academicJournals

Vol. 12(33), pp.2620-2624, 17 August, 2017
DOI: 10.5897/AJAR2015.9678
Article Number: 1E749EE65618
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Pollination activity and foraging behavior of local honeybee (*Apis mellifera)* under open and caged conditions in Mekelle, Tigray, Ethiopia

Haftom Gebremedhn

Apiculture and Sericulture Case Team, Mekelle Agricultural Research Center, Tigray Agricultural Research Institute, P. O. Box 492, Mekelle, Tigray, Ethiopia.

Received 3 March, 2015; Accepted 29 October, 2015

Locally there is cultivation of vegetables in greenhouse as a production system; however, it is not common to use honeybee as pollinators. This might be due to a fear of low pollination efficiency or activity of local bees under caged condition. Moreover there is no research related to the foraging behavior of local honeybee under caged condition. Hence, this investigation was designed to study foraging behavior of honeybees (*Apis mellifera*) and their pollination efficiency under managed condition. Pollination efficiency of the local bees was determined by comparing the seed yield and quality of self-pollinated crops with crops caged with honeybee. This was done during the blooming time of *Guzzotia abyssinica*. Data related to foraging behavior and seed yield and quality was analyzed using repeated measure analysis of variance and t-test, respectively using Genstat 14th version statistical software. Crops caged with honeybee had higher yield (200.3 g) compared to crops prevented from insect pollinators (115.2 g).The highest foraging rate of bees was recorded at 14:30-15:30pm (12.02 flowers /five minute), while the lowest foraging rate was recorded at 8:30-9:30am (8.15 flowers/five minute). The overall foraging trend of bees was similar under caged and open conditions. Finally, the use of local honeybees' pollination under managed condition was recommended for improving the seed yield and quality of *G. abyssinica* seeds.

Key words: Caged, foraging, honeybee, pollination.

INTRODUCTION

Honeybee pollination services benefit agricultural production significantly and important in crop production as water or fertilizer (Jacobs et al., 2006). The need for insect pollination in greenhouses or enclosures increased from time to time to produce uncontaminated seed or to increase seed or fruit following insect visits (Free, 1993). Due to the reduction of natural pollinator population by agrochemicals pollinating honeybee play important roles in modern agriculture (Mattu et al., 2012). Although many species are known to provide pollination services,

E-mail: haftush@yahoo.com.

honeybees (*Apis mellifera*) are often assumed to provide the majority of these services to agriculture (Breeze et al., 2011).

Previous research also indicates that honeybees (*A. mellifera*) are a feasible alternative to bumble bee pollination for greenhouse crops and financially viable for growers (Sabara and Winston, 2003). To use honeybees for such purposes however, the question arises among research workers whether the foraging and pollination efficiency of honeybee differs under such artificial conditions from the natural condition (Devkota and Thapa, 2005).

Moreover; locally it is not also common to use honeybee as pollinators in greenhouse cultivation of vegetables as a production system. This might be due to a fear of low honeybee pollination efficiency or foraging activity under cage or since there is no research related to the foraging behavior and pollination activity of honeybee (*A. mellifera*) under controlled condition. The great value of honeybees' pollinators is not also appreciated and understood locally (Jacobs et al., 2006). Better understanding of managed honeybee foraging behavior and pollination activity, however, can contribute to the improvement of management practice that aims to enhance crop pollination. Hence, this study was designed to study the foraging behavior and pollination activity of honeybees (*A. mellifere)* in *G. abyssinica* crop under caged and open conditions.

MATERIALS AND METHODS

Study area

The study was carried out at the Mekelle Agricultural Research Center farm, Illala site. Illala is geographically found in the North east of Mekelle city at elevation of 1970 m.a.s.l at 250° 51' N latitude and 390° 61' longitude.

Agronomic practice

The crop (*G. abyssinica*) was planted with a seed rate of 10 kg/ha, 40 cm, 10 cm distance between rows and between plants. Diammonium phosphate and urea were applied immediately after sowing and two weeks after sowing, respectively at a rate of 100 kg/ha.

Experimental management

To evaluate the foraging behavior of honeybee under open and caged conditions, the crop (*G. abyssinica*) was planted in a plot size of 3 m × 3 m and replicated four times. The crops caged with honeybee (five framed hive) and without honeybee were considered as treatment. In both treatments, plots were covered with mesh cages (3 m wide x 2 m long x 2 m high) shortly before flowering. After caging the plots, five framed hive colonies were placed on the respective experimental plots starting from its initial blooming (5 to 10%) to its final blooming period. This stage of flowering was selected to secured feed (pollen and nectar) for honeybees.

The pollination efficiency or activity of honeybee was determined by comparing yield and quality of *G. abyssinica* seeds obtained from crops caged with honeybee and crops caged without honeybee.

