | 11 | 27 | N/P |

**N/P= Nectar/Pollen*

**Table 2:** *Pollination effectiveness of pollinators in terms of visitation rates and stay time.*

| Pollinator species | Visit duration/ Flower (sec) | Number of flowers visited/minute |
|---|---|---|
| *Amegilla* sp | 8.89 ± 1.17 c | 6.4 ± 0.41 a |
| *A. dorsata* | 20.83± 1.32 a | 3.1 ± 0.90 b |
| *N. oxybeloides* | 13.01 ± 1.17 b | 3.4 ± 0.32 b |
| *A. florea* | 4.95 ± 0.22 d | 2.7 ± 0.28 c |
| *Eristalinus aeneus* | 8.19 ± 0.81 c | 2.33 ± 0.26c |

*Means with same letters in a column are not statistically different according to LSD at 5% level (± S.E.)*

peak activity period of insect pollinators. After single visit by a specific pollinator species, we re-caged the flower to avoid further visits. Different seed yield parameters (Capsule length, Capsule weight, no. of seed per capsule and seed weight per capsule) were measured to assess the pollination success of individual insect (Ali *et al*., 2011).

*Data analysis*

The data for visitation rate, visit duration, capsule length, capsule weight, no. of seed per capsule and seed weight per capsule were subjected to statistical analysis (ANOVA). Moreover, statistical analysis was accomplished using the computer software XLSTAT (2011). There means were compared by using Fisher LSD test at p=0.05.

## Results and Discussion

During the two growing seasons of sesame, eight bee and two syrphid fly species visited the sesame flowers. Overall, solitary and social bees comprised of 59% and 41% of total abundance, respectively. Among solitory bees, *Amegilla* sp. (606 individuals) was the most abundant followed by *N. oxybeloides* (304 individuals) while *Xylocopa sp.* (57 individuals) was the least abundant. Furthermore, among social bees, *A. dorsata* (751 individuals) was abundant followed by *A. florea* (304 individuals). Among syrphidae, *Eristalinus aeneus* (135 individuals) was the abundant followed by *Ischiodon scutellaris* (38 individuals) (Table 1).

In terms of visit duration, *A. dorsata* spent highest time per flower (20.83 ± 1.32 sec) followed by *N. oxybeloides* (13.01 ± 1.17 sec) while *A. florea* spent least time on a flower of sesame (4.95 ± 0.22 sec). Contrarily, visitation rate per minute was highest for *Amegilla* sp. followed by *N. oxybeloides* and *A. dorsata* (Table 2).

The number of seeds per capsule (F=13.8, df=5.0, p\0.0001) and seed weight per capsule (F=37.2, df=5.0, p\0.0001) were significantly different among the five pollinators (Table 3). Among all pollinators, *Amegilla* sp. produce more seeds per capsule and high seed weight in a single visit followed by *A. dorsata*, *N. oxybeloides* while least seed were produced by single visit of *E. aeneus*. Furthermore, there were statistical differences among capsule weights (F=7.9, df=5.0, p\0.0001) after single visits of pollinators (Table 3). Maximum capsule weights were observed after visit of *Amegilla* sp. followed by *A. dorsata*, *N. oxybeloides* and *A. florea*. Maximum capsule lengths (F=214, df=5.0, p\0.0001) were observed after visits of *Amegilla* sp. followed by *A. dorsata* (Table 3). The open pollinated flowers had better capsule weight and capsule length than the caged flowers.

**Table 3:** *Comparison of reproductive success parameters of Sesame crop.*

| Pollinator species | Capsule length (cm) | Capsule weight (gm) | Number of seed /capsule | Seed weight /Capsule (gm) |
|---|---|---|---|---|
| *Amegilla* sp | 2.20 ± 0.08a | 0.47 ± 0.04 a | 67.25 ± 6.11 a | 0.11 ± 0.03a |
| *A. dorsata* | 2.18 ± 0.12 b | 0.43 ± 0.18 b | 61.72 ± 6.35 b | 0.08 ± 0.02 b |
| *N. oxybeloides* | 1.56 ± 0.1 c | 0.42 ± 0.18 b | 57.01 ± 4.36 bc | 0.06 ± 0.01 bc |
| *A. florea* | 1.76 ± 0.15 c | 0.39 ± 0.03 bc | 57.0 ± 7.01 bc | 0.05 ± 0.02 c |
| *Eristalinus aeneus* | 1.36 ± 0.07cd | 0.36 ± 0.09 c | 56.72 ± 12.2 c | 0.04 ± 0.01 cd |
| Open flower | 2.34 ± 0.03 a | 0.54 ± 0.01 a | 71.14 ± 1.43 a | 0.12 ± 0.01 a |
| Caged flower | 1.24 ± 0.02 d | 0.34 ± 0.01 c | 55.62 ± 1.23c | 0.03 ± 0.01 d |

