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Evaluation of foraging activity and pollen collection by *Apis mellifera* L. on linseed crop at different day timings

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Abstract

Honey bees play a vital role in increasing production of many crops including oil seed crops through their foraging activity. Foraging activities starts early in the morning and ends in evening. These activities fluctuate throughout the day. Day timings have great impact on foraging activities and pollen collection. Pollen collection is recorded high in the afternoon session between 11.00 am to 1.00 pm. Forager bees prefer to collect different substances like pollen, nectar and water in these times. *Apis mellifera* species is mostly domesticated for honey production. The present study was investigated on the same species in the apiary of College of Agriculture, University of Sargodha. The experiment was conducted from November 2016 to March 2017. Number of entering and exiting forager bees in the hive were counted for 10 min/colony three times (morning, noon and evening) in a day from 8:00 am to 4:00 pm. Collected pollen were counted three times in a day on the same timings. Foraging activity were investigated on three linseed varieties (Chandani, Punjab and PR-24). Date were collected for two weeks and two days in a week. Experiment had three replications in RCBD design. Three varieties were sown on area of three canals. Three honey bee colonies were used in this experiment. Pollen collectors were used for the collection of pollens. Data were analysed and mean values were tested by using R software.

Keywords: *Apis mellifera*, beneficial insects, foraging, linseed, pollen, pollinators

Introduction

Honey bees are valuable social insect. Honey bees play important role in the pollination of agricultural crops [1]. Honeybee is considered as most favourite social insect of farmers. These have great importance because they produce honey and other products like bee wax, Propolis and venom [2]. Most valued activity of honeybee is pollination. Honeybee is a major pollinator among all insect pollinators and pollinate about 81% of insect pollinated crops [1]. Honey bees fly on all flowery plants in the field, blossom to blossom collecting pollen from one flower to the other [3]. This transport of pollen is called pollination. Pollination by honeybees cause to increase production of agricultural crops [4]. Pollination by honeybees showed increased 19% seeds per capsule, 22% total increase in seed weight and 2.2% weight increase per seed in Russia. Role of honey bees pollinators in increasing production of agricultural crops cannot be ruled out [5].

Honey has a great medicinal value. It is used in manufacturing of different pharmaceutical products [6]. It is mostly used against coughing, over 2000 tons is used annually in a mixture of different cough syrup Worldwide. It is also used as an antioxidant, anti-inflammatory, anti-cancer and antibacterial substance [7]. Some people use honey as a medicine. In Islamic perspective honey has great importance. In Hadith "honey is called as a healer of diseases [8].

Linseed *Linum usitatissimum*, its genus is *Linum* and family *Linaceae*. It is a food and fibre crop grown in cooler areas of the world [9]. The oil of linseed is very commonly used known as linseed oil. Its area extends from the eastern Mediterranean to India Flax was greatly grown in ancient Ethiopia and ancient Egypt [1]. It is an annual plant with a height of 18 -36 inches with short size leaves and blue flowers [10]. It is grown for both seed and oil purpose. The different parts of the plant uses in to produce fabric, medicines, paper, dye, fishing nets and soap. Linseed also use for animal feed [8].

Linseed seeds contain 33-43% oil of drying type and 24% protein. Oil of linseed has large amount of unsaturated fatty acids; it is commonly utilized in paint industries. Linseed oil have

75% linoleic acid and 17% linoleic acid [11].

Foraging is one of the distinguishing characters of *A. mellifera* from the other insects [2]. This character is the connection between the honey bee colony and the environmental conditions [1]. Foraging activity of honey bee is not beneficial only for the hive and for plant pollination but also has other advantages [6]. Limited foraging activity is very useful for plant pollination and honey bee colony [12]. Scout bees which look for the finest food supply and the reticent bees which stay in the hive awaiting the scout bees come back and provide them information regarding the food resource by dancing [8]. The reticent bees are 40–90% of the total forager population [1]. It is recognized that the foraging activity of honey bees is starting in early morning and stops in the evening [13].