Foraging behavior of honeybees was studied in the crops caged with five framed hive and in the open plots. This was done during the blooming time of *G. abyssinica* (starting from first to third weeks). The foraging behaviors of honeybees in both conditions were studied in terms of foraging rate, time spent/flower, pollen and/or nectar preference and their abundance. This observation was done five times a day: 8:30-9:30 am, 10:30-11:3 am, 12:30-13:30 pm, 14:30-15:30 pm and 16:30-17:30 pm at two hours intervals. Each observation time was considered as a treatment.

Abundance of honeybees was determined by counting the number of honeybee visiting in a station holding of five plants/five minutes. Foraging rate of honeybee was studied by counting the number of flowers visited by a bee/minute. Time spent by a bee/flower was determined by recording time from starting on landing on a flower to leaving that particular flower using a stopwatch.

Data analysis

Data associated to foraging behavior of honeybee (foraging rate, time spent, pollen and nectar preference and abundance) were analyzed using repeated measure analysis of variance. Mean comparison among means of hours of the day was done using least significant difference (LSD). Seed yield and quality of the crop under caged and open conditions was analyzed using t-test using Genstat 14th version statistical software.

RESULTS AND DISCUSSION

Effect of honeybees' pollination on yield and quality of *G. abyssinica* seeds

There was significant difference between crops caged with honeybee and without in relation to seed yield/plot and seed germination rate (Table 1). Crops caged with honeybee had higher yield (200.3 g) compared to crops caged without honeybee (115.2 g). This indicates that crops caged with honeybee had 42.5% yield increment over crops caged without honeybee. In the same crop, Sattigi et al. (2004) also reported higher yield in crops caged with honeybees compared to crops caged without bees.

Crops caged with honeybee also had higher germination rate (81.5%) than crops excluded from honeybee (55.5%) (Table 1). This showed that seeds from that caged with honeybee had 29.8% increment on seed viability over seeds excluded from insects. Dhurve (2008) also revealed higher germination rate in crops caged with honeybee over crops caged without honeybee. In onion, seeds from open pollinated crops also had higher germination rate than crops excluded from insect visitors (Adel et al., 2013). Regarding oil content and 1000 seed weight of *G. abyssinica* seeds, however, significant difference was not found between the crops caged with honeybee and without honeybee (Table 1) and this is similar to Dhurve (2008).

Table 1. Effect of honeybee pollination on seed yield and quality of *G. abyssinica.*

Variable	Mean	SD	t	df	p
Yield per plot (1.2 m^2)			3.98	6	0.007
With bee	200.3	26.87			
Without bee	115.2	33.19			
1000 seed weight			0.325	6	0.756
With bee	5.075	0.15			
Without bee	4.975	0.59			
Germination rate			3.57	6	0.012
With bee	86.2	5.56			
Without bee	60.50	13.30			
Oil content			1.66	6	0.147
With bee	41.49				
Without bee	38.98				

SD, Standard deviation; df, degree of freedom; t, student t-test value; p, probability value.

Table 2. Foraging behavior of honeybees under caged and open condition during the blooming time of *G. abyssinica.*

Treatment	Time spent	Foraging rate	Pollen	Nectar	Pollen and nectar
Caged	7.04^a	11.09^a	1.27^b	16.38^a	1.89
Open	6.03^b	5.89^b	2.06^a	13.47^b	3.93
P value	0.021	<0.001	0.026	<0.001	<0.001
LSD	0.855	0.5872	0.687	0.982	0.800

Figures in rows with the same letters are not significantly different at 5% level by LSD.

Foraging behavior of honeybees during blooming period of *G. abyssinica* under open and caged condition

There was significant difference between honeybees under caged and open condition related to foraging rate, time spent per flower, pollen and nectar preference of honeybees (Table 2). Bees under cage had higher foraging rate (11.09 flowers/min) and time spent/flower (7.04) compared to foraging rate (5.89 flowers/min) and time spent/flower (6.03) of bees under open condition. The difference on foraging rate between the bees under open and caged conditions might be related to the presence of other insect pollinators under the open condition. Awraris (2009) also stated that foraging behavior of honeybees was affected by other insect pollinators. This study also revealed that honeybees foraging time per head when interacting with other pollinators was significantly lower than interaction among honeybees only.

As demonstrated in Table 2, nectar preference of bees under caged condition had higher nectar preference (16.38) than bees in open condition (13.47). Adjaloo and Yeboah-Gyan (2003) also revealed that bees work slowly when collecting pollen than when they are collecting nectar.