*Means with same letters in a column are not statistically different according to LSD at 5% level (± S.E.)*

In our study, the proportional abundance of wild bees (57%) was greater than honey bees (43%). Contrarily, studies show in sesame crop proportional abundance of honey bees was higher than wild bee (Das and Jha, 2020; Mahfouz et al., 2012). However, Auguste *et al.* (2018) stated that there is equal proportional abundance of honey bees and wild bees in sesame. Similar trend was observed globally in other oilseed crops, the proportional abundance of wild bee (60%) was higher than honey bee (40%) in canola (Fuzaro *et al.*, 2019) and in sunflower proportion of wild bees was 70% and honey bees 30% (Silva *et al.*, 2018). In contrast honey bees were most abundant followed by wild bees and syrphid flies in mustard crop (Kunjwal *et al.*, 2014) and in sunflower (Chambó *et al.*, 2011). However, In Pakistan, the trend was same in some oilseed crops where proportional abundance of honey bees was higher than wild bees in mustard (Shakeel *et al.*, 2018), in canola (Ali *et al.*, 2011; Akhtar *et al.*, 2018) and in sunflower (Ali *et al.*, 2015).

Visitation rate is an important parameter for evaluating the efficiency of native insect pollinators (Albano *et al.*, 2009). In our study, visitation rate of wild bees was higher than honey bees. *Amegilla* bee has higher visitation rate followed by *N. oxybeloides* while *A. florea* has lowest visitation rate. In other oil seed crop wild bees have higher visitation rate than honey bees in rapeseed (Stanley *et al.*, 2013) and in canola (Ali *et al.*, 2011). In Pakistan, other than oil seed crops wild bees have high visitation rate than honey bees in *Capparis aphylla* (Latif *et al.*, 2016), cucurbits (Ali, 2017), *Ocimum basilicum* (Latif *et al.*, 2017) and in *Albizia lebbeck* (Latif *et al.*, 2018).

Visit duration is also an important parameter to asses efficiency of pollinators (Martinez and Wyatt, 2003). In our study, *A. florea* has highest visit duration while *Amegilla* bee and *N. oxybeloides* has lower visit duration. However, similar results were observed in canola where honey bee stays more longer on canola flower followed by wild bee (Ali *et al.*, 2011). Contrarily, in sunflower visit duration of wild bee is greater than honeybee. The variation in visit duration could be assessed in terms of proportion of nectar present in flower (Ahmad *et al.*, 2018).

The effectiveness of native pollinators can be asses as the proportion of seed formed in the result of single visit (Barrios *et al.*, 2016). In our studies single visit by wild bee *Amegilla* cause higher yield in term of capsule length, capsule weight, number of seed followed by *N. oxybeloides* while *E. aeneus* produce the least yield. Previous studies shows that visits of wild pollinators increase fruit set, even in the presence of managed bees which suggests that the wild pollinators contribution is unique and additive to that of managed bees (Carvalheiro *et al.*, 2010). Different studies have been reported in other oilseed crop, single visit by wild bee *Halictus* sp. in canola (Ali *et al.*, 2011), *Andrina* in sunflower (Mallinger *et al.*, 2018) *Andrena* spp. in rapeseed (Phillips *et al.*, 2018) produce significantly more seed then honey bees. Moreover, In Pakistan wild bee *Amegilla* is efficient pollinator of *C. aphylla* (Latif *et al.*, 2016) while *N. oxybeloides* is effective pollinators of cucurbit (Ali, 2017) and both are effective pollinators of *A. lebbeck* (Latif *et al.*, 2018) which increase seed yield in single visit. Previous studies show in agro-ecosystems wild bees provide better pollination than managed bees (Rader *et al.*, 2012).

## Conclusions and Recommendations

Our findings describe the potential of solitary bees and wild honey bees in sesame seed production. Therefore, conserving these effective native insect pollinators will lead to better seed yield and resultantly higher oil yield. For conservation of solitary bees, some areas should be left un-ploughed that will provide soil nesting bees better place to breed (Sajjad *et al*., 2008). Nest sites i.e., bee hotels, tree trunk should be provided at small scales in addition to maintaining abundant foraging resources in the landscape (Kline and Joshe, 2020; Everaars, 2012). Future research should focus on the effectiveness of these native solitary and wild honey bee species for other crops grown in South Punjab, Pakistan.

