



E-ISSN: 2320-7078

P-ISSN: 2349-6800

JEZS 2019; 7(5): 544-549

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Received: 16-07-2019

Accepted: 18-08-2019

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Studies on major pollinators and foraging activities of Indian honey bee *Apis cerana* Fab. on mango (*Mangifera indica* L.)

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Abstract

The present study was conducted to record the major pollinators of mango and foraging activity of Indian honey bee *Apis cerana* Fab. on mango during flowering season of the year 2018-2019 at Division No. 2, Mango Orchard, National Agricultural Research Project, Regional Fruit Research Station, Ganeshkhind (Plain Zone). Result revealed that, total 20 species of insect pollinators recorded during flowering period of mango and out of these 10 from Hymenoptera, 5 from Diptera, Coleoptera and Neuroptera observed 2 each and 1 from Lepidoptera order and all pollinators plays significant role in pollination and fruit setting.

Peak foraging activity of *A. cerana* (5.76 Bees/panicle/5 min./week) were found during peak flowering period i.e. 1st week of February (6th SMW). with maximum time (16 sec/panicle) spend by *A. cerana* at 8:00 -10:00 am and minimum time (9.60 sec/ panicle) spend at 2:00 - 4:00 pm on mango inflorescence. Maximum foraging activity of bees (*A. cerana*) found during 9:00-11:00 am (7.08, 7.36, 7.76 Bees/panicle/5 min) and No activity found at morning 6:00 am and minimum activity between 12:00 – 4:00 pm (5.06-2.80 Bees/panicle/5min./week).

Keywords: Mango, pollinators, *Apis cerana* Fab. foraging activity

1. Introduction

Mango is an important fruit crop of Maharashtra and plays an important role in the economy of Maharashtra. Mango has been cultivated from last four thousand years back due to its hardy nature, low cost of cultivation and maintenance. Now, it is a commercially cultivated in subtropical region as a important fruit crop [1].

During the flowering period, mango inflorescence is visited by a large number of insects viz., flies, wasps, bees, butterflies, moths, beetles, ants and various bugs from the orders Hymenoptera, Diptera, Lepidoptera and Coleoptera due to considerable quantity of nectar and pollen which play a significant role in pollination and increasing fruit set [2].

Foraging activity of honey bees is initiated in early morning hours and finishes in the evening. The foraging activity of honey bees fluctuates during the day time from the morning to evening [3]. The peak period of visit by *A. cerana* on mango was 09:00-10:00 hours of the day [4]. However, the information regarding the major pollinators of mango and peak foraging activity of *A. cerana* in west region of Maharashtra is lacking. Therefore, the present studies were conducted to record the major pollinators of mango in west region of Maharashtra during flowering season of 2018-19.

2. Materials and Methods

2.1 Studies on diversity of various insect pollinators on mango flowers at NARP, Ganeshkhind, Pune during the year 2019

The field experiment was conducted during the flowering period from the month of December 2018 to February 2019 (till to cent percent fruit setting) on mango at National Agricultural Research Project, Regional Fruit Research Station, Ganeshkhind, Pune. Before flowering, five number of mango plants of variety *Keshar* were selected from the orchard and tagged. All these plants were kept free from application of any insecticides from initiation of flowering till to fruit setting. Different types of insect visiting in the morning hours (8:00 to 10:00 am) were recorded by taking photographs and unidentified specimens collected by using insect collection net and glass vials from mango inflorescence and identified with the help of experts. All the pollinators classified according to their orders and presented.

2.2 Relative abundance, peak foraging activity and time spent by honey Bee *Apis cerana* Fab. on mango flower during different day hours on mango flower

The five plants which were tagged and used for recording the diversity of pollinators used for recording the observation on Relative abundance and peak foraging activities of honey bees in mango. The five panicles around the plant were selected and tagged for recording the observation. Observations on Relative abundance, peak foraging activity of bees *A. Cerana* recorded bee/panicle for 5 minutes period was recorded at one hour interval from 7.00 am to 5.00 pm once in a week from 1st meteorological week to 10th meteorological week during mango blossom till to 90 percent fruit setting. While time spent by bee on flower was recorded at two hours interval by observing the 5 bees on flower once in week and time recorded with stopwatch. The data of foraging activities of honey bees is correlated with meteorological data by following the methods used [5].

