

EVALUATION OF INDIGENOUS BEE ATTRACTANTS IN SUNFLOWER

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1. INTRODUCTION

Agriculture is the backbone of Indian economy with 75 per cent of the people depending on farming for their livelihood. Agriculture accounts for about 30 per cent of the gross domestic products. Agricultural production has stagnated since past one decade, despite of optimal use of essential inputs for production of economically important crops. Total cropped area in India is about 160 million hectares out of which 55 million hectare is under 'Entomophilous crops' i.e. crops depending on insects for their pollination. Many fruit, vegetable, oilseed, plantation, spice, beverage, forage, fiber and other field crops belong to this category. The production can further be enhanced by addition of important and essential input of bee pollination.

Use of pollinators is considered as one of reliable, cost effective and eco-friendly methods to enhance the cross-pollination and increase productivity and quality of crops. Among different pollinators, bees are considered as the best pollinating agents due to their suitable body size, hairiness, thoroughness, steadfastness, floral consistency and manageable populations. Being polytropic in nature and more flower-constant, they effectively pollinate a large number of crops. About one-third of the human diet comes from insect-pollinated plants, and the honey bees account for 80 per cent of pollination (FAO, 1995). The economic value of honey bees as pollinators of crop was estimated at about \$14.6 billion in the USA and yield of fruits, seed, and nut crops would be significantly reduced without the pollination services that bees provide (Morse and Calderone, 2000).

Oilseeds play a very important role in human diet, they provide raw material for agro based industry and contribute towards nation's gross domestic product. Among various oilseed crops, sunflower (*Helianthus annuus* L. Compositae) is considered as an important oilseed crop both for domestic and commercial uses. Sunflower is a native of Mexico and Southern United States of America. It is the fourth important oil seed crop in the world (Venkattakumar *et al.*, 2007). India has the fourth largest area under sunflower (2.15 mha) in the world. Its share in total world production is about 45 per cent (1.22 mt) and accounts for 9 per cent of world acreage (Damodaran, 2007). In Karnataka, it is cultivated in an area of 12.6 lakh ha with a production 4.3 lakh t (Pujari *et al.*, 2007).

Sunflower is a very good source of edible oil. Its seeds contain about 35% good quality edible oil and its cake has 40-45 per cent protein. Besides its high yield potential, wide adaptability, drought tolerance, high water use efficiency, short duration, photo and thermal insensitivity make it ideal for cultivation in any season. It has low seed rate and high seed multiplication ratio (1:80). Sunflower is protandrous in which male and female parts mature at different times. There appears to be a time lag of 18-24 hrs in the maturity of male and female parts (Singh, 1999). Thus it is essentially a cross pollinated crop and requires pollinating agents for proper seed production.

Although the development of self-compatible sunflower hybrid has reduced the need for cross-pollination (Free, 1970; Furgula *et al.*, 1979), variation in the level of self-compatibility still persists. Fick (1979) reported that even hybrids with 80- 90% self-compatibility, benefit from cross-pollination.

The flowers produce abundant quantity of nectar and pollen which attract large number of honey bees. Though pollination is performed by other pollinators, honey bees accounts for a major share among them.

Unfavourable weather conditions, poor flower resources (nectar and pollen) and other competitive forage sources around the field may act as major factors in failure of bee pollination in the target crop. Attracting bees to the target crop overlooking the other competitive forage sources is a challenging task in bee management for cross pollination. Hence, bee attractants play a very crucial role in this context.

Bee attractant is any material which is used to entice the bee pollinators to the target crop ensuring optimum pollination and productivity. By using these attractants, pollination of the target crop can be achieved at critical time. It can save a crop threatened by poor weather conditions or having less resource in terms of nectar and pollen. In many cases the initial attractant will establish foraging patterns that continue the pollination process.