## Novelty Statement

Best of our knowledge no previous work has been done on single visit seed set efficacy of insect pollinators in sesame. Diversity of native efficient insect pollinators has been described first time for sesame seed production in South Punjab, Pakistan.

## Author Contribution

**Mudssar Ali, Muhammad Awais Ahmad and Asif Sajjad:** Conceived and designed the experiments.
**Mudssar Ali and Muhammad Awais Ahmad:** Performed the experiments, analyzed the data and Wrote the paper.
**Mudssar Ali, Muhammad Awais Ahmad, Asif Sajjad and Shafqat Saeed:** Contributed reagents/ materials/ analysis tools.
All the authors commented on previous versions of the manuscript.

*Conflict of Interest*
There is no conflict of interests regarding the publication of this article.

## References

Ahmad, M. 2018. Diversity of sunflower insect pollinators and their foraging behavior under field conditions. Uludağ Arıcılık Dergisi, 18(1): 14-27. https://doi.org/10.31467/uluaricilik.427584

Aizen, M.A., L.A. Garibaldi, S.A. Cunningham and A.M. Klein. 2009. How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. Ann. Bot., 103(9): 1579-1588. https://doi.org/10.1093/aob/mcp076

Akhtar, T., M.A. Aziz, M. Naeem, M.S. Ahmed and I. Bodlah. 2018. Diversity and relative abundance of pollinator fauna of canola (*Brassica Napus* L. Var Chakwal Sarsoon) with managed *Apis Mellifera* L. in Pothwar Region, Gujar Khan, Pakistan. Pak. J. Zool. 50(2). https://doi.org/10.17582/journal.pjz/2018.50.2.567.573

Albano, S., E. Salvado, P.A. Borges and A. Mexia. 2009. Floral visitors, their frequency, activity rate and index of visitation rate in the strawberry fields of Ribatejo, Portugal: selection of potential pollinators. Part1. Adv. Horti. Sci., 238-245.

Ali, H., A.A. Owayss, K.A. Khan and A.S. Alqarni. 2015. Insect visitors and abundance of four species of Apis on Sunflower *Helianthus Annuus* L. in Pakistan. Acta Zool. Bulg., 67(2): 235-240.

Ali, M., S. Saeed, A. Sajjad and A. Whittington. 2011. In search of the best pollinators for canola (*Brassica Napus* L.) Production in Pakistan. Appl. Entomol. Zool., 46(3): 353-361. https://doi.org/10.1007/s13355-011-0051-0

Andrade, P.B.D., B.M. Freitas, E.E.D.M. Rocha, J.A.D. Lima and L.L. Rufino. 2014. Floral biology and pollination requirements of sesame (*Sesamum Indicum* L.). Acta Sci. Anim. Sci., 36(1): 93-99. https://doi.org/10.4025/actascianimsci.v36i1.21838

Auguste, P.M., D.C. Dounia, E.N.O. Atibita and F.N.T. Fohouo. 2018. Pollination efficiency of *Apis mellifera* L. (Hymenoptera: Apidae) on flowers Of *Sesamum indicum* L. (Pedaliaceae) At Bilone (Obala, Cameroon) Int. J. Res. Stud. Agric. Sci., 4(3): 12-20. https://doi.org/10.20431/2454-6224.0403003

Blal, A.E.H., S.M. Kamel, H.M. Mahfouz and M. Said. 2013. Impact of opened, non opened pollination and nitrogen fertilizer on sesame production in the reclaimed lands, Ismailia Governorate, Egypt. Cercet. Agron. Mold., 46(3): 155. https://doi.org/10.2478/v10298-012-0093-7

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

Carvalheiro, L.G., C.L. Seymour, R. Veldtman and S. W. Nicolson. 2010. Pollination services decline with distance from natural habitat even in biodiversity-rich areas. J. Appl. Ecol., 47(4): 810-820. https://doi.org/10.1111/j.1365-2664.2010.01829.x

Chambó, E.D., R.C. Garcia, N.T.E.D. Oliveira and

J.B. Duarte-Júnior. 2011. Honey bee visitation to sunflower: effects on pollination and plant genotype. Sci. Agric., 68(6): 647-651. https://doi.org/10.1590/S0103-90162011000600007