2.3 Statistical analysis of the data

The data recorded on peak foraging activity of honey bees was transformed in to $\sqrt{x + 0.5}$ and arcsin values as per the statistical methods and used for analysis and interpretation [6].

3. Result and Discussion

3.1 Diversity of various insect pollinators on mango inflorescence at NARP, Ganeshkhind, Pune during the year 2019

Regular observations of insect visiting to mango blossom were recorded during blooming period on variety *Keshar* at National Agricultural Research Project, Ganeshkhind, Pune during the year 2018-19 and it is presented in the Table 1. During blooming stage till to pea size fruit setting i.e. from the month of January to March 2019, a total of 20 species of insect visitors or pollinators which visited to the mango flowers for pollen and nectar and not caused any harmful damage to flowers or mango tree were recorded as a pollinators. The major insect species visiting, foraging, spend time in mango flowers for pollen as well as nectar and played important role in pollinating mango inflorescence were recorded and belonged to order Hymenoptera, Diptera, Lepidoptera, Neuroptera and Coleoptera. Out of 20 insect

species, insect pollinators from order Diptera (Housefly, Syrphid fly, blow fly) were most dominating and continuously active in mango flowers and spend most of the time of day hours in visiting flowers and are effective pollinators of mango.

Indian honey bee (*Apis cerana* Fab.), Giant honey bee (*Apis dorsata* Fab.), European honey bee (*Apis mellifera* L.) and stingless bee (*Tretragonula laeviceps* Smith.) belonged to family Apidae and order Hymenoptera. Red ants, black ants and Wasp (*Vespula orientalis* Lin.) from order Hymenoptera also observed on mango flowers. The insect pollinators from order Hymenoptera also found as a predominant pollinator order in mango. It is observed that large size of bee such as Giant honey bee, *A. dorsata* and European honey bee *A. mellifera* continuously visited the mango flowers during the day hours but when such large size bees viz., *A. dorsata* and *A. mellifera* visited and sit on flowers of mango, it is observed that due to heavy weight of large bee, the stalk of the delicate mango flowers brokened, flowers dried and flowers dropped on the ground. Small size bees such as Indian honey bee (*Apis cerana* Fab.) and stingless bee (*Tretragonula laeviceps* Smith) playing very important role in pollination of mango flowers. In case of small honey bees drying of flowers not observed after visiting of bees for nectar and pollen in mango.

A number of adults of lady bird beetle, *Coccinella septempunctata* Fab. and *Cheilomenes sexmaculata* Fab. (Coleoptera: Coccinellidae) were also recorded on the flowers of mango. Adults as well as larval stage of two species of chrysopids (*Chrysoperla zastrokei* Step. and *Mallada boninensis* Okamoto.) (Neuroptera: Chrysopidae), cabbage butterfly (*Pieris rapae* Lin.) from order Lepidoptera were recorded on mango flowers.

These finding were supported by a number of scholars viz. [7] hymenopteran insects viz., Honeybees (*A. cerana* and *A. mellifera*), allodapine bees (*Braunsapis hewitti*) and sweet bees (*Halictus* spp. and *Lasioglossum* spp.) while *Chrysomya megacephala* Fab. *Chrysomya pinguis* Fab. and *Musca domestica* Lin. from order Diptera in mango. The abundance of six insect visitors on mango [8]. *Camponotus compressus* abundance high (33.78%) as compared to others and which was followed by flesh fly.

Table 1: Diversity of various insect pollinators on mango inflorescence at NARP, Ganeshkhind, Pune during the year 2019