2. Materials and Methods

2.1 Experimental details

Experiments on foraging behaviour and pollen gathering activities of *Apis mellifera* on different linseed varieties were set up in College of Agriculture, University of Sargodha. This experiment was carried out during winter season November 2016 to March 2017. This trial was conducted in the research area of College of Agriculture, University of Sargodha, Sargodha. Three different sites were selected for sowing of Linseed. Three varieties of linseed were sown in these three plots. This experiment was conducted on an area of 1500 square meter.

Number of bees entering and exit in the hive were counted for 10 min/colony three times (morning, noon and evening) in a day from 8:00 am to 4:00 pm. collected pollen were counted three times in a day on the same timings. Foraging activity were investigated on three linseed varieties (Chandani, Punjab and PR-24). Data were collected for two weeks and two days in a week. Experiment had three replications in RCBD design. Three honey bee colonies were used in this experiment. Data were analysed and mean values were tested by using R software.

3. Results

Results obtained by effect of day timings on foraging behaviour and pollen gathering activities of honeybee on different varieties of Linseed are presented.

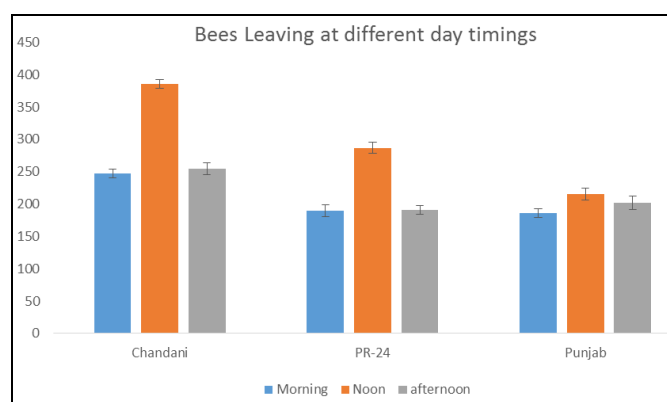


Fig 1: Average no of Bees leaving the colony at different day timings

Three varieties of linseed are in comparison in this graph (Punjab, Chandani and PR-24). Data was collected for two weeks and three times in a day (morning, noon and afternoon) in winter season. Bees leaving the box were counted for 10

mins from 8 am to 4 pm. According to data colony that was placed in Chandani has higher number of foragers while in PR-24 foragers recorded less as compare to Chandani and Punjab. Punjab has lowest numbers of foragers as compare to other two varieties.

During the morning session when temperature was low and humidity was high foraging activities were less, bees left the colony in less number. Same situation was observed in all three plots but the number of bees' forgers leaving the colony was high in Chandani as compare to PR-24 and Punjab. PR-24 and Punjab has same number of foragers. In the morning session from 8-10 am less number of foragers leaving the colony due high humidity and low temperature.

It was observed that concentration of bees leaving the colony was high in the noon session when temperature was high and less humidity. In all three plots high concentration of foragers were counted. Number of foragers during noon session observed higher as compare to other two plots. In PR-24 foragers were more in number than Punjab but less than Chandani.

During afternoon session same concentration was observed as it was in morning session. Bees leaving number was higher in Chandani while less in PR-24 and Punjab. In afternoon session forager bee concentration was higher in Punjab as compare to PR-24. It was observed that in morning and noon session bees leaving the colony in Punjab was less than Chandani and PR-24 but in afternoon session bees living in Punjab is higher than PR-24.

It was founded that day timings has great impact on the foraging activity of honey bees. In winter season as temperature increases bees leaving the colony also increases while with the decrease of temperature colony activities also decreases. Due to low temperature and high humidity in morning session bees leaving the colony in less number while in noon session bees concentration was higher than morning and afternoon session.

Other factors like humidity and rain also limited the activities of the colony. During the rainy season day forager bee left the colony in less number, so foraging activity was limited. It is observed that in high humidity less number of forager left the colony.

