Documentation of Honeybees flora and Blooming period in major Horticultural and Agricultural crops growing in dryland regions of Northern Karnataka

Abstract:

The present research work was carried out to know the diversity of nectariferous and polleniferous bee flora in order to develop their blooming period in and around Koppal district of Northern Karnataka. The flowering plants were visited and noted for their presence and also foraging activities of honeybees. Observed plants were recorded as bee foraging species when at least three honeybees had visited to the flowers within the period of 10 minutes. The identified bee flora visited by worker bees comprises different plant groups *viz*., fruit crops, vegetable cops, field crops, plantation, flower and ornamental plants etc. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. Totally there were 64 crops proved as foraging crops. Out of that nectar (14), pollen (13), both pollen and nectar (36) yielding plants were documented in Koppal district. Mid-December to February and mid-July to September were identified as honey flow periods and mid -April to mid- June were the critical dearth periods during the year. Based on the availability, utility status and flowering duration of flora, floral calendar was developed for the study area. Some of the common and important bee forage plants are, the species of *Syzygium*, *Cassia*, *Citrus*, *Pongamia*, *Azadirachta*, *Brassica*, *Areca*, *Cocos*, *Guizotia*, *Hilianthus*, *Albezia*, *Lagerstroemia*, *Polinathus*, *Sapindus*, *Tecoma* etc.

Keywords: Bee flora, beekeeping, honey flow period, dearth period, floral calendar.

Introduction:

Honey bees are highly evolved social insects gaining greater importance as efficient pollinators in the present times. Honeybees are social insects with which man has established a harmonious coexistence. It is due to bee pollination that the crop yield increases and improves in quality and quantity of seed and fruit yield. Therefore, bee keeping can play a vital role in improving crop yields besides resulting in to an additional source of income through honey and bee-wax (Sharma *et al*. 2015). Many investigations have consistently confirmed that yield levels can be increased to an extent of 50 to 60 per cent in fruits and plantation crops, 45 to 50 per cent in sunflower, sesamum and niger and 100 to 150 per cent in cucurbitaceous crops, through good

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management of pollinators (Melnichenko and Khalifman, 1960). Insect pollination of crops is an essential crop management practice and should be utilized skilfully by harnessing the activity of domestic honeybees, wild bees and other pollinators including solitary bees. Achievement of desired pollination lies in the planned and efficient use of honey bees to increase the yield as well as improving qualitative and quantitative parameters of the crop (Sharma *et al*., 2015).

The Indian bee, *Apis cerana* Fabricius is a predominant bee in Karnataka among other species, such as *Apis dorsata, Apis florea, Trigona irridipennis, Apis mellifera.* Indian honey bee, *A. cerana* is the base of Indian beekeeping and is widely distributed in India. The Indian honey bee, *A. cerana* is also distributed in Pakistan, Sri Lanka, Malaysia, Indo-China, Philippines, China, USSR, Japan and Indonesia (Ruttner, 1988; Hepburn *et al*., 2001). It thrives up to 2500 m above mean sea level. It has many desirable characters of biological and economic importance that include docile nature, less prone to the attack of parasitic mites and *nosema* disease. Hence, an investigation on study of bee flora and their blooming periods of honey bees in Koppal district was undertaken.

Material and Methods:

The study area comprising Koppal was (15° 21' 2.5488" North and 76° 9' 19.5624" East) selected for studying bee-flora and blooming period during November 2016 to November 2017. The average annual rainfall of Koppal district was 571.99 mm. In order to arrive the data 25 km radius from the study area representing 20 study sites are to be selected. Observations were recorded during flowering periods that are visited by worker bees of different plant group's *viz*., vegetable cops, fruit crops, field crops, plantation, flower and ornamental plants.

Identification of bee-flora: The data was collected during monthly visits to the study sites, during 2016 -2017. Each study visit served as pseudo replicates for the site and all observations were observed between 0700-1730 hours. The study included observations of activities of bees on flowers of different plant species. Whenever bees were found on the flowers of such plants, their foraging behavior was observed for a period of 10 minutes. If the success of any foraging attempt was ascertained, the plant was scored as bee foraging species if at least three (3) honeybees visited the flowers simultaneously within 10 minutes of the observations.