Bee attractants can be classified mainly into three categories: food, pheromone based, and plant origin. Food based attractant mainly comprises of glucose, maltose, sucrose, lactose, protein, fat, minerals, vitamins, gluconic acid etc. Some of the commercial products are Bee-Line, Bee Lure, Bee-Q etc. Pheromone based attractants are divided further into nasonov gland pheromone (e.g. Bee-here, Pollinus, Bee-Scent etc.) and queen mandibular pheromone (Fruit boost and Bee boost). Plant based pheromones though have given some encouraging results in laboratory studies, their evaluation under field condition is yet to be done. Studies made by Viraktamath and Patil (2002) have shown that Bee-Q and Fruit boost would enhance the yield parameters of sunflower. Field scale evaluation of Bee-Q and Fruit boost in sunflower has been made by Manjunatha (2003) with encouraging results. Potential benefits of the indigenous attractants in increasing yield in an eco-friendly way needs to be transferred to large Indian farming community.

Presently, all the commercial bee attractants viz. Bee-Q, Bee-scent, Bee-scent plus, Bee-here, Beeline, Fruit boost, Bee boost, Pollenaid, Bee lure, Pollinus, Api-fix are produced in the countries like France, USA and Canada. However, the Indian companies are involved in importing and marketing some of these, which makes the bee attractants, cost prohibited. Hence, there is a need to develop indigenous bee attractants so that use of attractants could become economically viable. Keeping the above in background the present investigations were carried out with the following objectives.

- ❖ To study the pollinator fauna and their relative abundance on Morden variety and KBSH-1 hybrid of sunflower
- ❖ To study the influence of bee attractants on bee visitation on Morden variety and KBSH-1 hybrid of sunflower
- ❖ To study the influences of bee attractants on yield parameters of Morden variety and KBSH-1 hybrid of sunflower

2. REVIEW OF LITERATURE

Review of literature pertaining to pollinator fauna and their relative abundance in sunflower, effect of bee attractants on bee visitation and yield parameters are presented in this chapter. Since studies on effect of bee attractants on sunflower are limited, the available literature on bee attractants on different crops is reviewed in this chapter.

2.1 Pollinator fauna of sunflower

Goyal and Atwal (1973) reported that during flowering period the sunflower crop attracted a large variety of insects such as moths, butterflies, bees, beetles, thrips, ants, house flies and other insect species. Among these the most successful and dominant insects were the honey bees. Sub-social bees like *Halictus* sp. and *Bombus* sp. also contributed as pollinators but their efficiency and abundance was very low. Role of all other insects as pollinators was also negligible.

Rangarajan *et al.* (1974) reported that two honey bee species viz. *Apis dorsata* F. and *A. florea* F. were the most dominant pollinators of sunflower and were most active during 0600 hr to 1000 hr compared to 1200 hr to 1430 hr.

The insect fauna of sunflower in Italy comprised many bees (*Apis*, *Bombus*, *Halictus* and *Ceratina* sp.), ants, other Hymenoptera and hemipterans from different families along with few thysanopterans and occasionally earwigs (Bagnoli, 1975).

The pollinator fauna of sunflower in Maharashtra included *A. cerana* F., *A. dorsata*, *A. florea*, *Melipona* sp., butterflies and moths. But under local conditions, *A. dorsata* ranked first as pollinator of sunflower followed by *A. cerana* (Deodikar *et al.*, 1976).

Panchabhavi and Devaiah (1977) reported that the important pollinator fauna of sunflower during winter and summer season in Bangalore included *A. cerana*, *A. florea*, *A. dorsata*, bumble bees and some dipterans.

Singh (1977) reported 72 species of insects belonging to 35 families and 9 orders visiting sunflower. He further observed that the *Pithitis smaragdula* (F) and *Xylocopa* spp. were the most effective pollinators. The insect pollinators were most numerous during spring rather than *kharif* and *rabi* season. The activity of the pollinators was more frequent in the forenoon (9-11 am) and in the late afternoon (4-5pm).

A. mellifera L. was the most important pollinator of sunflower in France while the other pollinator fauna included five species of *Bombus*, *Halictus* and *Andrena* (Delaude *et al.*, 1978).

The insect visitors of sunflower in Udaipur, India included 17 species of Hymenoptera. *A. dorsata* was the most dominant among all the pollinators. The pollinators' activity was higher at 1000 and 1200 hr compared to 1400 and 1600 hr of the day (Vaish *et al.*, 1978).

