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Studies on the foraging behaviour and pollination requirements of honey bees, *Apis cerana* in relation to rapeseed production

Ch. Soroja Devi[1], L Joymati Devi[2*], N Romabati Devi[3]
[1] Department of Zoology, Jiri College, Jerian District, Manipur, India
[2] Department of Zoology, Nematology Laboratory, D.M. College of Science, Imphal, Manipur, India
[3] Department of Zoology, Imphal College, Imphal West District, Manipur, India

Abstract
This paper presents foraging behaviour and pollination requirements of honey bee in relation to rapeseed production *Apis cerana* worker bee started foraging at 08.04h and ceased their foraging activity at 16.02h. Thus, the duration of foraging activity was 07.58h. The duration of single foraging trip was found to be 8.6 min Peak population was observed between 09.00h to 11.00h of the day. A cerana spent an average of 12.25 sec per flowers per min. Pollen loads on *Apis cerana* forages were maximum at 12.00h weighed 9.6mg. During the hours of the day, the number of hectare collectors increased from morning to evening whereas, the trend was reverse for pollen collectors. Effect of different pollination treatment revealed that the crop pollinated by *Apis cerana* caused 1177% and 9.7% higher seed yield than control (pollinator excluded) and open pollinated plants, respectively. Moreover, the siliqua setting, length of siliquae, number of seeds per siliquea were higher in bee pollinated plants as compared to control and open pollinated plants. The oil content and seeds germination was found from control and open pollinated plants, respectively.

Keywords: foraging, pollination, honey bee, rapeseed production

Introduction

Pollination is an important and essential stage in the reproduction of flowering plants which involves the transfer of pollen from anthers (male part) to the receptive stigma (female part) of the flower with the help of abiotic and biotic pollen dispersal agents. Abiotic agents for achieving pollination are wind, waters and gravity (O' Gara, 1910; Benedek, 1976) [26, 8] whereas biotic pollen transferring agents are animals and among them insert assume primary importance (Hutson, 1925; Rashad *et.al*., 1978) [14, 32]. Pollination by natural agencies is less reliable and more than 50% existing species of plants propogated by seeds are dependent upon insect for adequate pollination (Singh and Chaudhary, 1989) [33]. Approximately, 75% of the main crop species of the world rely on pollinators causes for fruit and seed set (Klein, *et.al*., 2007). Insufficient numbers of suitable pollinators cause severe decline in fruit and seed production (Pratap, 2001) [29]. Production deficit due to the absence of pollination ranges between 3-5% in the developed world and upto 8% in the developing world (Aizen *et.al*., 2009) [3].

Rape and mustard, the only major oilseed crops grown in wide scale in Manipur still remained as margined rabi crops cultivated with minimum inputs. The gap between the demand and supply is still wider as only 20 percent of the total requirements of oilseeds are produced in the state. So, efforts are necessary to be made to increase the production of oilseeds in order to meet the growing demands.

In rape and mustard, lotni type brown sarson, toria, Taramaria and banarasi rai are self-sterile (Singh,1958). In highly self-sterile crops, Presence of bees during their flowering period can influence their yield significantly. In the insect pollinated crops, any amount of irrigation, fertilizer or cultural care given to such self-sterile crops may not give even a fraction of their potential yield if bees or other pollinators are not available during their flowering period.

The pollination requirements of a particular crop is very essential to know the increase in their potential yield. The practical use of honey bees for the cross pollination of cultivated crops and increasing their yield started with the practice of moving bee colonies to the crops in bloom (Thakar, 1976). Some research workers introduced caged methods in practice in order to measure the relative.

Importance of pollination requirements of crops by insects (Free and Spencer Booth, 1963; Kakar,1980) [11, 15]. Kushair (1977) reported that for a positive effect on seed setting a flower require repeated visitation at different stages of its development at different times of the day. To fulfill this, adequate pollinators are required when the crop is in bloom. Insects responsible for bringing about cross pollination in rapeseed under natural condition are below the full needs of the crop and it was reported that the pod length, percentage pod formation, number of seeds per pod and weight of seeds of rapeseed increased if the field is supplemented with *Apis cerana* (Mohammed, 1935; Bish *et.al*.,1980) [23, 6]. Earlier few works has been reported to be done on the foraging behaviour of honey bee and its role in pollination of rapeseed in different places by some research workers (Eisikowitch, 1981; Longridge and Goodman, 1982; Fries and Stark, 1983 [13]; Prasad *et.al*., 1989 [28]; Free, 1970). But it has become increasingly clear that the pollination needs of a crop species vary greatly with locality concerned where it is grown (Free, 1970). It is therefore, necessary to study the foraging behaviour of honey bees under the agro climatic conditions of Manipur and also the role of honey bee in the quantity and quality of rapeseed production.

