Impact of Insect Pollinators on the Yield of Canola (*Brassica napus*) in Peshawar, Pakistan[1]

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ABSTRACT The impact of insect pollinators on the yield of two canola varieties ('Ganyou' in which pollen viability and germination are adversely affected by soil salinity, and 'Oscar' that is more tolerant of soil salinity) was studied at the Research Farm of the Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan in 2009 and 2010. Yields were similar between the two cultivars. Significant differences were observed between pollinated and covered plants for three yield parameters (i.e., total yield, number of seeds per sliquae, and weight of 100 seeds). Average yields were 189.3 ± 1.7 pods/plant in the pollinated plots and 142.2 ± 2.4 pods/plant in the covered plots. There was an average of 15.0 ± 0.9 seeds/siliquae in pollinated plots and 11.0 ± 0.8 seeds/siliquae in covered plots. The weight of 100 seeds was 0.55 ± 0.02 g in pollinated plots and 0.37 ± 0.01 g in covered plots.

KEY WORDS Pollinators, *Brassica napus*, Canola, varieties, Oscar, Ganyou

Canola, *Brassica napus* L. and *B. campestris* L. (Brassicaceae), are the major oil-producing crops in Pakistan. Canola is a winter crop grown in the Rabi season, with its cultivation starting in October/November and its harvest in March/April. This crop is grown in irrigated and rain-fed (barani) areas of Sindh, Punjab, and Khyber Pakhtunkhwa Provinces of Pakistan. The total area under canola cultivation in Khyber Pakhtunkhwa in 2008 was 17,500 ha, with total production of 8100 metric tons and an average yield of 463 kg/ha (MINFAL 2008). Canola has been one of the major sources of edible oil in the Asian subcontinent and China for centuries. Oil cakes have been used for feed for livestock (Ramachandran et al. 2007).

A sizable proportion of the human diet depends directly or indirectly on animal pollination (Aizen et al. 2008). The total economic value of pollination worldwide amounted to US $19.5 billion in 2005, which represented 9.5% of the value of the world agricultural production used for human food that year (Gallaia et al. 2009). Both conventional and genetically engineered crops, including canola, benefit from pollinators and wild bees in particular (Chiari et al. 2005, Morandin & Winston 2006). The dependence on pollination varies significantly among crops, with some crops having increased yields up to 100%, while others having increases of just a few percent (Chiari et al. 2005).

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Because most oilseed crops are cross-pollinated, adequate pollination is vital for significant seed production. Almost one-third of the total cropped area under oilseed production has been reported to be entomophilous (Mishra et al. 1988). Honeybees, *Apis mellifera* L. (Hymenoptera: Apidae), play a dominant role in pollinating rapeseeds (Mesquida et al. 1988). The yield of rapeseed and canola can be increased by several percent through pollination by insects (Manning & Wallis 2005, Sabbahi et al. 2005, 2006). Pollination not only improves the yield of the crop, but it also contributes to uniform and early pod setting (Abrol 2007a,b).

The first step in assessing the importance of insect pollination for food production and the impact of pollinator scarcity due to different environmental disturbances is to find out the pollination needs of different cultivated crops (Klein et al. 2007). In Pakistan, there is no baseline information on the impacts of pollinators on crop yields. The present research was conducted to assess the impact of existing pollinators on the yield of canola in the Peshawar District of Pakistan.

Materials and Methods

The experiment was conducted at the Research Farm of the Khyber Pakhtunkhwa Agricultural University, Peshawar, during the 2009–2010 growing season. The experiment was laid out in a Randomized Complete Block Design (RCBD) with canola cultivar (*B. napus*) serving as the blocking factor and pollination treatment serving as the treatment factor. Each cultivar-pollination combination was replicated three times. Two cultivars of canola ('Ganyou' in which pollen viability and germination are adversely affected by soil salinity, and 'Oscar' that is more tolerant of soil salinity) were sown in September 2009 on 45 m^2 plots. Distances between plants were 15 cm within row and 10 cm between rows. No insecticides were applied to the crop. The plot was irrigated three times during the growing season. For one treatment, a 4-m^2 area in each plot was covered with nylon cloth to prevent the entry of pollinators, while for the other treatment, a 4-m^2 area in the same plot was left open and accessible to pollinators. There were 24 plants in each 4-m^2 area.

The crop was harvested when the majority of siliquae had become tan and the seeds within them had turned black at maturity. At this point, seed moisture can be maintained at approximately 10 percent, which prevents shattering of seeds from siliquae. Twenty siliquae were collected from each pollinated and non-pollinated treatment plot in each replication. The seeds in each siliqua were counted to determine the numbers of seeds per siliqua. All the seeds from the 20 siliquae (from each pollination treatment) were combined. Three batches of 100 seeds were randomly collected from the combined seeds and weighted to determine the average seed weight. The number of siliquae per plant was calculated by counting the number of siliquae from 24 plants selected from the pollinated and non-pollinated areas in all replications. Yield calculations of the canola were carried out according to the methods used by Angadi et al. (2003), Stefen-Dewenter (2003), Manning & Wallis (2005), Sabbahi et al. (2005), and Duran et al. (2010). Yield parameters of both pollinated and non-pollinated plots of each cultivar were statistically analyzed by ANOVA using SPSS® version 15.0 for Microsoft Windows®. Turkey's multiple range comparison tests were used for the statistical separations of mean yield parameters.