Panchabhavi and Jairao (1978) reported that *A. florea* and *P. argyrocephala* Macq. and *Eristalinus arvorum* F. as the chief visitors of sunflower. Among these three, *A. florea* and *P. argyrocephala* were more dominant than the *E. arvorum* when sunflower was grown as mixed crop with niger. The activity of these pollinators was high at 0900 to 0930 hr in both the plots, coinciding with the peak period of anthesis of sunflower.

ChannaBasavanna (1979) recorded *A. cerana*, *A. dorsata* and *A. florea*, a few species of flies, *Helicoverpa armigera* Hub. and *Spodoptera litura* F. on the heads of sunflower.

The insect visitors of sunflower included three species of honey bees viz. *A. cerana*, *A. dorsata* and *Melipona iridipennis* Sm. while other bees recorded were *Xylocopa fenestrata* (F) and *X. disjuncta* (Goel and Kumar, 1981).

Freund and Furgula (1982) reported honey bees representing 83 per cent, wild bees 11 per cent and syrphids six per cent of all the pollinators observed foraging for nectar and pollen on sunflower.

Satyanarayana and Seetharam (1982) observed that sunflower capitulum was visited by insects belonging to 21 genera of seven orders. Honey bees (*A. cerana*, *A. dorsata* and *A. florea*) constituted more than 85 per cent of the total insects.

Rahoo *et al.* (1985) sampled insect pollinators of sunflower by assessing pollen carriers as pollinators. All 525 insects identified were hymenopterans consists of *A. florea*, *X. refercens* Sm. and *X. fenestrata* and the activity of pollinators peaked around mid day.

Potential pollinators of sunflower identified at provinces of Granda were 57 species of Hymenoptera. Of these 31 species belonged to Apoidea. Though honey bees were very important and numerous, many syrphids and *Heliotaurus reficolis* L. and *Rangonycha fulva* F., among coleopterans were also abundant (Ortiz-Sanchez and Tinaut-Ranera, 1987).

Among the insects visiting sunflower crop in Sudan hymenopterans were the most important pollinators and honey bees formed 75 per cent of all the pollinators. Ahmed *et al.* (1988) also recorded 20 genera of insects belonging to Lepidoptera, Diptera, Hymenoptera, Coleoptera, Odonata and Orthoptera. *Bombus* sp., *Halictus* sp. *Nomia* sp. and *Megachile* sp. were the other visitors.

Butignol (1990) recorded 25 species of insects on sunflower, of which Hymenopteran species constituted 94.7 per cent of the sampled pollinators at Florianopolis, Brazil. *A. mellifera* was the most frequent visitors (93.9% of total visitors) preferring earlier flowering stages.

A. cerana was the most dominant pollinator with maximal foraging activity at 1100 hr and 1400 hr while *A. dorsata* and *A. florea* were present at lower density. *A. florea* spent highest time (44.1 sec) followed by *A. cerana* (34.5 sec) and *A. dorsata* (31.9 sec) (Panda *et al.*, 1988).

Dimitrov *et al.* (1992) reported that a total of four families and five genera of insects were involved in pollination of sunflower at Toschevo region of Bulgaria. *Apis* (62.39%), *Bombus* (20.18%) and *Halictus* (13.76%) were the most frequent visitors.

A mean number of 45, 147 and 64 insects per 100 capitula were recorded at Settlers, Pretoria and Hortbeesfontein region respectively. *A. mellifera* was the most frequent visitor in all the three sites. Other well represented taxa included Diptera, Hemiptera, *Astylus atromaculatus* and solitary bees were rare (Toit and Holm, 1992).

Zandigiaco *et al.* (1992) reported that *A. mellifera* was the most important pollinator of sunflower comprising 68 to 77% of total population. Other pollinators included five species of *Bombus* (27% and 5%), and other bees (5% and 18%), two species of *Halictus* and one each of *Andrena* and *Xylocopa* at Friuli region.

A. cerana (51.33 %), *A. dorsata* (24.0 %), *Bombus* sp. (21.9 %) and *Nomia curvipes* (2.6%) aided in pollination of sunflower in North East India and maximum seed yield per head was obtained in open pollinated than bagged heads (Singh *et al.*, 1993).

Among 20 species of insects visiting sunflower heads at Hisar, *A. mellifera* and *A. dorsata* were identified as chief pollinators. Some dipteran and lepidopteran insects also acted as major pollinating agents. The maximum activities of these insects were between 0800 to 1100 hr with slight increase at evening hours (Arya *et al.*, 1994).