The observations on nectar and pollen source were based on activities performed by honeybees on different flowers observed by using Binocular (Nikon 8x42 Aculon Camo). Honeybees with

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their activity of extending their proboscis into the flowers are considered as nectar source and bees carrying pollen on their hind legs were determined as pollen source.

Honeybees with their activity of extending their proboscis into the flowers and also collecting pollen on their hind legs were determined as nectar and pollen yielding plants. Based on frequency visitation of worker bee to a flower, forage value established as low and high nectar and pollen rich plant. Such plants were identified using the books *in situ*. If the plants were recorded as bee foraging species at particular site and later encountered in subsequent survey on the other sites; it was only scored for presence. Plants that could not be identified in the field their portion or twig of a branch with necessary botanical features like its leaves, flower and portion of stem were cut and arranged in herbarium, identified with the help of botanist and compared with the published reports. The observations were recorded for three purposes.

A comprehensive consecutive data of flowering periods of the plants species was made during the survey. The data recorded in field's notebooks was compiled into annual floral calendar and also used to prepare honey flow and dearth period.

Result and Discussion:

In order to develop a comprehensive picture of the scenario of bee pollinators a field extensive and intensive field observation are required therefore bee flora and blooming period was documented under field conditions at Koppal district. The field observations were recorded from the month of November 2016 to November 2017. This basic information is required to time the pesticide application without causing any inimical effects on the pollinators. The flora of Koppal district was categorized in to 4 groups depending upon the type of the plants *viz*., Vegetables, fruits, field, plantation, flower and ornamental crops. The data is presented in table 1 to 4 and fig. 1. The results revealed that in Koppal district, 64 plant species were useful to honeybees, out of which vegetables (19), fruits (15), field crops (15) and plantation, flower and ornamental crops (15) identified and found in the study area. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants (Tables 1-4) out of 64 crops, nectar (14), pollen (14) and both pollen and nectar (36) yielding plants(Tables, 1-4 and Fig-1).

Among the 19 vegetables there were few plants *viz.*, Bhendi, Bottle guard and Pumpkin those served as both nectar and pollen source. Similarly among the fruit crops (15) majority viz., citrus, ber, custard apple, pomegranate, banana, guava etc served as both nectar and pollen

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source whereas rose apple, guava, banana, coronda, sweet lime, ber, custard apple are the source low pollen yielders. Among field crops (15) sunflower, blackgram, chickpea, ground nut, maize, niger, castor those served as both nectar and pollen source. Similarly in plantation, flower and ornamental crops (15) antigonum served as both nectar and pollen sources. These are the key crops that sustain the population of pollinators. The wild patches of vegetation also serve as indicators of pollinators which need to be conserved.

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The Present results are in close agreement with Bhalchandra *et al*. (2014) reported that the diversity of nectariferous and polleniferous bee flora and developed a floral calendar for Anjaneri and Dugarwadi hills. The flowering plants were visited and observed for the presence and foraging activities of honeybees. Plants were scored as bee foraging species when at least three honeybees had visited the flowers within 10 minutes. The results revealed that 52 plant species were useful to honeybees, of which 29 were agricultural crops and 23, wild plants.

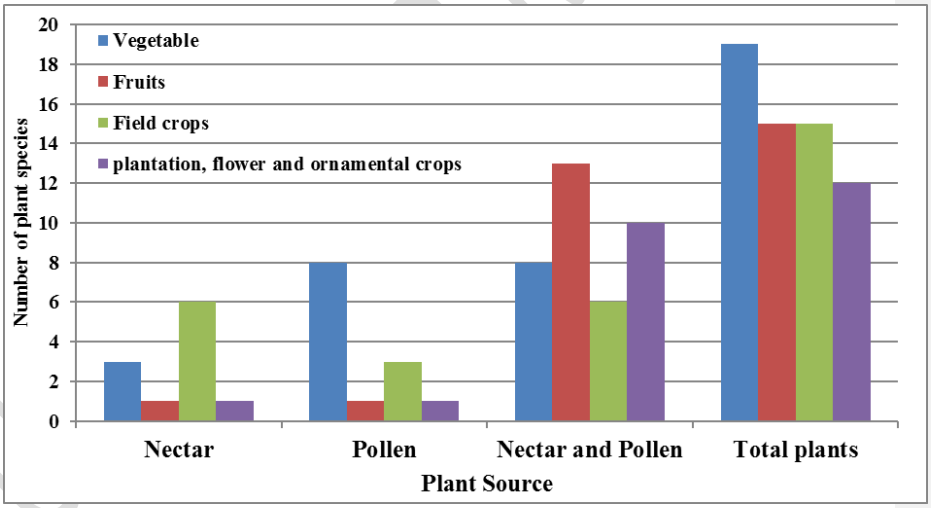

Fig.1 Nectariferous / polleniferous bee flora and floral calendar in crops at Koppal district