Average no of Bees come back to colony at different day timings

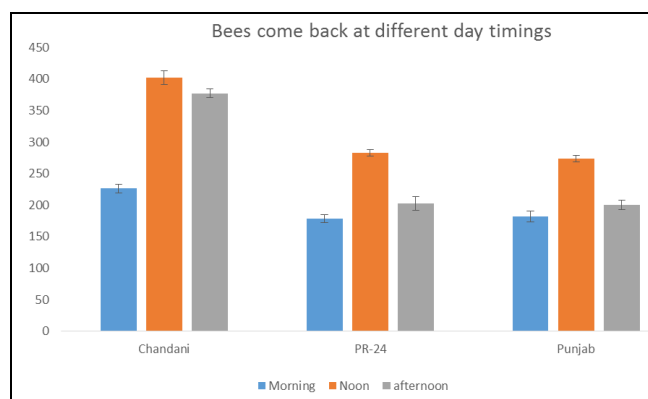


Fig 2: Average no of Bees come back to colony at different day timings

Day timing effect the honeybee activities. Forager bees leaving and returning to hive were counted. According to graph peaks in the morning session when temperature was

less and moisture was high less number of bees return to hive. In morning availability of pollen and nectar was less so bees can acquire food resources from the field. So the less number of foragers returns to hive without having pollen or nectar. As the temperature increases number of bees returning to the hive also increases.

In Chandani bees return to hive were recorded less in number as compared to noon and afternoon session. Returning of bees were higher in PR-24 and Punjab. Honeybee colony placed in Punjab variety show less return than Chandani but more concentration of bees returning to hive than PR-24. In three varieties concentration of bees returning to hive was less because in morning session less quantity of pollen and nectar were available. According to graphical data Chandani has more number of pollen than Punjab and PR-24 (Fig 4.2).

In the noon session as temperature increases foraging activities increased as well. Pollen availability increases when temperature is high. According to graph peaks, bees return to colony placed in Chandani variety were more than other two colonies. There was slight difference of honey bees concentration returning to colonies placed in PR-24 and Punjab.

In afternoon session when temperature was moderate and foraging activities were less as compare to noon session. According to recorded data bees returning to Chandani colony in afternoon session (Fig 4.2) were higher in number as compare to other two colonies placed in PR-24 and Punjab. Colonies placed in PR-24 and Punjab show same level of peaks in afternoon session.

Average no of pollen collection at different day timings on Linseed varieties

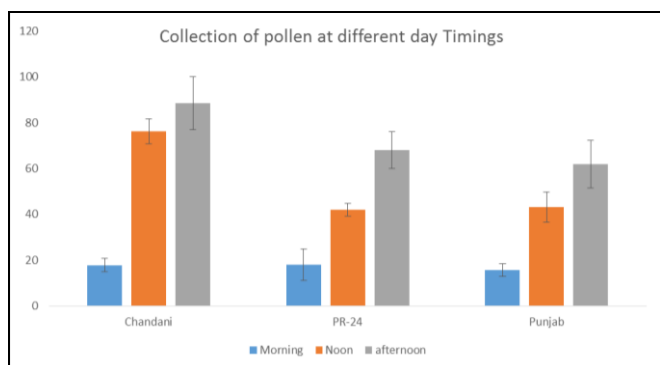


Fig 3: Average no of pollen collection at different day timings on Linseed varieties.

Different day timings affect the foraging activities of *Apis mellifera*. Pollen collection is also influenced by different day timings. In morning session when temperature was low and humidity was high collection of pollen recorded less in number. According to graph results in morning session when humidity high and temperature was low number of forager also less. Pollen collection was less due to less pollen availability. In all three varieties of linseed (Chandani, PR-24

and Punjab) graph peaks shows same results. In morning session moisture was high forager bees left the hive in less number because pollens were not available early in the morning in winter season.

As temperature increases foraging activity also increases. When the foraging activity increases collection of pollen also increases. Collection of pollens was observed high in the noon session when the temperature was moderate. In winter season as temperature increases foraging activity increases and pollen availability also increases. In Chandani collection of pollen in noon session was on its peak as compare to PR-24 and Punjab. Graph peaks shows in PR-24 during noon session pollen are slightly less than Punjab.

In the afternoon session collection of pollen was observed highly as compare to morning and noon. In Chandani peaks of the graph shows highest number of pollens as compare to PR-24 and Punjab. PR-24 shows slightly higher peak as compared to Punjab. According to results collection of pollen observed in noon and the afternoon session was higher in number as compared to a morning. During three different day timings observation it was found that collection of pollen higher in the afternoon session as compare to morning and noon session (Fig 4.3).