Time of the day also had significant effect on foraging rate, pollen and/or nectar preference of honeybees under both caged and open conditions (Tables 2 and 3). The highest foraging rate was recorded at 12:30-13:30 pm for both bees under caged (12 flowers/min) and open conditions (12.6 flowers/min), while the lowest foraging rate was recorded at 8:30-9:30am for both bees under caged (6.42 flowers/min) and open conditions (11.4 flowers/min). Kunjwal et al. (2014) also stated that the foraging rate of bees varies with time.

As demonstrated in Table 3, across the same hours of the day, bees under caged condition had higher foraging rate than bees under open conditions. However, time of the day had no significant effect on time spent/flower or flowering speed of bees under both caged and open conditions (Tables 2, 3 and 4). The time spent per flower of the local honeybees ranged from 6.02 to 7.95 s and 5.9 to 6.3 s under caged and open conditions, respectively. As regards average time spent per flower, Devkota and Thapa (2005) also found non-significant difference for honeybee (*A. mellifera*) under caged and open conditions.

The maximum numbers of honeybees collecting pollen were observed at 8:30-9:30 am under caged (6.23) and open conditions (7.7), while the least number of honeybees' collected pollen from 10:30-11:3 am to 16:30-17:30 pm under both conditions. This indicates that honeybees were vising the plants for its pollen in the

Table 3. Foraging behavior of honeybees across different hours of the day under caged condition.

Time	Time spent	Foraging rate	Pollen	Nectar	Pollen and nectar	Abundance
8:30-9:30AM	7.95	10.58^{b}	6.23^{a}	6.23^{b}	7.93^{a}	62.53^{ab}
10:30-11:3AM	7.42	11.00^{b}	0.00^{b}	19.90^{a}	0.19^{b}	68.53^{a}
12:30-13:30PM	6.79	12.00^{a}	0.00^{b}	19.53^{a}	0.21^{b}	56.80^{b}
14:30-15:30PM	6.02	10.77^{b}	0.15^{b}	19.07^{a}	0.88^{b}	44.27^{c}
16:30-17:30PM			0.00^{b}	19.89^{a}	0.23^{b}	21.27^{d}
LSD	1.99	0.83	1.31	1.44	1.57	5.80
P value	0.187	0.010	<0.001	<0.001	<0.001	<0.001

Column means with different superscript letters are significantly different (P<0.05).

Table 4. Foraging behavior of honeybees across different hours of the day under open condition.

Time of the day	Time spent	Foraging rate	Pollen	Nectar	Pollen and nectar	Abundance
8:30-9:30AM	6.0	11.4^{b}	7.7^{a}	5.3^{d}	7.0^{a}	28.3^{ab}
10:30-11:3AM	6.3	11.5^{b}	0.68^{b}	16.5^{ab}	2.9^{cb}	34.0^{a}
12:30-13:30PM	6.0	12.6^{a}	0.14^{b}	18.1^{a}	1.9^{cb}	24.0^{b}
14:30-15:30PM	5.9	11.6^{b}	0.48^{b}	16.0^{ab}	3.3^{b}	9.2^{c}
16:30-17:30PM			1.40^{b}	2.5	1.4^{b}	1.5^{d}
SE	0.23	0.28	0.46	1.02	0.97	2.88
P value	0.45	0.026	<0.001	<.001	0.017	<0.001

Column means with different superscript letters are significantly different (P<0.05).

Table 5. Effect of cage on foraging behavior of honeybees across the same hour of the day during blooming period of *G. abyssinica* under caged.

Time	Foraging rate					Time spent				
	Open	Caged	Grand mean	P value	SEM	Open	Caged	Grand mean	P value	SEM
8:30-9:30AM	5.71^{b}	10.58^{a}	8.15	<0.001	0.432	5.9	7.95	7.15	0.056	1.023
10:30-1:3AM	5.75^{b}	11.09^{a}	8.38	<0.001	0.406	6.4	7.42	7.03	0.198	0.774
12:30-3:30PM	6.29^{b}	12.09^{a}	9.15	<0.001	0.387	6.1	6.79	0.55	0.221	0.55
14:30-5:30PM	5.79^{a}	10.82^{a}	8.30	<0.001	7.44	5.8	6.02	5.94	0.812	0.917

Column means with different superscript letters are significantly different (P<0.05); SEM, Standard error of mean.

early morning. This might be due to the reason that, the flower of *G. abyssinica* opens and liberates pollen early in the morning (Weiss, 2000). Other authors also stated that pollen collection of honeybees varies significantly with time of day (Nascimento and Nascimento, 2012). Verma and Partap (2010) revealed that pollen collectors outnumbered nectar collectors during the morning.