The study revealed that more than 340 plants are useful to honeybees. The identified bee flora comprises of ornamentals, timber, medicinal, fruits, vegetables and other commercial important plants like spices, pulses, cereals, oil yielding, fibre, fodder, etc. Some of the common

and important bee forage plants are, the species of *Syzygium cumini* L., *Cassia tora*, Citrus, Pongamia, *Azadirachta*, *Brassica*, *Areca*, *Cocos*, *Guizotia*, *Helianthus annuus* L., *Albezia*, *Lagerstroemia*, *Polinathus*, *Sapindus*, *Tecoma* etc., (Sivaram, 2001). In Nigeria, the study reported that a total of 61 species of savanna plants visited by the honeybee, *Apis mellifera* were identified through direct observation of foraging bees.. The largest number of species (26.2%) was recorded for the family Fabaceae. Combretaceae ranked second with 9.8% of the species, while Arecaceae, Lamiaceae, Poaceae, Rhamnaceae and Rubiaceae ranked third each with 4.9% of the species (Dukku, 2013).

Honey flow and dearth period

For study area of Koppal districts the honey flow and dearth period was determined and results are summarized in (Tables 1-4). The peak periods of honeybee foraging activity (honey flow period) were recorded during June– October of winter season and January to March of summer season of the year. During the honey flow period (June– October), abundant bee floral plants were found blossoming and plants species were recorded as source of food for honeybees. The flowering plants of several plant families are blossoming at different time intervals of the year. Pollen and nectar availability to foraging bees fluctuated with time of the year and flowering of different species of plants (Free, 1970). The phase of the blooming period does not commence simultaneously in all the honey-flora participating in the main honey-flow. Depending on the soil type, climatic factors and the habitat, the time of blooming may change for even the same nectar plant (Rodionov and Shabanshov, 1986).

Major nectar rich plants includes *viz*., Beans *Phaseolus vulgaris*, Mung bean *Vigna radiate*, Cluster bean *Cyamopsis tetragonolobus*, Bitter gourd *Momordica charantia*, Mango *Mangifera indica*, Black gram *Vigna mungo* Chickpea *Cicer arietinum* Pigeon pea *Cajanus cajan* Mustard *Brassica rapa*, Lab lab, Cow pea *Vigna spp* , Pongemia *Pongamia pinnata*, Bajra *Pennisetum tyhhoides Stap.*

Pollen rich plants *viz*., Brinjal *Solanum melongena* Tomato *Lycopercicon esculentum* Chilli *Capsicum sp* Cucumber *Cucumis sativus* Musk melon *Cucumis melo*, Water melon *Citrullus lanatus*, Rajgiri/ Amaranthus *Amaranthus gracilus*, Ground nut *Arachis hypogaea* Maize *Zea mays* Mesta *Hibiscus sutrattensis* ,Coconut *Cocos nucifera*

Both nectar and pollen rich plants *viz*., Bhendi *Abelmoschus esculentus*, Bottle gourd *Lagenaria siceraria* Pumpkin *Cucurbita pepo* ,Onion *Allium cepa*, Drumstick *Moringa oleifera*,

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Ridge gourd *Luffa acutangula*, Pea *Pisum sativum*, Snake gourd *Trichosanthes anguina* ,Citrus *Citrus limon*, Ber *Ziziphus jujube*, Custard apple *Annona squamosa*, Papaya *Carica papaya*, Caronda (Kavale) *Carissa carandas*, Banana *Musa sp.*, Gauva *Psidium guajava*, Rose apple *Syzygium jambos*, Sunflower *Helianthus annuus*, Sesame *Sesamum indicum*,Niger *Guizotia abyssinica*, Paddy *Oryza sativa*, Castor *Ricinus comunis*, Cotton *Gossipium spp.* Tamarind *Tamarindus indicus*, Neem *Azardirhacta indica*, Antigonum *Antigonum leptopes* and other bee floras of the region supported honey production. The flowering plants of an area having good value as bee pasture are necessary to maintain bee colonies. Honeybees visited these plants extensively for honey production and colony multiplication.