Sr. No.	Name of the pollinator	Scientific Name	Systematic position	
			Family	Order
1	Indian honey bee	<i>Apis cerana</i> Fab.	Apidae	Hymenoptera
2	Giant honey bee	<i>Apis dorsata</i> Fab.	Apidae	Hymenoptera
3	European honey bee	<i>Apis mellifera</i> L.	Apidae	Hymenoptera
4	Stingless bee	<i>Tretragonula laeviceps</i> S.	Apidae	Hymenoptera
5	Robber bees	<i>Megachile conata</i> Cresson.	Megachilidae	Hymenoptera
6	Sharp tailed bees	<i>Coelioxys spp</i> Fab.	Megachilidae	Hymenoptera
7	Red ants	<i>Oecnophylla smaragdina</i> F.	Formicidae	Hymenoptera
8	Wasp	<i>Vespula orientalis</i> Lin.	Apidae	Hymenoptera
9	Black ants	<i>Lasius niger</i> Lin.	Formicidae	Hymenoptera
10	Wasps	<i>Vespula orientalis</i> Lin.	Pamphilidae	Hymenoptera
11	House fly	<i>Musca domestica</i> Lin.	Muscidae	Diptera
12	Blow fly	<i>Chrysomya megacephala</i> F.	Callophoridae	Diptera
13	Blow fly	Unidentified	Callophoridae	Diptera
14	Eristalinus spp.	<i>Eristalinus arborum</i> Fab.	Syrphidae	Diptera
15	Syrphid fly	<i>Syrphus corolla</i> Lin.	Syrphidae	Diptera
16	Lady bird beetle	<i>Coccinella septempunctata</i> L.	Coccinellidae	Coleoptera
17	Lady bird beetle	<i>Cheilomenes sexmaculata</i> F.	Coccinellidae	Coleoptera
18	Chrysopa	<i>Chrysoperla zastrokei</i> Step.	Chrysopidae	Neuroptera

19	Chrysopa	<i>Mallada boninensis</i> Oka.	Chrysopidae	Neuroptera
20	Cabbage butterfly	<i>Pieris rapae</i> Lin.	Pieridae	Lepidoptera

While *Chrysomya megacephala* Fab. (32.94%) as well as house fly, *Musca domestica* Lin. (25.44%). While abundance of *Ropalidia marginata* (0.62%) was lower than rock bee, *Apis dorsata* Fab. (3.70%) and little bee, *Apis florea* Fab. (3.42%), respectively. The insect pollinator *C. megacephala* spending more time in flowers and while *M. domestica*, *A. dorsata* and *A. florea* equally spend time in mango blossom. While mango tree are pollinated predominantly by insects, from the orders viz., Hymenoptera, Diptera and Coleoptera in mango [9]. They also concluded that majority of pollinators belong to order Hymenoptera and Diptera. Abdullah and the presence of insects pollinators from 9 orders viz., Coleoptera, Dermaptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Odonata and Orthoptera on leaves, flowers, fruits and branches of the mango tree which plays important role in the pollination of mango [10]. The numerous insects from the orders Hymenoptera, Diptera, Lepidoptera and Coleoptera visiting for mango pollination [8]. Pollen grains have been observed adhering to the bodies of many species belonging to these orders. On the basis of different studies, it is concluded that majority of pollinators belong to order Hymenoptera. Among, Hymenopterans insects, different species of honey bee are the most efficient flower visiting insect. Thus these results could support the findings of the current investigation.

3.2. Relative abundance, peak foraging activity and time spend by honey bee *Apis cerana* Fab. during different day hours on mango flowers at NARP, Ganeshkhind, Pune

3.2.1 Relative abundance of honey bee *Apis cerana* Fab. on mango flowers at NARP, Ganeshkhind, Pune

Foraging activity of *A. cerana* honeybees were observed throughout the present research study i.e. from I to X SMW i.e. from first week of January to second week of March,

2019. The foraging activity increased from I SMW to VI SMW week (first week of January to fourth week of February) as availability of flowers to *A. cerana* increased for pollen and nectar collection. 2.26 number of bee/panicle/5min. period recorded in I SMW as flowering started and activity increased with 2.70, 3.86, 4.14 and 5.02 bees/panicle/5 min. in II, III, IV and V SMW. Highest foraging activity recorded in VI SMW (fourth week of February) with 5.78 bees/panicle/5 min. as mango trees were in full flowering stage. Later on the foraging activity decreased from VII SMW with 5.14 bees/panicle/5 min., in VIII SMW with 5.25 bees/panicle/5 min., in IX SMW with 3.00 bees/panicle/5 min. and 1.94 bees/panicle/5 min. in X SMW.