Materials and methods

The experiment was conducted during the rabi season of 2018-19 in the Jiribam district, Kadamtala, Manipur, India on the rabi season of 2018-2019on rape seed was M.27. in the Jiribam district, Kadamtala, Manipur, there treatments replicated four times were imposed on each crop as follows: control (pollination without insects), open pollution (all the available natural pollinators are allowed to pollinate the crop) and bee pollination (*Apis cerana indica* in a cage with plants). For the control and bee pollinated plots, mosquito nylon nets were erected on the standing crop just before the initiation of following. In the bee pollination treatment, all four plots were caged together with 24mX5mX3m forming a single large cage and a strong colony of *Apis cerana* was placed inside the cage when about 10% of the crop was in bloom until the end of flowering. Separate individual nets measuring (6mX5mX3m) were erected on each plot of control treatment so as to prevent the entry of insect pollinators from outside. observations on the foraging behaviours of the bees were made on the daily time of initiation and censation of foraging, total duration of foraging activity, peak foraging hours, duration of foraging trip, number of flowers visited per minute by one bee, time spent on flowers, distance covered from flower to flowers, individual bee's choice of forage (nectar or pollen) and weight of pollen load carried by bees at different hours of the day. In orders to differentiate between nectar and pollen collector, returning forages were collected with an aspirator at the hive entrance and frozen to prevent regurgitation of nectar. Frozen bees were sorted for types of forage, following the method of Erickson *et.al*., (1973) [10]. The weight of pollen load was determined by anesthetizing samples of returning bees with Carbon dioxide (Von-Frisch,1967) [38] and then removing and weighing their pollen load, Duration of foraging trip was determined by marking 10 bees with nail polish of different colours and noting the time of ingress and egress of the marked bees.

Role of insects in pollination was ascertained from the quantitative and qualitative analysis of the seed. Tea plants were selected randomly at harvest from each plot and comparative effectiveness of the different pollination treatments were judged on the basis of percentage siliqua set, siliqua length number of seeds per siliqua, weight of 1000 seeds, seed yield, percentage seed germination and oil content. Data were analysed statistically using analysis of variance.

Results

Observations on the foraging behaviours of *Apis cerana* are summarized in Table 1. Worker's bees of *Apis cerana* foraged on rape flowers for 7.58h per day, starting early in the morning at 08.04h and ceased late in the evening at 1602h. The average duration of each foraging trip was 8.6 minute. Peak foraging activity was observed between 0900-1100 hours. Worker's bee of *Apis cerana* spent an average of 12.25 sec per flower and visited an average number of 8.78 flowers per minute covering an average distance of 27.4 cm from flower to flower. The average pollen load carried by an individual worker bee was maximum at 12.00h weighed 9.6mg of pollen load. The ratio between pollen and nectar collectors increased from morning to evening with greater amounts of pollen collected in the morning and greater amount of nectar collected in the evening.

The effects of *Apis cerana* pollination on the yield and quality of seed are summarized in Table 2. The number of siliqua per plant varied significantly due to pollination treatment. The result revealed that the highest number of siliqua per plant was found from BP treatment (308.43) followed by OP and the lowest numbers of siliqua per plant(53.20) was from control (PWI). Bee pollination significantly increased siliqua set by 161.66% over control and 26.8% over open pollination. BP increase the siliqua length by 14.61% compared to PWI and 13.32% compared to OP. BP also significantly increased the number of seed per siliqua by 49.39% over PWI and 22.14% over OP. However, seed weight was found highest in PWI treatment (2.50) followed by BP (2.44) and OP (2.36). The increase in seed yield in the BP treatment was 1177% over PWI and 9.7% over OP treatment. The quality of seeds assessed in times of percentage seed germination of seeds from BP plant was 51% greater than from PWI and 2.5% greater than OP plants. Moreover, seeds from BP plants showed 21.3% higher oil content than PWI plants and 4.1% than OP plants.

Table 1: Foraging behaviour of *Apis cerana* indica on rapeseed flowers during rabi-season of 2018.

