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RESEARCH ARTICLE
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Influence of Pollen Trapping on Honey Production of *Apis mellifera* L. (Hymenoptera: Apidae) High Strength Colony under Mustard Flowering Season

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ABSTRACT

Background: Bee colonies are fed with pollen supplemented diets to sustain them during unfavourable conditions. These pollen loads are collected from foraging bees using pollen traps mounted on colonies. However, intensive trapping may interfere with honey production. Therefore, a need was felt to regulate frequency of trapping to ensure sufficient honey storage in the colonies.

Methods: In this field based study, performed under mustard flowering seasons of 2016-17 and 2017-18, traps were mounted on colonies with varying frequencies namely, daily, alternate day, third day, weekly and control under two different mustard flowering locations in Haryana. Honey area and proportion of incoming pollen foragers were recorded from tested colonies.

Result: Daily trapping triggered 29% bees for pollen foraging that contributed to considerable reduction in the honey area (-103 cm^2). In contrast, colonies with weekly trapping regimes exhibited large honey area (4054 cm^2). Among the locations, large honey area was stored in the weekly trapping colonies at Kaul, Haryana than Hisar, Haryana.

Key words: Colony growth, Honey bee, Honey, Pollen loads, Pollen traps.

INTRODUCTION

Honey production is immensely benefitted from the vast areas of flowering rapeseed and mustard crop in sub-tropical India (Saini *et al*., 2020; Vazhacharickal *et al*., 2024). In response, mustard seed yield is substantially improved by bee pollination (Sarkar *et al.*, 2023). Besides honey, pollen trapping with traps is a subsidiary practice of apiculture for collecting pollen loads for human consumption and utilization for colony under flowering dearth period. Over the years, the improvement in the pollen trap designs has enhanced the efficiency of collecting of these pollen loads (Todd and Bishop, 1940; Raja *et al*., 2010). The primary aim of pollen loads collection using traps was intended to prepare diets that sustain brood rearing activity in bee colony during harsh floral dearth periods (Waller *et al*., 1981; Kumari and Kumar, 2020; Hoover *et al*., 2022). Front mounted pollen trap is a composite structure having a plate of circular grids and a collecting tray, which is mounted on the colony entrance to dislodge the pollen loads from the returning forager bee legs. Although pollen trapping may deplete stored pollen in the colony however, in response to depleted pollen reserves, the forager bees of the colony perform increased pollen foraging in place of nectar foraging (Fewell and Winston, 1992; Weidenmüller and Tautz, 2002). This shift in tendency towards pollen foraging may affect the honey reserves of colony. Considering these facts, this study was planned to understand the effects of pollen trapping on stored honey of the high strength bee colony.

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MATERIALS AND METHODS

Periods and locations of study

15 High strength (HS) Langstroth *A. mellifera* colonies were placed in two different locations (15 colonies×2 locations

=30 colonies) during mustard (*Brassica* spp.) flowering seasons using randomized block design. Each colony with super contained 12 bee covered frames of western honey bee, *Apis mellifera*. Five pollen trapping frequencies namely daily, alternate days, third day, weekly and control (No trapping) acted as treatments. Under each treatment three high strength colonies (3 colonies=3 replications), were tested. These colonies were kept during mustard flowering seasons at two locations that lasted 47 days (10 January-25 February) in the years 2017 (location 1) and 2018 (location 2). Location 1 situated at Ram Dhan Singh seed Farm CCSHAU Hisar (29.2447°N, 75.7209°E; 215 m above mean sea level), while location 2 in the premises of College of Agriculture, CCSHAU, Kaul, Haryana, India (29.8498°N, 76.6615°E; 237 m above mean sea level). Mustard flowering seasons at different locations were hereafter called as mustard location 1 and mustard location 2. During both years, the recommended packages of practices of the university were followed for mustard crop production (CCSHAU, 2016), but without pesticide application.

