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Effects of Foraging Activity of Honeybees (*Apis mellifera* L.) on Onion (*Allium cepa*) Seed Production and Quality

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Abstract: The effects of honeybee pollination on seed production and quality in onion cultivar *valencia* were studied in this research. Treatments were applied, plots caged with bees; open plots and other pollinators and plots caged without bees. Twenty colonies were equalized in population strength and maintained by throughout flowering period of the crop. Average seed yield, total seed yield, 1000 seed weight, germination rate, emergence rate, stressful condition emergence rate, mean days to germination, mean days to emergence, stressful condition mean days to emergence were determined in this experiment. Observations on foraging behavior were recorded for the daily initiation, cessation, peak hours of foraging activity, weight of pollen load and number of flowers visited per minute by a bee for determining foraging activity. Results revealed that the seed yield per bulb was higher in open plots (5.74 g/flower) than in caged plots (1.29 g/flower). Total seed yield per plot was 898.95 g/plot in open sided whereas it was 220.65 g/plot in caged groups. Other seed quality characteristics (germination rate, emergence rate, stressful condition emergence rate, stressful condition mean days to emergence) were also considerable higher in open plots than in caged plots. *Apis mellifera* L. workers foraged on onion plant from 8.15 to 16.30 h with peak foraging between 11.00 and 12.00 h. At 09.00, 12.00 and 15.00 h respectively, workers averaged visited 8.0, 13.0 and 4.0 flowers per minute and collected 8.0, 10.0 and 6.0 mg of pollen. These results approved that utilization of honeybees on onion seed production would effectively increase the seed quality and quantity.

Key words: *Apis mellifera*, pollination, *Allium cepa*, seed production, ecology

INTRODUCTION

Pollination is an important factor in producing high quality seed in onion. Inefficient pollination caused the difficulties in hybrid seed production and getting high quality. In lack of natural pollinators, honey bees play the vital role in onion pollination. Several pollination factors could be taken into consideration for agricultural production such as wind, hand-pollination, some pollen dispenser methods, insects. Wind has a little effects on onion pollination because of its sticky pollens^[1]. Even other insects and solitary bees have important supplement on onion pollination; especially honeybees are the most valuable ones^[1]. Onion flowers have so much quantity of nectar. That is why onion is so attractive for honey bees, solitary bees and other some hymenoptera species^[2]. Bohart *et al.*^[3] reported 267 species of insect visitors on onion flowers, the most important of which were honey bees, small syrphid flies, *megachile rotundata*, halictid bees and drone flies. Of these, only the honey bee can be manipulated and used in large-scale

seed production in onion. Gjorgji and Rukie^[4], reported that seed mass of onion pollinated with bees on average 10.57% higher than is the case with mechanical pollination. Seed germination is on average 3.67% higher. Onion needs at least 12-15 colonies per hectare for sufficient pollination^[1-5].

Alam^[2] reported that drone flies (*Calliphora* spp.) were more effective than honey bees on onion pollination in closed area, but the opposite situation was valid in open areas. McGregor^[10], showed that every bees could visited 100-150 onion flowers per fly. This number could be increased up to 50-60 million flowers visiting in healthy and strong colonies in a day. The same researcher ascertained that the pollination activity of honey bees were 80-90% in onion fields. Similar this approach, Banik^[7], approach that the pollination activity of wind was 10%, other pollinators were 3% and honey bees were 87% in onion pollination. In the same research, it was also specified that using of honey bees in onion pollination increased seed yield 0.5 g per bulb. Honey bee pollination also increases 1000 seed weight, viability and livability in

onion seed production^[8-11]. Munawar and Muzaffar^[12], proved that using honeybees in onion pollination increased seed yield 10-11 times more than control groups.

The aim of this study was to investigate the effects of foraging activity of honey bees on onion seed production and quality.

MATERIALS AND METHODS

This study was conducted in Ege University. Faculty of Agriculture among March and July in 2002. The effects of honeybee pollination were studied in the onion cultivar *Valencia*. Onion bulbs were sown at the beginning of March. Dimensions of plots were 1.5x4.5 m = 6.75 m². Plant distances between main rows were 90 cm, between double rows 30 cm and within row 20 cm. There were approximately 9 bulbs/meter^[13]. Treatments were applied, plots caged with bees; open plots and other pollinators and plots caged without bees. Twenty colonies were equalized in population strength and maintained by throughout flowering period of the crop.