The foraging activity of *A. cerana* initiated at earlier at 7.00 am in II SMW and at 8.12 am at X SMW in the morning while last honeybee of *A. cerana* seen foraging on mango flower at 6.08 pm in the evening which is mentioned in Table no. 2. The literature is available with earlier workers findings. The intensity of honey bee, *A. cerana* (6.40/panicle/hour) and blow fly, *Chrysomya* sp. (5.85/panicle/hour) during mango flowering period and the peak intensity of these pollinators was observed during 4th to 6th standard meteorological week and support the findings of present investigations [11]. Foraging activity of honey bees under desert conditions and concluded that honeybees foraging activity is initiated in early morning at 6.17 hrs and finishes in the evening [4]. Honeybee, *A. cerana* started foraging activity on cauliflower and cabbage crops at 07.00 hrs and 06.30 hrs, respectively, and ceased flight activity at 18.00 hr. and 18.30 hr., respectively [12]. Foraging on cauliflower started at ambient temperatures of 7 °C and peak foraging activity was between 11.00 hrs and 13.00 hrs on both the crops. But this commencement time can be greatly impacted by the region and climatic conditions.

Table 2: Relative abundance (mean foraging activity), Initiation and Cessation time of honey bee *Apis cerana* Fab. on mango flowers at NARP, Ganeshkhind, Pune during the year 2019

Standard Meteorological Week	Mean foraging activity (Bee/panicle/5mi)	Foraging activity		Temperature (°C)		Relative Humidity (%)	
		Initiation time (AM)	Cessation time (PM)	T max	T min	RH Morn	RH Even
I	2.26	7.06	5.54	30.56	8.73	93.00	23.00
II	2.70	7.00	6.01	30.59	9.59	93.00	25.00
III	3.86	7.25	5.57	30.89	11.87	92.00	27.00
IV	4.14	7.10	5.59	28.61	10.97	86.00	37.00
V	5.02	8.00	6.03	29.03	11.44	87.00	30.00
VI	5.78	8.10	6.08	29.71	10.17	86.00	24.00
VII	5.14	7.58	5.58	33.30	13.50	87.00	25.00
VIII	5.25	8.00	5.52	35.50	15.70	81.00	20.00
IX	3.00	7.30	5.59	33.00	13.50	80.00	17.00
X	1.94	8.12	6.01	33.80	15.00	80.00	22.00

3.2.2 Peak foraging activity of honey Bee *Apis cerana* Fab. during different day hours on mango flower

The foraging activities of honeybee *A. cerana* was recorded at one hour interval in a mango flowers from morning (6.00 am) till to evening (6.00 pm) once in a week till to fruit setting of mango (Table 3 and fig 1) during the year 2019 and the mean foraging activity calculated on hourly basis. No any activity of *A. cerana* was noticed at 6.00 am but the foraging activity honeybee *A. cerana* was observed from 7.00 in the morning to

18.00 hours in the evening of the day during the flowering period. The foraging activity commenced with 0.60 bees/panicle/5 min. at 7.00 hours early in the morning. The honeybee *A. cerana* activity increased along with day hours in the morning up to 11.00 hours with 3.06, 7.08, 7.36 and 7.76 bee/panicle/5 min. on mango flowers at 8.00, 9.00, 10.00 and 11.00 hours, respectively.

The foraging activity of honeybee *A. cerana* increased along with morning hours up to 11.00 hours, later on declined when

the day temperature reached at top level in the afternoon hours. 5.06, 3.62, 2.28 and 2.08 bee/panicle/5 min. at 12.00, 13.00, 14.00 and 15.00 hours, respectively. During the evening day hours, the foraging activity of bee increased with 2.80, 5.94 and 0.76 bee/panicle/5 min. at 16.00, 17.00 and 18.00 hours.

Foraging activity of honeybees started from 7.00 to 18.00 hours of the day i.e. from 3rd and 8th meteorological week when maximum number of flowers opened and when ample quantity of nectar and pollen available to honeybees. The foraging activity increased from 4th meteorological week (average 3.94 bee/panicle/5min./day) and increased and reached up to peak on 6th meteorological week with average 6.06 bee/panicle/5min./day. Later on, the foraging activity declined from 7th to 9th week i.e. from 4.92 to 2.37 average number of bee/panicle/5min./day.

comparative foraging activity of *A. cerana* Fab. during different weeks during flowering indicated that the total number of honeybees that visited the mango blossom increased during day hours from 1st meteorological week upto 6th meteorological week as most of mango flowers available to the bees for nectar and pollens. The maximum number of

bee foraging activity was observed during day hours in 6th meteorological week and it was in the range of 2.60 to 11.60 bee/panicle/5 min. The activity declined from 7th to 10th meteorological week. During these weeks, most of the flowers pollinated and fruit setting completed.