Das, R. and S. Jha. 2019. Insect pollinators of sesame and the effect of entomophilous pollination on seed production in new alluvial zone of West Bengal. Int. J. Current. Microbiol. Appl. Sci., 8(3): 1400-1409. https://doi.org/10.20546/ijcmas.2019.803.164

Elleuch, M., S. Besbes, O. Roiseux, C. Blecker and H. Attia. 2007. Quality characteristics of sesame seeds and by-products. Food. Chem., 103(2): 641-650. https://doi.org/10.1016/j.foodchem.2006.09.008

Everaars, J. 2012. The response of solitary bees to landscape configuration with focus on body size and nest-site preference.

FAOSTAT. 2012. Food and Agriculture Organization of the United Nations. Roma, Italy.

Federal Bureau of Statistics. 2017-18. Govt. of Pakistan, External Trade Section, Karachi.

Fuzaro, L., V. Andaló, S.M. Carvalho, F.A.N. Silva, F.J. Carvalho and L.S. Rabelo. 2019. Floral visitors of canola (*Brassica Napus* L.) Hybrids in Cerrado Mineiro Region, Brazil. Arquivos Do Instituto Biológizco, 86. https://doi.org/10.1590/1808-1657001312018

Gallai, N., J.M. Salles, J. Settele and B.E. Vaissiere. 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecol. Econom., 68(3): 810–821. https://doi.org/10.1016/j.ecolecon.2008.06.014

Hameed, K. and K. Azeem. 2017. Pakistan need to be self sufficient in edible oil production. J. Energy. Technol. Policy, 7(2): 48-57.

Hussain, F., M. Rafiq, M. Ghias, R. Qamar, M. K.Razzaq, A. Hameed, S. Habib and H.S.B. Mustafa. 2017. Genetic diversity for seed yield and its components using principal component and cluster analysis in sunflower (*Helianthus Annuus* L.). Life Sci. J., 14 (5): 71-78.

Kamel, S.M., A.H. Blal, H.M. Mahfouz and M. Said. 2013. The most common insect pollinator species on sesame crop (*Sesamum Indicum* L.) in Ismailia Governorate, Egypt. Arthropods. 2(2): 66. https://doi.org/10.2478/v10298-012-0083-9

Kleijn, D., R. Winfree, I. Bartomeus, L.G. Carvalheiro, M. Henry, R. Isaacs and R. Rader. 2015. Delivery of crop pollination services is an insufficient argument for wild pollinator conservation. Nat. Commun., 6(1): 1-9.

Klein, A.M., B.E. Vaissiere, J.H. Cane, I. Steffan-Dewenter, S.A. Cunningham, C. Kremen and T. Tscharntke. 2007. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: Biol. Sci., 274(1608): 303-313. https://doi.org/10.1098/rspb.2006.3721

Kline, O. and N.K. Joshi. 2020. Mitigating the effects of habitat loss on solitary bees in agricultural ecosystems. Agriculture, 10(4): 115. https://doi.org/10.3390/agriculture10040115

Kurt, C.E.M.A.L. 2018. Variation in oil content and fatty acid composition of sesame accessions from different origins. *Grasas y aceites*, 69(1): 241-244. https://doi.org/10.3989/gya.0997171

Latif, A., S.A. Malik, A.M. Alvi, Q. Saeed, S. Saeed, M.A. Shuja and N. Iqbal. 2017. Pollinators' community Of *Capparis aphylla* at Dera Ghazi Khan, Punjab, Pakistan. Saud. J. Biol. Sci., 26(7): 144-155.

Latif, A., S.A. Malik, S. Saeed, S.M. Zaka, Z.M. Sarwar, M. Ali and M.A. Shahzad. 2019. Pollination biology of *Albizia lebbeck* (L.) Benth. (Fabaceae: Mimosoideae) with reference to insect floral visitors. Saud. J. Biol. Sci., 26(7): 1548-1552. https://doi.org/10.1016/j.sjbs.2018.12.005

Mahfouz, H., S. Kamel, A. Belal and M. Said. 2012. Pollinators visiting sesame (*Sesamum indicum* L.) Seed crop with reference to foraging activity of some bee species. Cercet. Agronom. Mold., 45(2): 49-55. https://doi.org/10.2478/v10298-012-0014-9

Mahmoud, F.M. 2012. Insects associated with sesame (*Sesamun indicum* L.) and the impact of insect pollinators on crop production. Pesticidi i fitomedic, 27(2): 117-129. https://doi.org/10.2298/PIF1202117M