Experiment was conducted in a Randomized Block Design with four replications. Two types of treatments were applied; plots caged with gauze pads individually prevented for visiting of any insects and honey bees before flowering period and open plots allow visiting other pollinators and honey bees. First groups designed of 4 parcels referred as control whereas the second groups of 4 parcels were treatment. After finishing of flowering period at the end of June, gauze pad cages were opened and every umbel was taken for specifying of quality criteria of seed yield.

Onion bulbs were harvested manually, graded up to parcels and left to dry. Average Seed Yield (ASY), Total Seed Yield (TSY), 1000 Seed Weight (SW), germination rate (20°C), emergence rate (20°C), stressful condition emergence rate (15°C), Mean Days to Germination (MDG), Mean Days to Emergence (MDE), stressful condition Mean Days to Emergence (MDE_{sc}) were determined in the experiment. So the quality characteristics of seeds getting from different applications were tested and determined.

Twenty honey bee colonies were equalized in population strength as 7 frames (4 frames with adult bees+ 3 frames with pupa and larva) and maintained by throughout flowering period of the crop. The number of colonies were taken more in consider of pollination difficulties of male-sterile onion which is less attractive than male-fertile onion for honey bees^[1,14,15].

Observations on foraging behavior were recorded for the daily initiation and cessation and peak hours of foraging activity. The peak hours of foraging activity were

determined by counting the number of bees entering the hive in a three-minute period each hour from early morning until late evening. Observations of the weight of pollen load and flowers visited per minute by a bee were taken at 09.00, 12.00 and 15.00 h. The weights of pollen loads were determined by taken forager bees from entrance of the hives by using the aspirator collect foragers per colony^[16]. Then they were removed and weighted their pollen loads.

The other crops flowering periods considered as not to colliding with onion flowering period to prevent crop competition in flowering period. Besides that, bee colonies placed in the field maintaining the same distances (20 m) from the crop. By this application, more honey bees were prevented from visiting for specific plots. So the homogeneous dispersion of forager visiting in the field tried to maintain. Average temperature and humidity were recorded daily during the experiment. (Average temperature and relative humidity were determined as 28.2°C and 40.4% during the experiment, respectively).

The data obtained from the experiment was subjected to one-way ANOVA using the General Linear Models procedure SAS^[17]. Significant differences among means were determined using Duncan's Multiple Tests with data in the experiment.

RESULTS AND DISCUSSION

Results revealed that the seed yield per bulb in open plots (5.74 g/flower) showed more significant increase than in caged plots (1.29 g/flower). Total seed yield per parcel was 898.95 g/plot in open sided whereas it was 220.65 g/plot in caged groups (Table 1).

Other seed quality characteristics; Germination Rate (GR), Emergence Rate (ER), stressful condition emergence rate were also considerable higher in open plots than caged plots. Besides, germination and emergence dates were approximately 0.5 day earlier in open plots than in caged plots.

Seeds were more coarse and filled. Embryo and endosperm parts of seed were completed perfectly. Differences among treatments were also obtained in seed livability tests. Both, germination rate and emergence rate of seeds were found higher 12.0 and 11.5% in open plots, respectively. All these differences among treatments were significant ($p < 0.01$).

In the condition of low temperature (15°C), emergence rates of onion seeds taken from open plots were found 90.5%, whereas caged plots were 81.5% (Table 1).

Forager bees started at 8.15±0.06 h and stopped at 16.30±0.06 h on onion foraging (Table 2).

Table 1: The effects of treatment on seed yield, seed viability and some quality characteristics

Treatments	ASY (g/flower)	TSY (g/parcel)	SW (1000) (g)	GR (%)	ER (%)	ERS (15°C) (%)	MDG (days)	MDE (days)	MDES(15°C) (days)
Open Plot (OP)	5.74 ^a	898.95 ^a	3.64	97.00 ^a	94.00 ^a	90.50 ^a	4.41 ^b	6.61 ^b	13.95
Caged Plot (CP)	1.29 ^b	220.65 ^b	2.74	85.00 ^b	82.50 ^b	81.50 ^b	5.04 ^a	7.05 ^a	15.35
SEM	0.03	27.56	0.28	1.00	0.35	1.50	0.06	0.03	0.26
Significance level (P)									
OP-CP	0.0001	0.0033		0.1513	0.0136	0.0019	0.0513	0.0165	0.0104

a,b: Means with no common superscript in the same column for each effect differ significantly ($p < 0.01$), SEM: Standard error of mean.