During the present investigation, the foraging activity of *A. cerana* Fab. was recorded at peak for three times in a day hours with 7.76 bee/panicle/5 min. at 11.00 hours and 7.36 bee/panicle/5 min. at 11.00 hour in the morning and 5.94 bee/panicle/5 min. at 17.00 hour in the evening. While minimum number of bee foraged at 7.00 hours (0.60 bee/panicle/5 min.) in the morning and 18.00 hour (0.76bee/panicle/5min.) in the evening Maximum foraging activity of bees (*A. cerana*) at 9:30a.m, while the least foraging activity was recorded at 7:00a.m. the time of 9:00 a.m. to 12:00a.m. was also indicated as the most intense activity time when the highest numbers of bees (*A. cerana*) were seen on flower [13]. The peak foraging activity of *A. cerana* is during 09:00.am to 12:00 am [7]. Abundance of honey bees the lowest foraging activity observed at 7:00 – 9:00 am and the highest at 11:00-01:00pm [14].

Table 3: Peak foraging activity during different day hours and working hours of honey bee *Apis cerana* Fab. on mango flower

Day Hours	Foraging activity (I to X SMW)		
	Highest activity	Lowest activity	Mean
	Bees/panicle/5 min./week		
6.00	0.00	0.00	0.00
7.00	0.00	2.00	0.60
8.00	1.00	6.80	3.06
9.00	4.00	9.40	7.08
10.00	4.20	11.20	7.36
11.00	7.00	11.60	7.76
12.00	2.20	11.40	5.06
13.00	1.40	6.20	3.62
14.00	1.00	3.40	2.28
15.00	0.60	3.60	2.08
16.00	0.90	4.25	2.80
17.00	0.20	5.20	5.94
18.00	0.20	4.60	0.76

Thus, these observations of earlier workers could support the finding of the present investigation. However, little deviation also observed in the peak foraging activity and the peak foraging activity varied in different location.

Time spent by honey bee *Apis cerana* Fab. on mango flowers in day hours during flowering period

The results presented in the Table 4. (Fig 2) revealed that the time spent per flower per forage was found statistically non-significant but varied with hour of sampling. The range of maximum time 13.45 to 16.00 seconds/panicle) was recorded by *A. cerana* during day hours while minimum time ranged in between 9.60 to 11.00 seconds/flower. The maximum time spent on mango flower was 16.00 second/flower was recorded

in between 8.00 to 10.00 day hours interval while minimum time (9.60 seconds/ panicle) was in between 14.00 to 16.00 day hours interval on mango.

Maximum time spend by *A. cerana* on mango flower is at 8.00 -10.00 am and minimum at 4:00 -6:00 pm.

Maximum time spend by *A. cerana* on mango flower is in between 9:00 -10:00 am (6.48sec/ panicle) and minimum between 1:00 -2:00 pm and 5:00-6:00 pm (4.15 and 4.56 sec/ inflorescence respectively) [4]. Maximum time spend by *A. cerana* on sesamum inflorescence is at 10:00 am (10.50 sec/ inflorescence) and minimum at 6:00(0.17 sec/flower) pm [15]. Thus, the present observations in this respect are in accordance with the findings of these earlier research workers