In relation to nectar preference, honeybees were collecting nectar highly at 12:30-13:30 pm under both caged (18.83) and open conditions (18.1), while the least number was recorded at 8:30-9:30 am under both caged (5.78) and open conditions (5.3) (Table 5). This might be due to the reason that a floret of *G. abyssinica*, which is the nectar source, emerges about midday and this makes it possible for honeybees to collect nectar at midday (Weiss, 2000)(Figure 1).

In bees both under caged and open conditions, time of the day had significant effect on the abundance of honeybees/flower/min (Tables 2 and 3). The highest abundance of bees was recorded at 10:30-11:3 am under both open (34.0) and caged (68.53) conditions. However, bees had lowest abundance towards the evening, 16:30-17:30 pm in both conditions.

Although under open and caged conditions bees showed a slight deviations in their foraging rate and time spent across different hours of the day, the overall foraging trend was similar under caged and open conditions across the different hours of the day (Tables 2 and 3).

CONCLUSIONS AND RECOMMENDATION

1) Honeybees' pollination had significant effect on increasing seed yield and germination rate of *G.*

Figure 1. Five framed hive under cage during blooming time of *G. abyssinica.*

abyssinica seeds and crops caged with honeybee had higher seed yield and germination rate compared to crops caged without honeybee.

2) Time of the day had a significant effect on the foraging rate of honeybee. The highest foraging rate of bees was recorded at 14:30-15:30 pm (12.02 flowers/five minute), while the lowest foraging rate was recorded at 8:30-9:30am (8.15 flowers/five minute).

3) Bees under open and caged conditions bees showed a slight deviation in their foraging rate and time spent across different hours of the day; however the overall foraging trend was similar under caged and open conditions.

4) Hence, there is need to consider honeybees as efficient pollinators under managed condition to improve seed yield and quality of *G. abyssinica* seeds.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Adjaloo MK, Yeboah-Gyan K (2003). Foraging of the African honeybee, *Apis mellifera Adanisoni*, in the humid semi deciduous forest environment of Ghana. J. Sci. Technol. 23(1).

Adel MR, Namaghi HS, Hosseini M (2013). Effects of insect pollinators on onion seed production quality and quantity. J. Crop Prot. 2(4):395-402.

Awraris GS (2009) Behavioural response of honeybees (*Apis mellifera scutellata Lep*.) to wild pollinators on sunflowers (*Helianthus annuus* L.). Submitted in partial fulfillment of the requirements for the degree Master of Science (Agric): Entomology. In the Faculty of Natural and Agricultural Sciences University of Pretoria Pretoria.

Breeze TD, Bailey AP, Balcombe KG, Potts SG (2006). Pollination services in the UK: how important are honeybees? Agric. Ecosyst. Environ. 142(3-4):137-143.

Devkota FR, Thapa RB (2005). Foraging preference of *Apis cerana* and *Apis mellifera* I. To broccoli under caged and open conditions in chitwan. J. Inst. Agric. Anim. Sci. 26:167-168.

Dhurve SS (2008). Impact of honey bee pollination on seed production of *Guizotia abyssinica*. M.Sc. Thesis. Dharwad University of Agricultural Sciences, India.

Free JB (1993). Insect Pollination of Crops. Academic Press, London, UK.

Jacobs FJ, Simoens C, Graaf DC de, Deckers J (2006). Scope for non-wood forest products income generation from rehabilitation areas: focus on beekeeping. J. Drylands 1(2):171-185.

Kunjwa N, Kumar Y, Khan MS (2014). Flower-visiting insect pollinators of Brown Mustard, *Brassica juncea* (L.) Czern and coss and their foraging behavior under caged and open pollination Afr. J. Agric. Res. 9(16)1278-1286. 2014.

Mattu VK, Hem Raj, Thakur ML (2012). Foraging behavior of honeybees on apple crop and its variation with altitude in Shimla Hills of western Himalaya. Int. J. Sci. Nat. 3(1):296-301.

Nascimento DL do, Nascimento FS (2012). Extreme effects of season on foraging activities and colony productivity of a stingless bee (Meleponaasilavai Moure, 1971) in Northeast. J. Entomol. pp. 267-361.

Sabara HA, Winston ML (2003). Managing honey bees (Hymenoptera: Apidae) for greenhouse tomato pollination. J. Econ. Entomol. 96(3):547-54.

Sattigi HN, Kambrekar DN, Gundannavar KP, Kulkarni K A (2004). Effect of bee pollination on the yield parameters of Niger *arnataka.* J. Agric. Res. 17(4):831-832.

Verma LR, Partap U (2010). Foraging behaviour of *Apis cerana* on cauliflower and cabbage and its impact on seed production. J. Agric. Res. 33 (4):231-236.

Weiss EA (2000). Oil seed crops. Second edition. Blackwell Science Ltd. pp. 229-231.