Table 1. Average (±SE) numbers of siliquae per plant, seeds per siliqua, and weight of 100 seeds for two cultivars of canola (Oscar and Ganyou) grown in open-pollinated or covered plots in Peshawar, Pakistan.

Canola cultivar	Pollination treatment	No. of siliquae per plant	No. of seeds per siliqua	Weight of 100 seeds (g)
Oscar	Open-pollinated	192.0 ± 3.2 a	14.7 ± 0.9 a	0.55 ± 0.1 a
Oscar	Covered	144.3 ± 2.4 b	12.0 ± 0.8 b	0.36 ± 0.1 b
Ganyou	Open-pollinated	186.7 ± 4.4 a	15.3 ± 0.9 a	0.57 ± 0.1 a
Ganyou	Covered	142.0 ± 2.7 b	10.0 ± 0.8 b	0.38 ± 0.1 b
Combined	Open-pollinated	189.3 ± 1.7	15.0 ± 0.9	0.55 ± 0.02
Combined	Covered	142.2 ± 2.4	11.0 ± 0.8	0.36 ± 0.10

Data were analyzed by ANOVA ($\alpha = 0.05$) with a RCBD. Means within the same canola cultivar with the same letters were not significantly different between the pollination treatments according to Tukey's test.

Results

European honey bee (*Apis mellifera* L.) (Hymenoptera: Apidae), small bees (*Apis florea* F.), giant honey bees (*Apis dorsata* F.), rock bees (*Apis cerana* F.), bumble bees (*Bombus* sp.) (Hymenoptera: Apidae), drone flies (*Eristalis tenax* L.) (Diptera: Syrphidae), and other hover flies (*Simosyrphus grandicornis* Macquart, *Episyrphus balteatus* De Geer, and *Eristalinus aeneus* Scopoli) (Diptera: Syrphidae), were observed foraging among the canola plants in 2009 and 2010. The abundance of the pollinators was similar between the two canola cultivars. However, more pollinators were found foraging in the morning (10–11 am) than in the afternoon (4–5 pm) (Shakeel & Inayatullah, unpublished).

Number of siliquae per plant. There was no significant difference between cultivars in the number of siliquae per plant ($F_{1,10} = 1.73$, $P = 0.218$ (Table 1). However, there was a significant difference between the number of siliquae per plant on covered versus pollinated plots ($F_{1,10} = 7.3$, $P = 0.022$) (Table 1). This represented a 24.9% increase in the number of siliquae per plant due to pollination.

Number of seeds per siliqua. There was no significant difference ($F_{1,10} = 1.31$, $P = 0.279$) between cultivars in the number of seeds per siliqua (Table 1). However, there was a significant difference ($F_{1,10} = 6.60$, $P = 0.027$) between the number of seeds per siliquae for covered and pollinated canola. This represents a 26.7% increase in the number of seeds per siliquae due to pollination.

Weight of 100 seeds. There was no significant difference ($F_{1,10} = 3.20$, $P = 0.103$) between cultivars in the weight of 100 seeds for Oscar and Ganyou (Table 1). However, there was a significant difference ($F_{1,10} = 6.30$, $P = 0.030$) between weight of 100 seeds for covered and open-pollinated canola. This represents a 33.9% increase in the weight of seeds due to pollination.

Discussion

Nine species of pollinators were recorded in canola, among which *A. mellifera*, *A. florea*, *A. dorsata,* and *A. cerana* were the major pollinators (Shakeel &

Inayatullah, unpublished). Visitation by many species ensured that the absence of one particular species would not severely affect yield.

This study showed that open-pollinated canola had significantly higher yields than unpollinated (covered) canola. These results agree with the observations of Chand & Singh (1995) on *Brassica juncea* (L.) Czern., and Mishra et al. (1988) on *B. campestris* L. var. *sarson*. Khan & Chaudhry (1988), Singh (1997), and Singh et al. (2004) showed that insect pollination leads to the formation of well-shaped and larger seeds than self-pollinated plants. Our results also support the observations of Morandin & Winston (2005), in which seed set in *B. napus* increased with a higher population density of wild bees.

Dhakal (2003) discovered that seed yield in *B. campestris* var. *toria* increased significantly due to bee pollination in comparison with caged plants and those receiving other sources of pollination. Yield parameters, such as siliquae or seeds per plant and average seeds per pod, were significantly higher in open and bee pollinated crops. Higher numbers of canola seeds were recorded in open plots than in covered plots, which show the impact of pollination on this crop (Manning & Wallis 2005, Sabbahi et al. 2005, 2006). Tara & Sharma (2010) compared the qualitative and quantitative effects of pollination on controlled (covered) and open-pollinated plants of *B. campestris* var. *sarson*. They found that fruit set was higher in open-pollinated (88.1%) compared to controlled (80.0%) plots. Differences were also found in the number of seeds per pod (open, 10.2; controlled, 11.2) and mean weight of 100 seeds (open, 0.42 g; controlled, 0.17 g).

This study has demonstrated the importance of insect pollinators on the yield of canola. Due to decreases in the abundance of pollinators around the world, conservation of pollinating insects and their impacts are major subjects of debate in the agricultural sector (Klein et al. 2007). Steps should be taken by farmers and others to conserve these valuable pollinators by using environmentally friendly pest control methods.

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