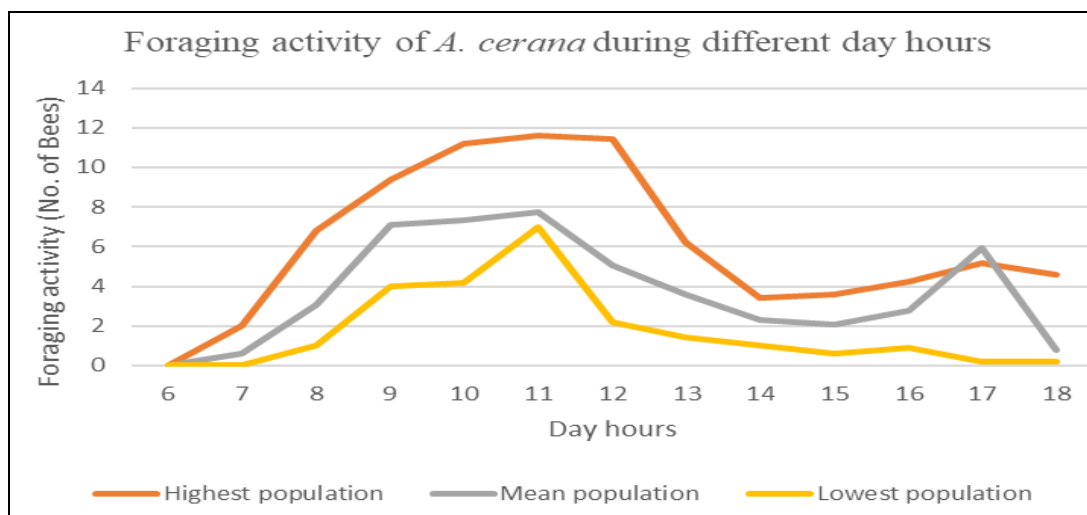


Fig 1: Peak foraging activity of honey bee *Apis cerana* Fab. during different day hours on mango flowers

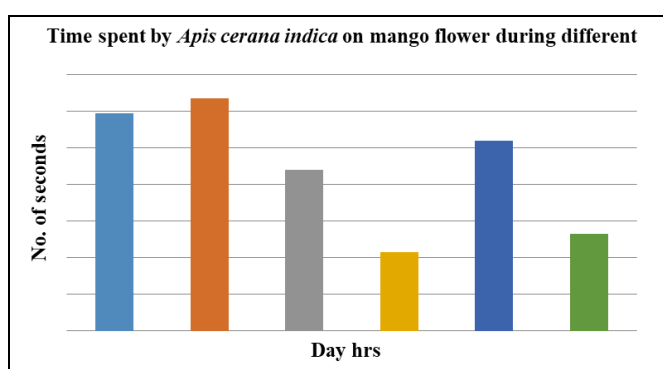


Fig 2: Time spent by honey bee *Apis cerana* Fab. on mango flowering during day hours

Table 4: Time spent by honey bee *Apis cerana* Fab. on mango in day hours on mango flowers during flowering period

Day hours	Time spent by <i>Apis cerana</i> Fab. on mango flower (Sec/flower)		
	Minimum	Maximum	Mean
	No. of Seconds/flower		
6.00- 8.00	11.00	14.10	12.39 (3.59)
8.00 -10.00	11.00	16.00	12.47 (3.60)
10.00 -12.00	10.00	14.20	12.08 (3.55)
12.00 -14.00	10.15	13.45	11.63 (3.48)
14.00 -16.00	9.60	14.33	12.24 (3.57)
16.00- 18.00	10.75	12.33	11.73 (3.50)
SE ±			N. S.
CD at 5%			0.20
CV			6.31

*Figures in parenthesis are $\sqrt{x+0.5}$ transformed values

4. Conclusion

Total 20 species of insect pollinators observed during flowering period of mango, out of these 10 from hymenoptera, 5 from Diptera, Coleoptera and Neuroptera observed 2 each and 1 from Lepidoptera. plays significant role in pollination and fruit setting. Peak foraging activity of *A. cerana* (5.76 Bees/panicle/5 min./week) found during period at 1st week of February, i.e (6th MW). maximum time spend by *A. cerana* on mango flower is at 8.00 -10.00 am and minimum at 4:00 -6:00 pm. Maximum foraging activity of bees (*A. cerana*) found during 9:00-11:00 am (7.08,7.36, 7.76 Bees/panical/5 min./week) and minimum activity found at morning 6:00 am (0Bees/panicle/5min./week) and between 12:00 – 4:00 pm (5.06-2.80 Bees/panicle/5min./week).The

foraging activity of *A. cerana* initiated at earlier at 7.00 am in II SMW and at 8.12 am at X SMW in the morning while last honeybee of *A. cerana* seen foraging on mango flower at 6.08 pm in the evening.

5. Acknowledgement

Authors are thankful to the College of agricultural Pune and National Agricultural Research Project, Regional Fruit Research Station, Ganeshkhind (Plain Zone). For providing the funds and facilities for conducting the present research work.

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