Summer season was critical dearth period with high temperature (over 35^0C), scarcity of water and few flowering plants. The few agricultural plants like *Coriandrum sativum, Vigna aconitifolia, Arachis hypogaea, Punica granatum, Pennisetum tyhhoides* and wild plants like *Azardirhacta indica, Jacarandaa mimosifolia, Cassia tora, Tridax procumbens, Antigonum leptopes* (creeper) were blossomed during the season. However, their number per unit area was less or having lesser quantity of pollen or nectar. These minor sources are utilized by bees during the time of scarcity of major bee flora. Because of high temperature and scarcity of water for flowering plants this period was found unfavorable for honeybee foraging.

The present findings are supported by Choudhary and Kumar (1998) reported *Apis florae* L. as the most abundant visitor on niger (84.50%), followed by *Apis cerana* L. (7.90%) and *A.mellifera* (5.7%) in Pune. Activity of *A.florea* was from 0600 to1830 h, where as *A.cerana* and *A. mellifera* activity was from 0600 to 1630 h and 600 to 1730 h, respectively. Bisht and Pant (1968) reported that *A.cerana* gathered pollen throughout the year under Delhi conditions. The higher pollen gathering activity was recorded during January-March where as May and June was the period of lesser activity.

Viraktamath and Anagoudar (2002) studied the foraging profile of *A.cerana* in Raichur (Karnataka). He observed major pollen foraging (up to 80%) before noon and nectar foraging throughout the day with a major peak during 0600 to 1100 h and another peak during 1600 to 1800 h. The first peak was in March with 72 to 81 per cent of the returned bees were loaded with pollen and the second peak was in May with 79 to 79 per cent probably because of high flowering rate and favorable environmental conditions.

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Honeybees were excellent pollinators in tomatoes during winter months producing high quality of fruits resulting in 98 percent fruit set (Sabara *et al.*, 2002) which is comparable to fruit set by bumblebees. *A.cerana* was the principal pollinating insect and was found to be efficient pollinator than *A.florea* and *Trigona*,. Further, *A.cerana* bee population was maximum at 0900 h and also during the period the pollen collection was more. Abundance of all insect pollinators irrespective of the species was more at 1200 to 1400 h on onion crops (Priti, 1998).

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Honeybee and plant have a special symbiotic relationship. Bee flora is important for establishing bee keeping industry. The awareness to maintain the existing bee flora and multiplication of plant species is important for its sustainability. Plant types and their flowering duration differ from one place to other due to variation in topography, climate and other cultural and farming practices. The knowledge of bee flora of a Baramati region enable beekeepers to utilize them at the maximum level, so that they can harvest a good yield of honey and other bee products in addition to effective pollination, which enhances crop yields. This region has its own honey flow and floral dearth periods of short and long duration. Such knowledge on bee flora help in the effective management of bee colonies during such periods. Based on available flora, major characteristics of these plant species, pollen and nectar availability and flowering duration, a bee floral calendar as per the season were developed. To conserve these floras, attention must be given to maintain and multiply the existing flora. Considering these facts, the present study is carried out to prepare an inventory of existing bee flora and develop floral calendar for that particular region (Kumar *et al.*, 2013).

Conclusion:

The present investigation was conducted to study the diversity of nectariferous and polleniferous bee flora and to develop a floral calendar for Koppal district. The flowering plants were visited and observed for the presence and foraging activities of honeybees. Plants were scored as bee foraging species when at least three honeybees had visited to the flowers within the period of 10 minutes. The identified bee flora comprises visited by worker bees of different plant groups *viz*., vegetable cops, fruit crops, field crops, plantation, flower and ornamental plants etc. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. The result revealed that in Koppal district, 64 plant species were useful to honeybees, out of which vegetables (19), fruits (15), field crops (15) and plantation, flower and ornamental crops (15) identified and found in the study area. The identified flora was further

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Table 1. Nectariferous / polleniferous bee flora and floral calendar in vegetable crops in Koppal district

