The Impact Of Insect Pollinators On Yield And Yield Components Of Faba Bean (*Vicia faba* L.)

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Abstract: Faba bean (*Vicia faba* L.) is relatively an important leguminous food crop in Middle East. Inadequate pollination is considered a major constraint to the potential yield of faba bean. Three pollination treatments T0 (Open pollination by all insects including honeybees), T1 (Cages pollination by honeybees only) and T2 (Cages pollination without honeybees and other insects) were applied on two cultivars of faba beans during two consecutive years to evaluate the effect of insect pollinators on faba bean yield its components. The highest means of biological yield (7.13 t/ha.), seed yield (3.43 t/ha.), number of pods/plant (31.31), number of seeds/plant (86.28), seed weight (57.45g) and 100-seed weight (59.79g) were found with the treatment of T0, followed by T1 and T2 treatments, respectively. On the other hand, the lowest biological yield (4.81 t/ha.), seed yield (2.26 t/ha.), number of pods/plant (22.88), number of seeds/plant (62.51), seed weight (12.0 g) and 100-seed weight (46.87 g) were obtained from the treatment T2 pollination without honeybees and other insects).

Key words: Faba bean, *Vicia faba,* Honeybees, Insects, cages and open pollination.

Introduction

Faba bean (*Vicia faba* L.) is a broad bean originated in the Middle East and remained as an important human food and livestock nutrition crop in Australia, China and several Mediterranean and African countries. It is a self-fertile with about equal amount of self and cross-pollination occurring depending on the presence of insect pollinators. Inadequate pollination is considered as a major obstacle to achieve the potential yield of faba bean. Insects appear to be the major pollinators of faba bean, in agreement with pollination syndrome suggested by the morphology of its flowers. Direct observations of insects visiting faba bean flowers suggest that honeybee (*Apismellifera* L.) is a major pollinator of commercially grown faba bean in Saudi Arabia. As an efficient insect pollinator the honeybees can increase the yield of faba beans by 19-52% (Somerville, 2002). Besides a rich source of protein faba beans conserve soil nitrogen and fix more than 80% of their nitrogen needs. Therefore, faba beans has got more importance in recent years and has been selected for breeding program for improved yield (Hovinen, 1988).

Stoddard (1991) surveyed commercial crops of faba bean in South Australia and Western Victoria for flower visitors and incidence of pollination where he found only honeybees as pollen vector and an average 80% incidence of

pollination. Somerville (1999) recorded 25% higher seed yield in cages with bees than in those without bees and recommended the use of honeybees to improve the faba bean yield. Pollination increases crop yield without harmful environmental effects (Levin and Waller, 1989). In Australia, the yield of faba bean where the plots were caged with honeybee increased 24% than plots caged without honeybees (Somerville, 1994).

Oschman (1957) found that field bean plants enclosed in cages to exclude bees, produced only 71% as many pods and 77% as many seeds as plant in open plots.

Riedel and Wort (1960) reported that field bean plants enclosed in cages with honeybee colonies produced about half as many beans as those did in open plots but not significantly more than in cages without bees. Wafa and Ibrahim (1960) concluded that faba bean plants caged with honeybees produced 14% more pod than the plants isolated from insects. Bond and Poulsen (1983) in New Zealand identified inadequate bee pollination as a major constraint in potential yield of faba beans. Honeybee pollination increased 19 to 37% yield of faba bean was recorded in Europe (Watts and Marshall, 1961; Poulson, 1975; Frusciante and Monti, 1980; Varis and Brax, 1990). Monti and Frusciante (1982) found 22% and 19% decrease in yield from the plants grown from self-pollinated seed because of inbreeding depression and decreased ability to auto-fertilize, respectively. Seriven *et al.* (1961) found similar calculated yield (wt./acre) in a plot of field beans caged with bees and in an open plot, but the yield was about halved in a cage excluding insects. Free (1966) reported that plants caged with bees had more pods and abut twice as many seeds as in similar plants caged without bees, but fewer than plants not caged. Allen and Scriven (1957) concluded that one colony of honeybees per acre should give adequate coverage to field beans. Brandenburg (1961) reported a double increase in faba bean yield with the introduction of honeybees and suggested to introduce a new group of bees to bean plots every 7 to 14 days.