Sl. No.	Parameter		Rape seed flowers
1.	Time of initiation of foraging activity (hours)		08.04±0.04
2.	Time of cessation of foraging activity(hours)		16.02±2.01
3.	Duration of foraging activity (hours)		07.58±0.05
4.	Duration of foraging trip (min)		8.6±1.69
5.	Park foraging hours (time of day)		09.00-11.00
6.	No. of flowers visited/min		8.78±0.41
7.	Time spent on flower (sec)		12.25±0.89
8.	Distance covered from flower to flower (cm)		27.42±1.34
9.	Pollen load(mg) at different hours of day	1000	8.2±0.45
		1200	9.6±0.67
		1400	7.5±0.4
10.	Ratio between pollen collectors and nectar collectors (P: N) at	1000	112.94:34.6
		1200	50.4:130.7
		1400	25.1:38.0
	Values are mean ± standard error		

Table 2: Effect of different pollination treatments on the seed yield and quality of the rapeseed. Yield parameters

Sl. No.	Yield Parameter	BP	OP	PWI	CD at 5%	%Increase over PWI	%Increase over OP
1.	Siliqua set per plant	308.43 (17.48)	243.23 (15.53)	53.20 (7.29)	(2.38)	479.76%	26.81
2.	Siliqua set (%)	76.98 (61.59)	72.30 (58.48)	29.42 (32.71)	(11.10)	161.66	6.47
3.	No. of seeds per siliqua	14.73 (3.90)	12.06 (3.54)	9.86 (3.22)	(0.21)	49.39	22.14
4.	Wt. of 1000 seeds(gm)	2.44 (1.71)	2.36 (1-69)	2.50 (1.73)	N.S.		
5.	Siliqua length	5.02 (2.35)	4.38 (2.21)	4.43 (2.22)	(0.11)	13.32	14.61
6.	Seed yield q/ha	18.26	16.64	1.43	4.71	1177	9.7
7.	Oil content (%)	40.33 (39.41)	38.75 (38.48)	33.25 (35.18)	(0.81)	21.3	4.1
8.	Germination (%)	83.00 (66.02)	81.00 (65.98)	55.00 (47.93)	(5.21)	51.0	2.5

Figures within parentheses are angular transformed values.

Discussion

In the present study, it was observed that *Apis cerana* initiates foraging early in the morning and ceases late in the afternoon. The total foraging duration activity was 8hrs per day and the average duration of foraging trip was found to be 8.6±1.69 min (Table). Benedek and Prenner (1972) [4] reported that duration of foraging trip of *Apis cerana* on *Brassica Campestris* as 35.5min. Ribbands (1949) [31] opined that the duration of foraging trip is influenced by the number of flower available, their nectars and pollen content and the amount of competition Mohamed (2021) suggested that foraging speed(time spent per flower/min) is an important factor to determine pollinating efficiency of different Apis species because chances of pollination are more when more number of flowers are visited per unit time as it may pollinate more number of flowers in less time. Mohr and Jay (1988) [21] found the foraging speed of honey bees on *Brassica Campestris* was more 94.6-6.7 sec/flowers) as compared to the same in case of *B. napus* (6.1-6.9 sec/flower). In the present studies *A. cerana* visited 8.78 rape flowers spending 12.25 sec. on each flower. Murrel and Nash (1981) [25] recorded that *A. cerana* spent 3.0sec. on *Brassica Campestris* Var. toria. Pollen load on *A. cerana* foragers were heaviest at 12.00h. Bisht and Naim (1979) [5] observed the average weight of pollen load carried by *A. cerana* from mustard crop as 8mg. The slight variation in pollen load may depend on the availability of pollen in different seasons and locality of the crop. In the present investigation bees collected either pollen or nectar during a single foraging trip but never both. The number of nectar collector increases from morning to evening however a reverse trend was observed for pollen collectors. According to Radchenko, 1964; Mohr and Jay (1990) for rape flowers, nectar production is greatest at the beginning of the day and the sugar concentration increases towards the evening of the day. Shuel (1955) [37] also reported that nectar secretion is greatest on a sunny day than a dull day reflecting the fact that the nectar sugar is product of photosynthesis which in turn is influenced by sunlight. It can be inferred from the present findings that pollen availability was maximum in the morning so bees may tend to collect pollen in the morning avoiding nectar which contains less sugar concentration Precise rise and fall in the activities of foraging bees showed that they can interchange functions depending upon the availability of pollen and nectar and also the time of the day. Brittain (1933) [7] and Abrol and Bhatt (1987) [1] reported that pollen collector possess the most behavioural characteristic of efficient pollinators as the pollen collecting activity brought bee into contact with stigma.