ASY: Average seed yield; TSY: Total seed yield, SW (1000): Seed weight, GR: Germination rate, ER: Emergence rate;

ERS: Emergence rate of stress condition, MDG: Mean days to germination, MDE: Mean days to emergence,

MDES: Mean days to emergence of stress condition.

Table 2: Foraging behavior of honeybees (*Apis mellifera* L.) on onion plant (Mean±SE)

Parameter	Measurement
Initiation of foraging on onion (time of day)	8.15±0.06 h
Cessation of foraging on onion (time of day)	16.30±0.06 h
Peak foraging hours (time of day)	11.00±12.00 h
Flowers visited per minute (number)	
09.00 h	8.00±0.3b
12.00 h	13.00±0.5a
15.00 h	4.00±0.4c
Weight of pollen load (mg)	
09.00 h	8.00±0.3b
12.00 h	10.00±0.5a
15.00 h	6.00±0.5c

a,b,c: Differences in all these parameters among different hours of the day are significant at $p < 0.01$.

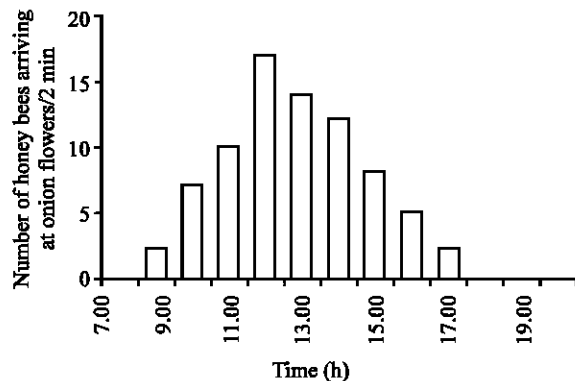


Fig. 1: Initiation, cessation and peak hours of foraging activity of *Apis mellifera* L. On onion flowers

Peak foraging occurred from 11.00 to 12.00 h (Fig. 1). Bees visited an average of 8.0 ± 0.3 , 13 ± 0.5 , 4.0 ± 0.4 flowers per minute for observations at 09.00, 12.00 and 15.00 h, respectively. Pollen loads averaged 8.0 ± 0.3 , 10.0 ± 0.5 and 6.0 ± 0.5 mg, respectively.

Present investigation proved that the seed yield per bulb in open plots was significantly higher than in caged plots. This result was 10 fold more from Banik^[7] who specified that using of honey bees on onion pollination increased seed yield 0.5 g per bulb. The evaluation for some quality criteria proved that seed quality of onions gave better results in the open plots leaved free for honey bee visitation than in caged plots. This result is also in agreement with these reported by Munawar and

Muzaffar^[12] determined high seed yield 10-11 fold increase in honey bee pollination on onion cultivar.

Honeybee pollination increased germination rate, emergence rate, stressful condition emergence rate, mean days to germination, mean days to emergence. This result agreed with findings obtained by Glohov^[8] and Martin^[10] who found germination rate and emergence rate 97 and 93.5% in open plots whereas they were 85.5 and 81% in caged plots, respectively.

In agreement with the Ahmed and Abdalla^[15], in the present study honey bee pollination provides seeds to be more coarse and filled. Increase of germination rate and emergence rate of seeds in open plots resulted of a superior pollinating efficiency of honey bees. Similarly, Gjorgji and Rukie^[4] reported that the seed germination rate was greater on average 3.67% in onion with honey bee activity.

In this study, foraging activity peaked between 11.00 and 12.00 h. Mc Gregor^[1] observed that the maximum activity of *A.mellifera* L. foraging on onion to be between 09.00 and 13.00 h, with only a few bees foraging after 16.00 h. *Apis mellifera* L. foragers collected heavier pollen loads during morning hours and at noon^[16]. In this study this situation was probably because the maximum number of pollen grains presented by onion was during these time intervals.

As a result of this research, seed yield per flower and several seed quality properties of onion could be increased. Honey bees pollinate the onion crop especially at late morning and noon time. In addition foragers load much more pollen at this time.

It is concluded that bee pollination increased the yield and enhanced the quality of onion seeds as well. In practice, utilization with honey bee in onion pollination would be advisable to farmers for getting high quality and quantity crops.

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