The present study was carried out to assess the role of insect pollinators including honeybees on seed yield of faba bean and its components.

Materials and Methods

The study was carried out at the Experimental Research Station at Derab, College of Agriculture, King Saud University, Riyadh, during 2000/2001 and 2001/2002 growing seasons. It involved three treatments, namely T0 (Open pollination by all insects including honeybees); T1 pollination by honeybees only) and T2 (Cages pollination without honeybees and other insects) and two cultivars of faba bean (Riena blanka and Giza 461).

Faba bean plants were grown in rows, 50 cm apart and 20 cm between hills. Two seeds were had sown/hole during 18 Oct., 2000 and 20 Oct., 2001 in the first and second seasons, respectively. Each plot contained 6 rows, 50 cm width and 4.0 m length, occupying an area of 3x4 m.

A split plot design with four replicates was used. The main plots were assigned to the following three pollination treatments:

T0: Open pollination by all insects including honeybees

T1: Caged pollination by honeybees only

T2: Caged pollination without honeybees

and other insects.

The sub plots were devoted to faba bean cultivars, namely Riena blanka and Giza 461.

The soil at the experimental site was highly calcareous, non-saline sandy clay loam. The plots were irrigated on weekly basis. Other normal agronomic practices for faba bean production were followed as the usual manner, except the studied treatments.

At maturity stage, the inner two rows of each subplots were harvested in order to estimate yield and yield components. Five plant samples were taken randomly, for yield components. Data was recorded on biological yield (BY), seed yield (SY), number of pods/plant (POD), number of seeds/plant (S), seed weight/plant (SW) and 100-seed weight (SI).

Obtained data were subjected to the proper statistical analysis as the technique of combined analysis over years of the split plot in randomized complete bock design. According to the method stated by Gomez and Gomez (1984). Treatment means were compared using the least significant difference (LSD) method, whereas the level of significant differences among treatments means were tested at 5% probability level.

Results and Discussion

Analysis of variance for various characters studied under three treatments during two growing seasons has been presented in Table 1. showed a significance difference for year wise comparison among biological yield, seed yield, number of seeds/plant, seed weight and 100-seed's weight, while a non-significant difference was witnessed for number of pods/plant whereas year wise replication comparison remained non-significant for all traits Comparison of treatments showed a highly significant difference for all tested traits while the year wise comparison of treatments revealed no significant difference except for no. of pods/plant whereas year wise treatments replication comparison also remained non-significant. Comparison of cultivars revealed a significant difference between all tested traits except seed yield but a non-significant interaction was recorded for year* cultivar except for seed yield and plant height. Pollinators X Cultivar interaction was found non-significant for seed, no. of pods/plant, number of seeds/plant, and seed weight but was significant for biological yield and 100-seed's weight. The year X Treatment X Cultivar (Three-way interaction) was not found significant for all tested traits.

The treatment comparison of different characters related to the impact of honeybees on faba bean has been statistically analyzed and the treatment means are presented in Table 2. Analysis of the data revealed a significant differences among all treatment means of Biological yield. The maximum biological yield (7.13 t/ha.) was obtained from the treatment of T0, followed by T1 (5.50 t/ha.) and T2 (4.81 t/ha.). This might be due the fact much of the photosynthesis have been directed to vegetative growth due to the low number of pods/plant and seed/plant.

Analysis of data concerning seed yield also presented a significant difference among all the treatment means. Maximum seed yield (3.43 t/ha.) was obtained from the treatment of T0, followed by T1 (2.85 t/ha.), whereas T2 gave the lowest seed yield (2.26 t/ha.). This could be attributed to the effect of visiting honeybees and other insects to faba bean flowers which led to better pollination and

Table 1. Results of the combined analysis of variance calculated for the estimated traits over the two seasons (2000/2001 and 2001/2002).