Effects of bee pollination on the yield attributing characters of rapeseed in the present investigation, *A. cerana* play a significant role in improving the seed quantity and quality of rapeseed. Bee pollination increased siliqua set, siliqua length, number of seeds per siliqua, seed yield, germination rate and oil content in comparison with open pollination rapeseed plants. Increase in siliqua set and seed set as a result of bee pollination could be owing to greater number of pollination in the plots caged with bees. In open pollination treatment, some flowers may be left unpollinated at their most receptive period or some flower may be visited only once or twice due to lack of pollinators transferring only little amount of pollen which was not sufficient for normal seed setting. The findings clearly showed that adequate pollen transfer is necessary for normal seed setting. Kushnir (1977) [18] reported that a flower required repeated visitation at different stages of its development at different times of the day for a positive effect on seed setting.

Alles (1977) [2] quoted that in evaluating the significance of pollination activity by bees, one should not be satisfied with just quantitative increase in yield. An improvement in seed quality is of equal value and is determined by the oil content of the seed and their germination rate. In the present study the quality of seeds in terms of seed germination and oil content was found highest in BP treatment and lowest in control plots. It may be due to the fact that in BP plots, flowers may be pollinated in the phase of fully functional generative organs producing better quality seeds. Earlier Kozin (1976) [17] and Khalifman (1977) [16] concluded that bees repeatedly visited the flower at different stages of its development at diff. times of the day providing the most favourable conditions for the selectivity of pollen thereby the viability and absolute weight of seeds and germination improves. However, Oz *et.al*., 2008 concluded that honey bee pollination increased the seed yield significantly but not protein and oil percentage in seeds of rapeseed.

Conclusion

Honey bee forging activity in rapeseed crop increased the quantity and quality of seeds. Therefore, it is recommended to keep sufficient number of honeybee colonies in the vicinity of rapeseed crop field during the flowering period to increase the pollination efficiency and thereby enhance seed productivity.

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References

1. Abroll DP, Bhatt AA. Influence of atmospheric condition and floral reward on diurnal activity pattern, floral visitation rates and pollination effectiveness A. cerana Fab foragers, Res.Dev Rep,1987:4:13-15.