Abrol (1996) reported that the pollinator fauna of sunflower includes a number of insects viz. *Bombus haemorrhoidalis* Sm, *A. cerana*, *Xylocopa* sp., *Halictus* sp., *Syrphus* sp., *Formica* sp., wasps, butterflies, moths, bugs and beetles. Among all these insects, bumble bees and honey bees were the chief pollinators constituting more than 60% of the total flower visitors. On an average foraging rate of *Bombus* was higher than *Apis* and *Xylocopa*.

In Panthnagar, *A. mellifera*, *A. dorsata*, *A. cerana* and *A. florea* were the major visitors of sunflower constituting 55.3, 32.3, 10.7 and 1.5 per cent respectively (Ajantha and Rathore, 1998).

At Hisar Mahavir Gupta (1999) recorded *Apis* species as a predominant pollinator of sunflower contributing 55 per cent of total foragers. Fifteen insect species were identified as pollinators of sunflower that included *A. dorsata*, *A. mellifera*, *A. cerana*, *X. fenestrata*, *X. pubescence* Spinola., *Musca domestica* (L), *Polistis* sp., *Vespa orientalis* L., *Megachile lanata*

L., *M. femorata* Sm., *M. cephalotes* Sm., *Andrena*, *Bombus*, *Nomia melandria* and *Papilio* spp.

Calmasur and Ozbek (1999) from Erzurum region of eastern Turkey reported that five families of bees as foragers of sunflower. Among all the bees *A. mellifera* contributed 80-88 per cent of total visitors while wild bees accounted for 12-20 per cent.

The pollinator fauna of sunflower included insects from six orders, 23 families, and 41 genera. *A. mellifera*, *A. dorsata*, *A. florea* constituted 42.2 per cent of total foragers (Singh *et al.*, 2000).

Sunflower bloom attracted *A. dorsata*, *A. mellifera*, *A. cerana*, *A. florea*, *Trigona* sp., *Halictus* sp., *Amegilla* sp., *Danaus chrysippus* (L.), *Catopsila pyranthae* and *Papilio demoleus* L. Among these, honey bees collectively formed 97.87 per cent of total pollinators. *A. dorsata*, *A. mellifera*, *A. florea* and *A. cerana* contributed 55.08, 23.67, 10.80 and 8.32 per cent respectively (Viraktamath *et al.*, 2001).

Manjunatha (2003) reported that pollinator fauna of sunflower at Dharwad, Karnataka constituted 13 species of hymenopterans, six species of lepidopterans and one species of dipterans. Hymenopterans were the predominant and frequent visitors of sunflower throughout the flowering period. *A. dorsata* was the dominant pollinator with 52.71 per cent followed by *A. mellifera* (31.25 %), *A. cerana* (10.42 %) and other pollinators (5.61%).

Kumar *et al.* (2005) reported *A. dorsata*, *A. cerana*, *A. mellifera*, *A. florea*, house fly and the other insect visitors as the main pollinators contributing 4.13, 10.04, 7.81, 13.75, 13.38 and 40.89 per cent of total pollinators respectively in winter and 12.86, 10.37, 14.52, 15.77, 8.30, and 38.17 per cent of total pollinators respectively in summer. The other insects recorded belonged to Hymenoptera, Lepidoptera, Hemiptera and Coleoptera groups.

2.2 Effect of bee attractants on pollinator visitation

Woodrow *et al.* (1965) screened and selected natural and synthetic materials as attractant of *A. mellifera*. Of the 195 formulations, four were rated as weak to moderately attractive and 19 moderate to very strongly repellent. Three of the attractive materials were alcohols and one was fatty acid having four carbon atoms.

Waller (1970) studied the attractiveness of geraniol, citral and anise oil to honey bees on lucerne (*Medicago sativa*). He reported that geraniol was more attractive than citral when applied in a solution containing five or ten per cent of sucrose, but less attractive than citral when applied in water.