Source of Variation	Degrees of Freedom	Characters (Traits)					
		BY	SY	POD	S	SW	SI
Years (Y)	1	**	**	N.S	*	*	**
Replications/years	6	-	-	-	-	-	-
Treatments (T)	2	**	**	**	**	**	**
Y*T	2	N.S	N.S	N.S	N.S	N.S	N.S
Error 1	12	-	-	-	-	-	-
Cultivar (C)	1	**	N.S	**	**	**	*
Y*C	1	N.S	*	N.S	N.S	N.S	N.S
T*C	2	**	N.S	N.S	N.S	N.S	**
Y*T*C	2	N.S	N.S	N.S	N.S	N.S	N.S
Error 2	18	-	-	-	-	-	-

*and **=Significant at 5 and 1% level of probability, respectively.

Table 2. The treatment comparison of different traits means related to the impact of honeybees on faba bean.

Treatments	BY (t/ha.)	SY (t/ha.)	POD (No.)	S (No.)	SW (gm)	SI (gm)
T0	6	-	-	-	-	-
T1	2	**	**	**	**	**
T2	2	N.S	N.S	N.S	N.S	N.S

Average followed by the same letter(s) is (are) not significantly differed at 5% level of probability.

fertilization during seed initiation stage. The presence of seeds in un-caged plants suggested that pollinators and wind seemed to play a significant role in faba bean pollination through geitonogamy, in which pollen grains fall from upper most panicles onto stigma of lower panicles may account for good level of pollination. Moreover, the high seed yield of un-caged plants lead to strong support to the hypothesis that large insects including honeybee are the major pollinating agent of faba bean than small insects e.g., ants play no role in the pollination of faba bean.

Analysis of data related to number of pods per plant showed a significant difference between all treatment means. The highest average number of pods/plant (13.3 pods) was observed in the treatment T0, followed by treatment T1 (27.7) and treatment T2 (22.9). The role of insect pollinators can be judged through the higher no. of pod/plant which resulted from to better pollination, fertilization and development of pods and seeds.

The results clearly showed that wind did not carry faba bean pollen grains very far. Although the action to the wind shacked panicles and dropped pollen grains out of the anthers on to lower stigmas. Ants ware frequently seen visiting faba bean inflorescence which might have no role in faba bean pollination in Central region of Saudi Arabia.

Analysis of data recorded for number of seeds per plant showed a significant difference between all treatments means. The average maximum number of seeds per plant (86.28) was observed in treatment T0, followed by

treatment T1 (75.64) and T2 (62.51).

Analysis of data concerning seed weight showed a significant difference between all pollination treatments. The average maximum seed weight was observed in treatment T0, followed by treatment T1, while the lowest mean was noticed with T2 treatment.

Analysis of data related to 100-seed weight showed a significant difference between all treatment means. Maximum 100-seed weight (59.79g) was observed with the treatment T0, followed by treatment T1 (53.03g), whereas the treatment T2 produced the lowest seed weight (46.87g). The results recorded during present study revealed that treatment T0 demonstrated best results in each trait, which was attributed to the high population of insect pollinators including honeybees.

The effect of season on different agronomic traits related to the impact of honeybees on faba bean has been statistically analyzed and presented in Table 3. Analysis of the data revealed a significant difference between means values of biological yield, seed yield, number of pods/plant, number of seeds/plant and 100 seed weight, while the mean values in the traits related to seed weight were found statistically at par with each other during both consecutive years.

The comparison of two cultivars of faba bean for different traits related to the impact of honeybees on faba bean was made and the data recorded was statistically analyzed and presented in Table 4. Analysis of the data revealed a significant difference between means values of biological yield, number of pods/plant, number of seeds/plant, seed weight and 100-seed's weight while the mean values in the trait related to seed yield were found statistically at par for both cultivars.