Mallinger, R.E. and C. Gratton. 2015. Species richness of wild bees, but not the use of managed honeybees, increases fruit set of a pollinator dependent crop. J. Appl. Ecol., 52(2): 323-330. https://doi.org/10.1111/1365-2664.12377

Mallinger, R.E., J. Bradshaw, A.J. Varenhorst and J.R. Prasifka. 2019. Native solitary bees provide economically significant pollination services to confection sunflowers (*Helianthus Annuus* L.) (Asterales: Asteraceae) grown across the northern great plains. J. Econ. Entomol., 112(1): 40-

48. https://doi.org/10.1093/jee/toy322
Michener, C.D. 2000. The bees of the world (Vol. 1). JHU press.
Mustafa, H.S. 2019. Prospects of oilseeds in Pakistan. Directorate of Oilseeds, Ayub Agricultural Research Institute, Faisalabad (Pakistan) ISBN: 978-969-7594-14-6.
Neha, K., K. Yogesh and M.S. Khan. 2014. Flower-visiting insect pollinators of brown mustard, *Brassica Juncea* (L.) Czern and coss and their foraging behaviour under caged and open pollination. Afric. J. Agric. Res., 9(16): 1278-1286.
Parmar, R.S., V.P. Chovatia, H.R. Bara and G.K. Sapara. 2017. Method of pollination using female parents in Sesamum (*Sesamum indicum* L.) for different Time during summer.
Phillips, B., A. Williams, J. Osborne and R. Shaw. 2018. Shared traits make flies and bees effective pollinators of oil seed rape (*Brassica Napus* L.). Basic Appl. Ecol., 32: 66–76. https://doi.org/10.1016/j.baae.2018.06.004
Rader, R., B.G, Howlett, S.A. Cunningham, D.A. Westcott and W. Edwards. 2012. Spatial and temporal variation in pollinator effectiveness: do unmanaged insects provide consistent pollination services to mass flowering crops? J. Appl. Ecol., 49(1): 126-134. https://doi.org/10.1111/j.1365-2664.2011.02066.x
Ranjithkumar, G. and R.B.V. Kumar. 2020. Sesame (*Sesamum Indicum* L.): vital source of major nutrients. Agrinenv. 4.
Shakeel, M., H. Ali, S. Ahmad, F. Said, K.A. Khan, M.A. Bashir and H. Ali. 2019. Insect pollinators diversity and abundance in *Eruca Sativa* Mill. (Arugula) and *Brassica rapa* L. (Field Mustard) crops. Saud. J. Biol. Sci., 26(7): 1704-1709. https://doi.org/10.1016/j.sjbs.2018.08.012
Silva, C.A., W.A. Godoy, C.R. Jacob, G. Thomas, G.M. Câmara and D.A. Alves. 2018. Bee pollination highly improves oil quality in sunflower. Sociobiol., 65(4): 583-590. https://doi.org/10.13102/sociobiology.v65i4.3367
Stanley, D.A., D. Gunning and J.C. Stout. 2013. Pollinators and pollination of oilseed rape crops (*Brassica napus* L.) in Ireland: ecological and economic incentives for pollinator conservation. J. Insect. Conserv., 17(6): 1181-1189. https://doi.org/10.1007/s10841-013-9599-z
Stein, K., D. Coulibaly, K. Stenchly, D. Goetze, S. Porembski, A. Lindner, S. Konaté and E.K. Linsenmair. 2017. Bee pollination increases yield quantity and quality of cash crops in Burkina Faso, West Africa. Sci. Rep., 7(1): 1-10. https://doi.org/10.1038/s41598-017-17970-2
Van Der Sluijs, J.P. and N.S. Vaage. 2016. Pollinators and global food security: the need for holistic global stewardship. Food Ethics., 1(1): 75-91. https://doi.org/10.1007/s41055-016-0003-z
Vockeroth, J.R. 1969. A revision of the genera of the Syrphini (Diptera: Syrphidae). The Memoirs of the Entomological Society of Canada, 101(S62): 5-176. https://doi.org/10.4039/entm10162fv
Wietzke, A., C. Westphal, P. Gras, M. Kraft, K. Pfohl, P. Karlovsky and I. Smit. 2018. Insect pollination as a key factor for strawberry physiology and marketable fruit quality. Agric. Ecos. Environ., 258: 197-204. https://doi.org/10.1016/j.agee.2018.01.036