Pollen gathering depends on the availability of pollens, in high humidity pollen availability was less, so the collection of pollen in morning session observed less in number. Rain also affects the foraging activity of honey bees. Bees visit less number of flowers so collection of pollen decreases due to rain.

Table 1: Co-relation of pollen collection in different varieties of Linseed at different day timings

Linseed Varieties	Estimate Std.	Error	t value	Pr(> t)
Variety Chandani	88.667	2.037	43.519	0.0001
Variety PR-24	-20.417	2.881	-7.086	2.05e-10 ***
Variety Punjab	-26.083	2.881	-9.053	1.27e-14 ***
Time Morning	-70.917	2.881	-24.612	0.0001
Time Noon	-12.500	2.881	-4.338	3.46e-05 ***
VarietyPR-24:TimeMorning	20.667	4.075	5.072	1.84e-06 ***
Variety Punjab: Time Morning	23.333	4.075	5.726	1.10e-07 ***
varietyPR-24:TimeNoon	-13.750	4.075	-3.374	0.00106 **
Variety Punjab: Time Noon	-6.917	4.075	-1.697	0.09276

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

According to given data intercept Chandani showed positive co-relation and significant results (t 43.519, p < 2e-16). PR-24 showed (t, -7.086, p 2.05e-10) negative co-relation and significant results. Punjab showed (t, -9.053, p 1.27e-14) show negative co-relation and significant result. In morning PR-24 showed (t 5.072, p 1.84e-06) positive co-relation and significant results. Punjab showed (t 5.726, p<1.10e-07) positive co-relation and significant results. In noon PR-24 and Punjab (t,-3.374, t -1.697) showed a negative Co-relation. Punjab showed non-significant (p<0.09276) results in noon.

Table 2: Co-relation of bees returning to the beehive in Linseed varieties at different day timings

	Estimate Std.	Error	t value	Pr(> t)
Variety Chandani	377.417	2.238	168.677	0.0001
varietyPR-24	-174.583	3.164	-55.173	0.0001
Variety Punjab	-177.250	3.164	-56.015	0.0001
Time Morning	-150.833	3.164	-47.667	0.0001
Time Noon	24.750	3.164	7.822	5.77e-12 ***

Variety PR-24:Time Morning	126.833	4.475	28.343	0.0001
Variety Punjab: Time Morning	133.000	4.475	29.721	0.0001
VarietyPR-24:Time Noon	55.667	4.475	12.439	0.0001
Variety Punjab: Time Noon	12.833	4.475	2.868	0.00505 **

Significant codes: 0 **** 0.001 *** 0.01 ** 0.05 . 0.1 ' 1

Chandani showed (t 168.677, p < 2e-16) positive co-relation and significant results. PR-24 and Punjab showed negative co-relation and significant results. PR-24 and Punjab (t 28.343, t 29.721) showed positive co-relation and significant

results respectively. In noon PR-24 (t 12.439, p < 2e-16), positive co-relation and significant results showed, same trend was found in Punjab (t 2.868, p 0.00505).

Table 3: Co-relation of bees leaving the bee hive in in Linseed varieties at different day timings

	Estimate Std.	Error	t value	Pr(> t)
Variety Chandani	254.833	2.414	105.552	0.0001
varietyPR-24	-63.083	3.414	-18.476	0.0001
Variety Punjab	-53.000	3.414	-15.523	0.0001
Time Morning	-7.167	3.414	-2.099	0.0384 *
Time Noon	130.750	3.414	38.294	0.0001
Variety PR-24:Time Morning	5.000	4.829	1.035	0.3030
Variety Punjab: Time Morning	-8.583	4.829	-1.778	0.0785
varietyPR-24: Time Noon	-35.500	4.829	-7.352	5.7e-11 ***
Variety Punjab: Time Noon	-116.750	4.829	-24.179	0.0001

Significant Codes: 0 **** 0.001 *** 0.01 ** 0.05 . 0.1 ' 1

Chandani showed (t 105.552, p < 2e-16) positive co-relation and significant results. PR-24 and Punjab showed (t -18.476 p < 2e-16) (t -15.523, p < 2e-16) negative co-relation and significant results respectively. PR-24 in morning showed positive (t, 1.035) while Punjab showed a negative (t,-1.778) co-relation and both showed (p 0.3030, p 0.0785) non-significant results. PR-24 and Punjab showed a negative co-relation and significant results.