“Benzene extract of pollen”, also referred as “attraction fraction” has been reported as a source of stimuli which attracted bees to almond pollen. Pollen supplement containing benzene extract attracted 90 per cent bees compared to untreated check. Fructose-glucose syrup to pollen was more attractive than pollen and water. Similarly benzene extract of pollen supplement was more attractive when mixed with fructose-glucose syrup than water alone (Doull, 1974).

Two compounds, 2-keto-tridecan-1yl acetate and 2-keto-tridecanol were identified in the extract of the *Evodia hupehensis* Dode. fruit that attracted honey bees. Gellert *et al.* (1985) reported that the crude extract of the dried fruit was attractive to honey bees when sprayed on lucerne plots.

Pinzauti (1985) while evaluating different substances that attract pronubial insects including honey bees, reported that among various solutions sprayed on the plots of safflower (*Carthamus tinctorious*), oil of lemon and orange were found to be attractive along with Bee-line.

Jay (1986) reported the modification of bee behaviour by the use of pheromones and pollen attractants that could offer the best method for maintaining honey bees on a specific crop.

Zvedenok (1996) reported that the secondary attractants such as citral, geraniol, limonene and carrot seed extract can be used to improve the pollination of onion crop in presence of the competitors like sunflower or buckwheat.

Effect of attractants and repellants of *A. mellifera* were investigated *in vitro* and on chopped cane sugar for bovine feeding. Tests were performed on plates located near to the hives and on bovine-hods. On plates, Bee-here was the most attractive (Malerbo-Souza and Nogueira-Couto, 1998).

Naik *et al.* (2003) reported that sugar syrup containing extract of dried fruits of *Fagara budrunga* Roxb. plants were more attractive to *A. cerana* than sugar syrup alone.

Malerbo-Souza *et al.* (2004) reported that Bee-here, eugenol, geranol, citral and lemon grass extract, diluted in water were effective in attracting bees to sweet orange orchards.

Naik *et al.* (2005) reported leaf extract formulation of the plant Chirayata, *Swertia densifolia* (Griseb.) in liquid paraffin were found attractive to *A. cerana* at higher concentrations (136-376 mg/ml). The same formulation at concentration above 125 mg/ml was attractant for *A. florea* (Naik *et al.*, 2007).

2.2.1 Fruit crops

Beeline- a commercial bee attractant when sprayed on red clover, did not increase the bee visitation, amount of pollination of individual clover heads or yield compared to the untreated plots (Burgett and Fisher, 1979).

'Delicious' and 'Golden delicious' apples (*Malus domestica* Borkch.) when sprayed with a high-conversion corn syrup consisting of 38-40% glucose, 28% maltose, 10% maltotriose and 22% higher sugars plus strawberry flavouring, red dye and a preservative (Bee lure), no difference was found between the number of foraging bees or the percentage of bees collecting pollen on sprayed versus unsprayed trees or in fruit set (Rajotte and Fell, 1982).

Two commercial bee attractants namely Bee scent and Bee scent plus attracted greater number of foraging bees (*A. mellifera*) when sprayed on blooms of pear, plum and apple trees (Mayer *et al.*, 1989).

Three different concentrations of honey bee (*A. mellifera*) queen mandibular pheromone were applied to 0.4 ha blocks of apple (*M. domestica*) and pear (*Pyrus communis* L.) by air blast sprayer. Concentration of 1000 queen equivalent (QEQ) ai/ha increased the number of honey bees foraging on both apple and pear under a wide range of environmental conditions, orchard management systems and geographical locations. Bee activity on plots sprayed with pheromone concentration of 0.1 or 10 QEQ ai/ha did not differ significantly from control. The pheromone was most effective one day after spray and declined to the level of control by the third day (Currie *et al.*, 1992a).

Honey bee (*A. mellifera*) queen mandibular pheromone was applied to blocks of cranberry (*Vaccinium macrocarpon* Ait.) blue berry (*V. corymbosum* L.) by helicopter and air blast sprayer, respectively. The number of bees attracted was both dose and crop dependent. Concentration of 100 QEQ ai/ha of pheromone was most effective in attracting honey bee foragers to cranberry. On blue-berry, concentrations of 100 or 1000 QEQ ai/ha. of pheromone were attractive to bees (Currie *et al.*, 1992b).