Preparation of *A. mellifera* colonies for the experiment

Prior to the start of experiment, all the colonies were adjusted for similar queen's age, worker population, stored honey and nectar area, stored pollen area and brood area (both capped and open brood including eggs) during onset of flowering seasons according to the standard protocol adopted previously by Dimou *et al*. (2006) and Delaplane *et al*. (2013). All the pollen traps used in the entire study at both locations were similar in size, design and specifications. There were 225 holes in the pollen traps through which foragers carrying pollen loads passes through and diameter of each pollen trap hole was 5 mm. Pollen trapping was restricted on days with precipitation. From 8 a.m. (morning) until 5 p.m. (evening), traps were affixed to their respective colonies according to the trapping frequency.

Materials used for observations

Colony growth parameters (CGP) measuring grid frame was constructed from a typical deep Langstroth wooden frame with holes drilled every inch along all four bars. A coloured plastic wire was crisscrossed through these holes to create a square cell measuring one inch^2. This counting frame contained a total of 112 square cells arranged in 16 columns and seven rows. During colony inspection, CGP measuring frame was superimposed over frames of treatment colonies to record the area covered under honey and nectar.

Recording of observations

To investigate the effect of varied trapping frequencies on colony growth parameters (CGPs), the following observations were recorded from treatment colonies as mentioned below.

Colony inspections to record growth parameters

During both mustard locations, four colony inspections were performed using a CGP measurement frame. The colony growth parameters (CGPs) namely, honey and nectar area were recorded from all treatment colonies in inch^2. The area thereafter were converted into cm^2 by multiplication factor of 6.45 (1 inch^2=6.45 cm^2). First inspection began prior to mounting pollen traps on 0 day and continued at fortnight intervals (15 days) after mounting traps until 45thday (fourth inspection). Using equations 1, the net area of honey produced or lost in a colony under different mustard locations were evaluated in cm^2.

$$\text{Net honey area in a colony} = \text{Honey area at 0 day} - \text{Honey area at 45 day} \quad ....(1)$$

Proportion of incoming pollen foragers

This was estimated from all treatment colonies by counting the incoming pollen-bearing foragers out of the total number of foragers (equation 2) entering the colonies every two minutes around 12:00-02:00 pm on 21st day under both mustard locations.

Proportion of incoming pollen foragers (%) =

$$\frac{\text{Pollen carrying foragers}}{\text{Total foragers}} \times 100 \quad ....(2)$$

Statistical analysis

The recorded data of honey area from treatment colonies under consideration were first subjected to Shapiro-Wilk test for testing its normality. To compute the effect of different pollen trapping frequencies, mustard locations and their interaction effects on net honey area and proportion of pollen foragers (%) entered in the experimental colonies; the data were subjected to two-way ANOVA with Tukey's HSD post hoc test at 5% level of significance using SPSS version 23.0 software (2015). In addition, correlation was also established between pollen trapping frequencies, honey area and proportion of incoming pollen foragers entered the colony to understand relationships between them.

RESULTS AND DISCUSSION

Effect of pollen trapping frequencies on net honey area produced in *A. mellifera* colonies under different mustard locations