Sl.No.	Common name	Botanical name	Family	Flowering period	Bee forage value		
					Nectar	Pollen	Nectar + Pollen
Vegetables							
1.	Brinjal	*Solanum melongena*	Solanaceae	Jan to March, June to July.	-	P2	-
2.	Tomato	*Lycoperci Lycopersicon esculentum Mill. con esculentum*	Solanaceae	Jul-Sep	-	P1	-
3.	Chilli	*Capsicum sp.*	Solanaceae	Jul-Feb	-	P2	-
4.	Bhendi	*Abelmoschus esculentus*	Malvaceae	Aug – Nov	-	-	P1N2
5.	Beans	*Phaseolus vulgaris*	Fabaceae	Dec-Feb	N2	-	-
6.	Bottle gourd	*Lagenaria siceraria*	Cucurbitaceae	Oct – Feb.	-	-	N2P2
7.	Cucumber	*Cucumis sativus*	Cucurbitaceae	Aug – Oct.	-	P1	-
8.	Musk melon	*Cucumis melo*	Cucurbitaceae	March – May.	-	P1	-
9.	Pumpkin	*Cucurbita pepo*	Cucurbitaceae	Aug – Oct.	-	-	N2P2
10.	Water melon	*Citrullus lanatus*	Cucurbitaceae	July – Aug.	-	P1	-
11.	Onion	*Allium cepa*	Liliaceae	Jun– Aug.	-	P1	-
12.	Drumstick	*Moringa oleifera*	Moringaceae	Nov – Feb.	-	-	N1P2
13.	Ridge gourd	*Luffa acutangula*	Cucurbitaceae,	July – Oct.	-	-	N1P1
14.	Pea	*Pisum sativum*	Fabaceae	Aug- Sep.	-	-	N1P1
15.	Cluster bean	*Cyamopsis tetragonolobus*	Leguminosae	Jun - Aug.	N2	-	-
16.	Rajgiri/ Amaranthus	*Amaranthus gracilus*	Amaranthaceae	Feb-Mar	-	P1	-
17.	Bitter gourd	*Momordica charantia*	Cucurbitaceae	Aug-Oct	N2	-	-
18.	Snake gourd	*Trichosanthes anguina*	Cucurbitaceae	Jan-Mar	-	-	P2N2
19.	Little gourd	*Coccinia grandis*	Cucurbitaceae	Aug-Oct	-	-	N1P1

N1 = Low nectar yield N2 = High nectar yield " -" = absent
P1 =Low pollen yield P2 = High pollen yield

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Table 2. Nectariferous / polleniferous bee flora and floral calendar in fruit crops in Koppal district

Sl.No.	Common name	Botanical name	Family	Flowering period	Bee forage value		
					Nectar	Pollen	Nectar + Pollen
Fruit crops							
1.	Citrus	*Citrus limon*	Rutaceae	Oct – Jan, July – Sep.	-	-	N2P1
2.	Mango	*Mangifera india*	Anacardiaceae	Dec- Jan	N2	-	-
3.	Ber	*Ziziphus jujuba*	Rhamnaceae	July – Oct.	-	-	N2P2
4.	Custard apple	*Annona squamosa*	Annonaceae	Aug – Oct.	-	-	N1P2
5.	Pomegranate	*Punica granatum*	Punicaceae	March – June	-	-	N2P1
6.	Sweet lime	*Citrus aurantifolia*	Rutaceae	Nov – March	-	-	N2P2
7.	Caronda (Kavale)	*Carissa carandas*	Apocynaceae	Mar-Apr	-	-	P2N2
8.	Water melon	*Citrullus lanatus*	Cucurbitaceae	Sep-Oct	-	P1	-
9.	Mandrin	*Citrus reticulata*	Rutaceae	Mar-Apr	-	-	P2N1
10.	Banana	*Musa sp.*	Musaceae	Jan-Dec	-	-	P2N2
11.	Gauva	*Psidium guajava*	Myrtaceae	Mar-Jun	-	-	P2N1
12.	Rose apple	*Syzygium jambos*	Myrtaceae	Mar-Jun	-	-	P2N1
13.	Sapota	*Manilkara achras L.*	Sapotaceae	Mar-Jun	-	-	P1N1
14.	Amla	*Phyllanthus emblica*	Phyllanthaceae	April-may	-	-	P1N1
15.	Jamun	Syzygium cumini	Myrtaceae	Apr-May	-	-	P2N2