Queen mandibular pheromone when applied by helicopter on cranberry in Massachusetts (USA), foraging activity of *A. mellifera* increased significantly but bumble bees and native bees showed no change in their activity (Mackenzie and Averill, 1992).

Synthetic queen mandibular pheromone, Fruit boost, was applied to 'Anjou' pear, *P. communis*, and 'Bing'-type sweet cherry trees, *Prunus avium* L., in bloom using air blast sprayers. In pear, there were no significant increases in bee visits or fruit set in treated versus untreated plots. Two consecutive pheromone applications were not significantly different than the single application. In cherry, sprays of 100 or 500 QEQ / ha did not affect bee visits, fruit set or fruit size. Hence, Ken-Naumann *et al.* (1994) concluded that application of mandibular pheromone can enhance pollination in pear but not in sweet cherry.

Bee-line, when applied to flowering plots of raspberry at doses of one, three and five kg per ha, the number of bees visiting flowers and average time spent by bees on flower were higher in plants treated with Bee line than the untreated plots (Niera and Barriga, 1995).

Tsirakoglou *et al.* (1997) reported that spraying of Bee-here has no significant effect on bee visitation to kiwi fruit. Number of bees visiting kiwi fruits before spray and 4, 24, 72, 96 or 120 hr after spray was same as water treated control treatments. Feeding sugar syrup and weeding to remove wild plants did not seem to affect kiwi fruit pollen collection.

In vitro studies of attractants and repellants of *A. mellifera* revealed that Bee here was the most attractive and citronella oil was the most repellent chemicals tested (Malerbo-Souza and Nogueira-Couto, 1998).

Study conducted by Bhat and Sudarshan (1999) to evaluate the efficacy of bee attractant 'Bee-Q' in augmenting cardamom revealed that number of bee visits increased by 104.8 per cent in the attractant sprayed treatment.

Bee-scent was effective in attracting more honey bees to treated apple orchards during early flowering period but did not seem to increase the number of pollen-collecting foraging honey bees. Subsequent analysis of fruit quality and quantity was also positively influenced by Bee-scent applications (Tew and Ferree, 1999 a).

At recommended label rates by using air blast sprayers, three commercial attractants, Bee-Scent, Bee Here and Fruit Boost were applied to individual apple orchard quadrants when blooms were approximately 5% open. There was a highly significant difference in honey bee foraging between Fruit Boost and the control, also between Fruit Boost and other two treatments. Fruit Boost treated trees had highest fruit set percentage (11.38) and the greatest number of seeds per fruit (5.2) and had the lowest average fruit weight (185g). There was no significant difference in fruit set, fruit weight or seeds per fruit in either Bee Scent or Bee Here tests. (Tew and Ferree, 1999 b).

2.2.2 Vegetable crops

Ortiz-Sanchez (1993) from Almeria, Spain reported efficacy of Bee -here as honey bee attractants on marrow crop (*Cucurbita pepo* L.). Under green house condition honey bees did not exhibit preference among plants sprayed with Bee-here with recommended dose (3ml/l), half the dose, with water and untreated control plants indicating ineffectiveness of Bee-here as honey bee attractants.

Winston and Slessor (1993) reported improved bee visitation to cucumber sprayed with Bee scent and Bee line.

Ambrose *et al.* (1995) conducted a study on the effect of commercial bee attractants on bee visitation on cucumber and watermelon. In the experiment, the bee activity was monitored for five consecutive days from 0800 to 1500 hr. There was no difference in total or daily activity between treated and untreated plots.

Higo *et al.* (1995) reported that combination of increased requirement of foragers and greater time spent by the foragers, with increased flower visitation, contributed to the enhancement in pollination of blooming crops treated with queen mandibular pheromone.

Two applications of Bee-Q, Bee-here and sugar solution enticed more number of bees (4.01 to 4.97/5 flowers/min) up to 5th day after 1st and 2nd spray compared to unsprayed crop of *Cucumis sativa* L. (3.25 to 3.59 bees/5 flower/min) on staminate flowers. Similar higher visitation was recorded on pistillate flowers on the sprayed crop (Viraktamath and Anagoudar, 2002).

The foraging activity of bees was significantly higher (3.54 bees/m²/5min.) on the first day after the spray of sugar solution followed by second and third sprays (3.35 and 3.20 bees/m²/5min, respectively). Activity of bees on the fourth day after spray was the same as it was observed one day before spray (Narayanan and Gavigowda, 2005).