Results discussed above proved that our findings were found in agreement with those of Oschman (1957), Scriven (1961), Riedel and Wort (1960) who reported that bean plants in open plots presented a better yield than the faba bean plants enclosed in cages with honeybees better than faba bean plants enclosed in

Table 3. Seasonal effects on various agronomic traits means related to the impact of honeybees on faba bean.

Treatments	BY (t/ha.)	SY (t/ha.)	POD (No.)	S (No.)	SW (gm)	SI (gm)
1st year	5.969a	2.987a	27.320a	76.432a	50.452a	55.591a
2nd year	5.666b	2.718b	27.297a	73.201b	49.470b	50.881b

Averages followed by the same letter(s) is (are) not significantly differed at 5% level of probability.

Table 4. Comparison of two cultivars of faba bean means, related to the impact of honeybees on faba bean for different agronomic traits.

Treatments	BY (t/ha.)	SY (t/ha.)	POD (No.)	S (No.)	SW (gm)	SI (gm)
Riena blanka	6.03a	2.92a	28.14a	77.34a	51.51a	54.39a
Giza 461	5.60b	2.77ab	26.47b	72.29b	48.41b	52.07b

Average followed by the same letter(s) is (are) not significantly differed at 5% level of probability.

excluding honeybees, respectively. Monti and Frusciante (1982) found 2% and 19% decrease in yield from the plants grown from self-pollinated seed because of inbreeding depression and decreased ability to auto-fertilize, respectively. These results are in consistent with our results as we obtained a minimum yield in treatment T2 where the insect pollination was avoided.

The present findings are also in line with those of Wafa and Ibrahim (1960) and Free (1966) who concluded that faba bean plants caged with honeybee produced more pods than the plants isolated from insects. Somerville (1999) also recorded 25% yield increase in cages with honeybees than in those without bees. Similar results obtained by Watts and Marshall (1961), Poulson (1975), Frusciante and Monti (1980). Moreover, Varis and Brax (1990) who recorded 19-37% increase in yield of faba bean in Europe by using honeybee as crop pollinator which also confirmed our results. In commercial production of faba bean plants, where high yields are required efficient pollinators are pre-request. In this context *Apis mellifera* L. is probably the main pollinating agent of faba bean in Central Region of Saudi Arabia. In fact, the insects showed the highest frequency of flower visit in faba bean fields. It is clear that the achievements made during present research work do support the findings of the aforesaid scientists. Keeping in view all the results recorded during present study it is concluded that provision of sufficient number of honeybee colonies improves pollination and hence yields of faba bean.

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تأثير الملقحات الحشرية على المحصول البذري ومكوناته لنبات الفول البلدي

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ملخص البحث: يعتبر محصول الفول البلدي أحد أهم المحاصيل البقولية والغذائية في منطقة الشرق الأوسط ولكن أحد المعوقات الرئيسية للحصول على أعلى محصول من البذور هو قلة التلقيح الخلطي . ولذلك فقد تم دراسة مشكلة التلقيح وتأثيرها على المحصول البذري ومكوناته لصنفين من نباتات الفول البلدي هما رينا بلانكا وجيزة 461 خلال موسمين زراعيين (2000-2001 م) ، حيث تم دراسة ثلاث معاملات هي : زراعة نباتات الفول البلدي بدون شبك حماية (مفتوح التلقيح) ، زراعة النباتات داخل شبك حماية مع وجود خلايا نحل فقط والمعاملة الثالثة زراعة النباتات داخل شبك حماية بدون وجود خلايا نحل . وذلك لتقييم أثر الملقحات الحشرية على المحصول البذري ومكوناته . أوضحت النتائج المتحصل عليها تفوق المعاملة الأولى على بقية المعاملات وأعطت أعلى محصول بيولوجي ومحصول بذري وعدد القرون ووزن بذور النبات وكذلك وزن مائة بذرة وتلاها المعاملة الثانية وأخيرا المعاملة الثالثة كانت الأقل .