4. Discussion

Foraging activities were analysed by using different parameters, such as the number of bees leaving the beehive, the number of bees returning to the beehive, day timings and pollen gathering activity of *Apis mellifera* L. It is known that the foraging activity of honeybees is initiated early in the morning and finishes in evening. Three cultivar of linseed used in research work was Chandani, Punjab and PR-24. Maximum foraging activity was recorded in morning when temperature was low. In morning bees leaving the hive more in number due to moderate temperature. As temperature increased foraging activity decreased. In noon foragers were observed less in number as compare to morning while in afternoon more number of forager bees were observed as compare to noon session. In noon high temperature effect the foraging activity and bees prefer to stay in hive while in afternoon as temperature decreased foraging activity increased. As temperature decreased in afternoon more number of forager bees visited the field as compare to noon. According to different studies it was confirmed that that peak the activity of honey bees in morning time mostly from (9:00 am-11:00 am).

Honeybee started foraging activities early in the morning and ends in evening. Foraging activity initiated at 6.18 am. This commencement time varies region wise [10, 4] founded that in desert condition bees left the colony from 8 am to 10 am. High temperature during the noon period from 11:30 am to 2:30 pm effects the foraging activities. During this time period foraging activities recorded less as bees leaving the colony in less number due to high ambient temperature. Present findings were supported by the findings of [14, 11] where more number of forager bee visit the field during 10:00

am to 11:00 am. [15] conducted a research on foraging of honeybee visited onion flowers during the whole day (8 am to 4 pm). It was founded that foraging activities were high during 11.00 to 12.00 h. worker bees have ability to know at which time food resources available in good quality and quantity during the whole day [16]. This natural ability of forager bees increased its foraging activity.

[17-19] founded that during foraging activity of Yemeni bees were higher than Carniolan bees at different day timings and also founded that under desert condition Yemeni had higher foraging rate than Carniolan honeybees. [20] studied that foraging activity on *Brassica napus* was highest in morning from 8:00 am to 10:00 am and less activity observed in afternoon. During morning higher number of worker bees visit the flowers of *Brassica napus* [13, 21, 22] studied that in morning bees foraging was maximum which is strongly in accordance with present findings [23]. Studied that honeybee foragers were attracted by Loquat flowers. Visitors were attracted actively in morning towards Loquat flowers. [24] founded that foraging activity of *A. mellifera* were highest during 9:00 to 11:00 am in India. Present findings are supported by [11, 26, 27] where it was concluded that foraging activity of honeybees were maximum in the morning.

Pollen gathering activity was observed during morning, noon and afternoon on linseed crop. Three cultivars Punjab, Chandani and PR-24 were grown. It was observed that collection of pollens in morning was less than noon & afternoon session. In morning high relative humidity and low temperature affect the foraging activity. These factors affect the availability of pollens during morning. Pollens collection observed higher in number noon when temperature was moderate. In afternoon period pollen collection was recorded more than morning and noon. According to data foraging rate was higher in noon session and pollen collection during noon observed higher than morning. It is observed that day timings greatly affect the foraging activity and availability of pollens. Different factors like environmental factors, high/low temperature, rain, humidity, wind and insecticides use had great impact on pollen collection.

The findings of present studies were strongly supported by the findings of [28-30] where it was reported that a significant

negative correlation was found between foraging activity, relative humidity and pollen gathering activity of honeybee. [31] observed that pollen collection by honeybee depends upon the availability of pollen rich flowers and favourable environmental conditions [4, 10, 7, 32, 33]. Stated that Temperature and RH positively and negatively respectively affect the outgoing rate of honeybee

5. Conclusion

It was concluded that foraging activities were maximum in noon session, while pollen collection was maximum in afternoon period. Maximum of honeybees visit Chandani for foraging and pollen collection. So Chandani variety should be shown by farmers and beekeepers for high production of seed and honey.

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