2.2.3 Field crops

Williams *et al.* (1981) reported that honey bees respond very positively to the source of nasonov odour due to presence of 'foot print pheromones'. So synthetic nasonov pheromone would prove highly efficient in attracting bees for crops needing pollination.

Henning *et al.* (1992) conducted an experiment on honey bee behavioral response to primary alfalfa floral volatiles. The result of the study revealed that specific alfalfa volatiles

affect honey bee foraging behaviour and are likely to be important for pollination. Among five antennally perceived alfalfa volatiles only linalool appeared attractive to honey bees.

Singh and Sinha (1996) reported the effect of Bee-Q spray on sunflower hybrid PSFH-17. They applied Bee-Q at different dosages of 2.5, 3.75, 5.00, 6.25, 7.5 kg/ha and calculated the number of bees/ 2min/ head. The study was conducted over two years 1995 & 1996. The result showed no significant difference between unsprayed plots and those plots sprayed at different concentration of bee attractant.

Srimathi *et al.* (1999) conducted experiment on effect of Bee-Q on honey bee visits and seed yield of hybrid sunflower KBSH-1. Bee-Q was applied at different concentrations but failed to attract additional honey bees compared to control plot.

Studies made by Viraktamath and Patil (1999), Patil (1999) and Patil *et al.* (2000) revealed that Bee-Q and Bee-hera when applied to sesame, increased bee visitation significantly up to fifth day.

Sanjivan Kumar *et al.* (2000) reported that sunflower crop sprayed with sugar syrup attracted maximum bees (20.74 bees/5flowers/min), followed by Bee-Q (18.10 bees/5 flowers/min).

Guruprasad (2001) reported that Fruit boost sprayed at 0.5 ml/l of water attracted significantly more number of *A. dorsata* upto seven days after first and second spray on niger. Bee-Q @ 12.5 g/l, cinnamon leaf extract at 5 % and tuberose flower scented water at 10 % were the next best treatments in attracting more number of pollinators.

Viraktamath and Patil (2002) reported that application of Fruit boost and Bee-Q resulted in more attraction of bees on sunflower. Similarly application of Bee-Q, sugar solution, cinnamon leaf extract and molasses enticed more pollinators on mustard flowers (Murasing and Viraktamath, 2002).

Manjunatha (2003) reported that spraying of Fruit boost and Bee-Q significantly enhanced visitation by *A. dorsata*, *A. mellifera*, *A. cerana* and other pollinators in sunflower. However, the effect of the attractants lasted for three to five days. *A. mellifera* foraged for longer time (0.43-0.51 min) in treated plot.

Nidagundi (2004) reported that spraying cacambe at 10 %, Bee-Q at 1.25 % and jaggery solution at 10% enhanced bee visitation in bitter gourd.

Fruit boost spray on Bt cotton (at 0.5 and 1.0 ml/l) attracted significantly more number of *A. dorsata*, *A. mellifera* and *A. florea* upto fifth day after spray during first and second spray and upto third day during third spray. Bee-Q spray was the second best in attracting significantly higher number of bees upto third day during first and second spray and upto one day during third spray. Tuberose floral scented water along with sugar solution was able to entice significantly higher number of bees only on first day after spray (Ganapathi, 2005).

2.3 Effect of bee attractants on yield parameter

2.3.1 Fruit and Vegetable crops

Burgett and Fisher (1979) reported that there was no significant increase in yield levels in clover after spraying of Bee line.

Rajotte and Fell (1982), conducted study on the effect of an attractant spray on honey bee behavior and fruit set within an orchard. But they reported that the attractant (Bee-lure) sprayed at the recommended rate had no visible effect on fruit set of apple.

According to the report of Mayer *et al.* (1989), Bee scent application increased fruit set by 23 to 27 per cent on cv. Barlett pear, 44 per cent on Anjou pear, 12 per cent on Van cherries and 5 to 22 per cent on Red delicious apple. Similarly, another nasonov pheromone product, Bee scent plus increased fruit set by 44 per cent on Bartlett pear, 15 per cent on Van cherries, 88 per cent on President plums and 6 per cent on Red delicious apple. Both the products when applied on blooming pear, plum and apple increased the fruit set in treated plots.