Considering both mustard locations, daily pollen trapping depleted the honey area of the colonies (Table 1) as net honey area was recorded less (-103±1121 cm^2). However, honey area improved with subsequent decrease in trapping frequency, which suggest significant inverse relationship (Table 3; r=-0.951) between these two factors. In contrast, the weekly trapped colonies expanded net honey area by 4054±2065 cm^2/colony was on par with control colonies (3634±1693 cm^2). Similar net gain in honey area was recorded under mustard location 1 (1833±360 cm^2) and location 2 (2501±1762 cm^2) (F value=1.99; df=1, 18; P=0.18). Non-significant interaction effect (F value=0.86; df=4, 18; P=0.51) between pollen trapping frequency and mustard locations indicate that the relationship between net honey area and different pollen trapping frequencies was not influenced by different mustard season. The previous studies noted that flowering seasons at different locations differ in richness, diversity, spatial and temporal extent of bee-preferred flowering plants and may in turn result in differences in honey growth (Lau *et al*., 2019). Mustard (*Brassica* spp.) is the most productive honey flow season in North India as bulk of Indian honey is produced in this season followed by eucalyptus, *T. alexandrium,* sunflower, multi-flora and other minor honey seasons (Chaudhary, 2003a,b).With the onset of flowering season, honey area of colonies at location 1 and location 2 expanded but responded differently under varied trapping frequencies (Fig 1a and b). There are some previous reports that recorded depletion in honey reserves of colony due to pollen trapping (Duff and Furgula, 1986; Nelson *et al*., 1987; Hoover and Ovinge, 2018). Pollen trap fitted colonies exhibited 20% less honey than trap-free colonies (Nelson *et al*., 1987). Occasional (twice a week) pollen trapping reduced honey stores of the colonies by 5.89 Kg/colony (Hoover and Ovinge 2018). Duff and Furgala (1986) reported decreased honey areas due to regular pollen trapping for entire season than the intermittent trapping. Pollen trapping reduces stored pollen area inside the colony, which subsequently triggers off pollen foraging impulse by recruiting extra foragers for more pollen collection instead of nectar collection. Such trigger of pollen impulse led to poor build-up of honey and nectar area in the trap fitted colonies (Fewell and Winston, 1992; Camazine, 1993; Pankiw *et al*., 1998; Dreller *et al*., 1999; Dreller and Tarpy, 2000; Weidenmuller and Tautz, 2002). This study established inverse relationship (between net honey area and proportion of incoming pollen foragers, which indicate less honey area expansion of colonies under higher pollen foraging impulse caused by frequent or higher pollen trapping frequency.

Table 1: Effect of different pollen trapping frequencies on net honey area produced in a *A. mellifera* colony under different mustard locations.

	Net honey area (cm^2) (Mean±SD)					
Trapping frequency→ Location↓	Daily	Alternate day	Third day	Weekly	Control	Location mean
Mustard location 1	-594±616aA	2133±514bA	1344±711abA	3085±781bcA	3197±1184bcA	1833±360 A
Mustard location 2	387±2290aA	1404±546aA	1621±591aA	5022±3349bA	4070±2402bA	2501±1762A
Trapping frequency mean	-103±1121a	1768 ±228b	1483±537b	4054±2065c	3634±1693c	

	ANOVA		
	Trapping frequency (TF)	Mustard location (ML)	Interaction (TF×ML)
F-value	10.26	1.99	0.86
DF	4,18	1,18	4,18
p	0.000	0.180	0.510

Trapping frequency means along the rows followed by different lowercase alphabets are significantly different as per Tukey's HSD post hoc test ($p<0.05$); Location means along the columns followed by different uppercase letters are significantly different as per Tukey's HSD post hoc test ($p<0.05$).