2. Alles PT. Effect of intra and intermarietal pollination on the quality anf yield of fiber flex seed. In: Mel'nichenko,A.N(ed) pollination of Agricultural crops by Bees. Vol II; Amerind publishing Co, N. Delhi, India, 1977, 223-229.
3. Aizen MA, Garibaldi LA, Cuningham SA, Klein A. How much does agriculture depend on pollinators? Lesson from long term trends in crop production. Annals Bot.,2009:(103):1579-1588.
4. Benedek P, Prenaer J. Effect of temperature on the behaviour and pollination efficiency of honey bees on winter rape flowers. Z. Angew. Ent.,1972:(71):120-124.
5. Bisht DS, Naim M. pollen gathering capacity of the Indian honey bee Apis cerana F Indian J. ent.,1979:41:295-296.
6. Bisht DS, Naim M, Mehrotra Kn. studies on the role of honey bees in rapeseed production. Proe. 2nd Ent.Conf.Apic. Trop. Clim., N. Delhi,1980, 491-496.
7. Brittain Wh. Apple pollination studies in the Annapolis valley, N.S. Canada 1928-1932. Bull Dep. Agric. Cam. New Ser,1933:162:91-157.
8. Benedek P. Structure of flower visiting insects' pollinators and effect of environmental conditions in blooming winter rapeseed and their bearing on pest control Novenytermeles,1976:25;65-74.
9. Eisikowitch D. Some aspects of pollination of oil seed rape (Brassica rapus L) J. Agric Sci.1981:96:321-326.
10. Erickson EH, Whitfoot LO Kissinges WA. Honeybee: a method of delimiting the complete profile of foraging from colonies envision. Entomol,1973:2:531-535.
11. Free JB, Spencer Booth Y. The pollination of mustard by honey bees. J. Apic. Res,1963:2:69-70.
12. Free JB. Insect pollination of crops Academic Press, Inc. (London) Ltd. U.K.,544.
13. Fries, I and Stark, Measuring the importance of honey bees in rapeseed production. J. Apic. Res,1983a:22(4):272-276.
14. Hutson R. The honey bee as an agent in the pollination of pears, apples and cranberries, J. Econ. Entomol,1925:18:387-391.
15. Kakar KL. Prospects of bees as pollinating agents of Cauliflower. Proc. 2nd Int. Conf. Apic. Trop Clim., N. Delhi, India, 1980, 545-556.
16. Khalifman A. Bee pollination and the phenomenon of heterosis in apicultured plants In: Mel'nichenko, A. N.(ed) pollination of Agricultural crops by Bees Vol. III Amerined Publishing Co. N. Delhi India, 1977, 22-27.
17. Kozin RB. Pollination of Entomophilous Agricultural Crops by Bees. Amerined publishing co. Pvt. Ltd. New Delhi, India, 1976, 414.
18. Kushnir LG. Economic and technical efficiency of different methods of pollination of agricultural crops. In; Mel nichenko, A.N. (ed). Pollination of Agricultural crops by Bees. Vol.III. Amerined publishing Co. N. Delhi, India, 1977, 134-135.
19. Langridge DF Goodman RD. A study on pollination of oilseed rape (Brassica campestris) J.Agric. Ani.Husb,1975:15:285-288.
20. Langridge DF, Goodman RD. Honeybee pollination of oilseed rape cultivar Midas. Aust. J Exp Agric. Anim. Hurb,1982:22:124-126.
21. Mohr NA, Jay SC. Nectar and pollen collecting behaviour of honey bees on Canola (Brassica Campestris L and Brassica napus) J. Apic. Res,1988:27:131-136.
22. Mohr NA, SC. Nectar production of selected cultivors of (Brassica Campestris L and Brassica napus) J. Apic. Res.,1990:27:131-136.
23. Mohammed A. Pollination studies in Lara (Brassica napus L. Nar. Dichotsma prain) and Sarson (Brassica Campestris L and Brassica napus) J. Apic. res.,1935:27:131-136.
24. Mohammed AM, Lesa, Foraging behaviours of Apidac bees on rapeseed flowers (Brassica napus) under open conditions. Journal of Xi an Shiyou University, Natural Science Edition,2021:64:08:2021.
25. Murrel DC, Nash WT. Nectar sections by toria (Brassica Campestris L var. Toria) and foraging behaviour of three Apis species on tornia in Bangladesh. J. Apic. Res, 1981, 20:34.
26. O'Gara. pollination of Pomaceous fruits, Proc. Wash. Sta. Hortic. Ass,1910:7(6):102-104.
27. OZ M, karasu A. cakmak I, Goksoy A, Ozmen N. Effect of honeybee pollination on seed setting, yield and quality characteristic of rapeseed (Brassica napus oleifera) Indian Journal of Agricultural science,2008:78:680-683.
28. Prasad D, Hameed SF, Singh R, Yazdani SS, Singh B. Effect of bee pollination on the quantity and quality of rai crops (Brassica Juncea). Indian Bee J.1989:5(2):45-47.
29. Pratap, T., 2001. Mountain agriculture marginal land and sustainable livelihood: Challenges and opportunities. International symposium on Mountain Agriculture in HKH region, ICIMOD, Kathmandu, Nepal
30. Radchenko TG. The influence of pollination on the crops and the quality of seed of winter rape Bdzhelnitstevo,1964:1:68-78.
31. Ribbands CR. The foraging behaviour of individual bees. J. Anim. Ecol,1949:18:47-65.
32. Rashad SE, Ewies MA. Rabi HG. Insect pollination of sesame (sesame indicum L.) with special reference to role of honey bees. Proc. IV th Int. Symp. pollin, Maryland, 1978, 231-234.
33. Singh BP, Chaudhary JL. Agroforestry and Apiculture. Indian Bee J,1989:51(2):72-73.
34. Singh BP. Rape and mustard. Publ. Indian Central oilseed Committee, Gandhi Sawan, Hydrerabad, India, 1958.
35. Sinha SN. Chakrabarti AK. Bee pollination and its impact on cauliflower in seed production. Proc. 2nd Int. Conf. Apic. Trop Clim., N. Delhi, India, 1980, 649-655.
36. Svendsen O. Experiment on the importance of honey bees for the pollination of spring rape (B. napus) under Sgelse overt honingbiernes betidingi for bestvningeri varraps. (B. napus) Tidsskriff for plantrar,1990:94:141-148.
37. Shuel RW. Nectar secretion Am. Bee J.,1955:95:229-234.
38. Von-Frisch K. The dance language and orientation of bees. Havard Univ. Press, Cambridge, 1967.