N1 = Low nectar yield N2 = High nectar yield " -" = absent

P1 =Low pollen yield P2 = High pollen yield

Table 3. Nectariferous / polleniferous bee flora and floral calendar in field crops in Koppal district

Sl.No.	Common name	Botanical name	Family	Flowering period	Bee forage value		
					Nectar	Pollen	Nectar + Pollen
Field crops							
1.	Sunflower	*Helianthus annuus*	Compositae	March – April.	-	-	N2P1
2.	Blackgram	*Vigna mungo*	Fabaceae	Aug – Sep.	N2	-	-
3.	Chickpea	*Cicer arietinum*	Fabaceae	Dec – March.	N2	-	-
4.	Groundnut	*Arachis hypogaea*	Fabaceae	July - Oct, April – June.	-	P2	-
5.	Pigeonpea	*Cajanus cajan*	Fabaceae	July – Sep.	N2	-	-
6.	Sesame	*Sesamum indicum*	Pedaliaceae	July – Aug.	-	-	N1P2
7.	Maize	*Zea mays*	Poaceae	Aug – Sep, Feb – March.	-	P2	-
8.	Mustard	*Brassica rapa*	Brassicaceae	Jan – March.	N1	-	-
9.	Mesta	*Hibiscus sutrattensis*	Malvaceae	Aug-Nov	-	P2	-
10.	Niger	*Guizotia abyssinica*	Asteraceae	Sep-Nov	-	-	P1N1
11.	Paddy	*Oryza sativa*	Poaceae	Aug-Sep	-	P2	-
12.	Castor	*Ricinus comunis*	Euphorbiaceae	Feb-Apr	-	-	P2N2
13.	Lab lab (Dolichos bean)	*Lablab purpureus*	Fabaceae	Jul - September	N1	-	-
14.	Bajra	*Pennisetum typhoides*	Poaceae	Jul - September	N2	-	-
15.	Cotton	*Gossipium spp.*	Malvaceae	Sept-Jan	-	-	P2N2

N1 = Low nectar yield N2 = High nectar yield " -" = absent
P1 =Low pollen yield P2 = High pollen yield

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Table 4. Nectariferous / polleniferous bee flora and floral calendar in plantation, flower and ornamental crops in Koppal district

Plantation crops							
1.	Coconut	*Cocos nucifera*	Arecaceae	Jan-Dec	-	P1	-
2.	Tamarind	*Tamarindus indicus*	Fabaceae	Apr-Jun	-	-	P2N1
3.	Pongemia	*Pongamia pinnata*	Fabaceae	Feb-Apr	N1	-	-
4.	Neem	*Azardirhacta indica*		Mar-Apr	-	-	P2N1
5.	Cashew nut	*Anacardium occidentale*	Anacardiaceae	Dec-Jan	-	-	P2N1
Flower and ornamental plants							
1.	Antigonum	*Antigonum leptopes*	Polygonaceae	Apr- May	-	-	P1N2
2.	Jasmine	*Jasminum* sp.	Oleaceae	July-Aug	N1		
3.	Rose	*Rossa* spp	Rosaceae	April-june			N1P1
4.	Gladiolus	*Gladiolus communis*	Iridaceae	Nov-Dec	N1	-	-
5.	Marigold	*Tagitus* sp	Asteraceae	Oct-Nov	-	-	N1P2
6.	Chrysanthimum	*Chrysantimum sinararifolium*	Asteraceae	August-Oct	-	-	N1P1
7.	Tuberose	*Polianthes tuberosa*	Asparagaceae	Sept- Oct	-	-	N1P1
8.	Gaillardia	*Gaillardia aristata*	Asteraceae	Sept- Oct	-	-	N1P1
9.	Nandi Battlu/ crape jasmine	*Tabernaemontana coronaria*	Apocynaceae	Sept- Oct	N1	-	-
10.	Kantaphala/ brahma dande	*Echinops echinatus*	Asteraceae	Throught year	-	-	N1P1

N1 = Low nectar yield N2 = High nectar yield " -" = absent
P1 =Low pollen yield P2 = High pollen yield

Commented [a40]: Correct the word spacing