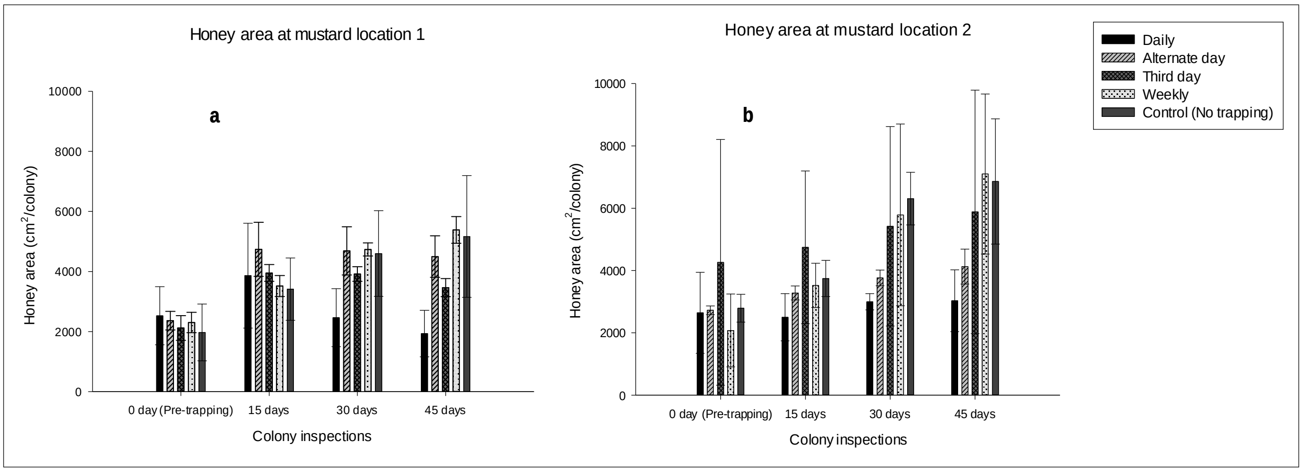

Fig 1: Variation in honey area (a and b) at fortnight intervals in *A. mellifera* colony under different trapping frequency in different mustard location.

Table 2: Effect of different pollen trapping frequencies on proportion of incoming pollen foragers under different mustard locations.

Trapping frequency→ Location↓	Daily	Alternate days	Third day	Weekly	Control	Location mean
	Proportion of incoming pollen foragers (%) (Mean±SD)					
Mustard location 1	27.9±4.1aA	27.3±2.5aA	24.8±9.4abA	20.0±8.0bA	21.7±0.1bA	24.3±4.2A
Mustard location 2	30.1±3.9aA	25.1±2.5abA	19.8±3.6bA	21.4±4.9bA	16.9±0.1cA	22.7±2.2A
Trapping frequency mean	29.0±4.6a	26.2±2.1a	22.3±7.4c	20.7±3.4c	19.3±0.4d	

ANOVA

	Trapping frequency (TF)	Mustard location (ML)	Interaction (TF×ML)
F-value	3.68	0.81	0.64
DF	4,18	1,18	4,18
p	0.020	0.380	0.640

Trapping frequency means along the rows followed by different lowercase alphabets are significantly different as per Tukey's HSD post hoc test (p<0.05); Location means along the columns followed by different uppercase letters are significantly different as per Tukey's HSD post hoc test (p<0.05).

Table 3: Correlation matrix indicating relationship between trapping frequency and other colony parameters.

	Pollen trapping frequency	Net honey area	Proportion of incoming pollen foragers
Pollen trapping frequency	1	-0.951*	0.964**
Net honey area		1	-0.979**
Proportion of incoming pollen foragers			1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Effect of pollen trapping frequencies on proportion of incoming pollen foragers of *A. mellifera* colonies under different mustard locations

It is pertinent to note that high proportion of pollen foragers was observed entering the daily (Table 2; 29.0±4.6%) and alternate day pollen trapped colony (26.2±2.1%), which were significantly higher (F value=3.68; df=4,18; P<0.05) than third day (22.1±7.4%) and weekly trapped (20.7±3.7%) colony. In contrast, only 19.3% pollen foragers entered the control colonies. Furthermore, pollen forager proportion exhibit negative correlation (Table 3) with net honey area (r=-0.979), depletion of honey stores in higher trapping frequency colonies. Higher pollen trapping frequency caused significant increase in the entry of pollen foragers in the colonies (Table 2) in relation to control colonies (F value=3.68; df=4,18; P=0.02), which indicate strong positive correlation between the two factors (Table 3; r=0.964). However, this proportion did not differed with mustard locations (F value=0.81; df=1, 18; P=0.38).

Daily trapping caused significant increase in proportion of incoming pollen foragers on colony entrance. Previous studies also proved similar increase in proportion of pollen foragers in trap fitted colonies, which led to higher pollen loads collection in the traps (Levin and Loper, 1984; Webster *et al*., 1985; Gemeda *et al*., 2018).

CONCLUSION

This study showed that the honey area expand with occasional pollen trapping. However, minor gain in honey area in colonies under alternate day and third day pollen trapping may not be sufficient to sustain harsh floral dearth periods. In contrast, weekly trapping achieved immense gain in honey areas equivalent to control colonies.

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Conflict of interest

Authors declare they have no conflict of interest.

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