Similarly, application of Bee scent to strawberry cv. Selva increased fruit weight reduced the misshapen fruits as compared to the control treatment (Butts, 1991).

Elmstrom and Maynard (1991) conducted an experiment on efficacy of bee attractants on watermelon. Two applications of Bee-Scent, at 2.47 l/ha were made to watermelon in five farms in central and southwest Florida. Application of bee attractant increased bee activity, total yield in one field in central Florida (approximately 3000 fruits, per acre compared to 1500 fruits per acre without treatment). This resulted in an increase in early yield at all three locations. When the products were checked for their quality standard, they found that soluble solids content of mature fruit was not directly affected by treatment but the treatment increased the seed content of fruit in three of the five farms.

Contrarily, when Bee scent was sprayed over alternate 18 row strips of *Citrullus lanatus* there was no increase in yield (Looper and Rossette, 1991).

Three different concentrations of honey bee (*A. mellifera*) queen mandibular pheromone (QMP) were applied to 0.4 ha blocks of apple (*M. domestica*) and pear (*P. communis*) by air blast sprayer. The pheromone at the concentration of 1000 QEQ ai/ha did not improve any yield or quality parameters in apple. However, fruit diameter in pear was increased by the pheromone, resulting in an estimated average increase in return of \$1,055/ha (Currie *et al.* 1992a). When the same pheromone was applied to blocks of cranberry (*V. macrocarpon*) and blue berry (*V. corymbosum*); it increased yield and total revenues by up to \$8,804/ha on cranberry and \$986/ha on blueberry (Currie *et al.*, 1992b).

Application of Bee-here to watermelon cultivar Big crimson during spring at 2-3 l/ha during early pistillate bloom stage recorded early and significant higher yield and average fruit weight for the whole season (7.10 vs 3.8 t/ha and 10.60 vs 9.90 kg, respectively) (Maynard *et al.*, 1992).

Extensive study made by Winston and Slessor (1993) revealed that application of queen mandibular pheromone to pear, cherry, apple, cranberry and blueberry increased the profit to an extent of 60 per cent (US\$ 31000/ha) in pear, 41 per cent (US \$ 980/ha) in blueberry. While sunflower crop, when sprayed with Be-scent and Bee-Q produced better yield.

Application of Fruit boost @ 1000 QEQ (ai/ha) to 'Anjou' pear, resulted in seven per cent increase in fruit size and a \$400 per ha net increase in income. However, in cherry, sprays of 100 or 500 QEQ per ha did not affect bee visits, fruit set or fruit size (Ken-Naumann *et al.* 1994).

Bhat and Sudarshan (1999) recorded an increase in fruit set by 13 per cent and number of seeds per fruit by 2.7 per cent; while recovery per cent was comparatively more in Bee-Q sprayed plot (21.5%) than that of untreated control plot (20.80%) of cardamom.

Watermelon crop sprayed with Bee-Q at two concentrations (12.50 and 15.00 g/l produced higher yield (19.56 and 19.45 t/ha, respectively). The treated plots also produced maximum good fruits, minimum malformed fruits, bigger size and heavier fruits of watermelon (Sattigi *et al.*, 2001a).

Schulthesis *et al.* (1994) recorded increased yield as well as bee visitation in cucumber when sprayed with Bee scent and Bee line. But Ambrose *et al.* (1995) reported that there was no increase in the value of subsequent harvest in cucumber and watermelon in spite of Bee line application.

Lingappa *et al.* (1999) recorded an increase of 21.80 and 31.80 per cent in fruit formation and total yield, respectively when Bee-Q was sprayed twice on watermelon.

2.3.2 Field crops

Mohana Rao and Suryanarayana (1990) reported that *A. dorsata* and *A. cerana* were the efficient pollinators of niger with more filled seeds/head and seed yield in 'open pollination' and 'cerana bee pollination' treatments.

Bhosle *et al.* (1992) reported that sunflower cv. Morden when sprayed with 2.5 per cent sucrose solution, resulted in greater seed yield than control.

Visits by *A. cerana* resulted increase in yield (40.3%), weight of seed per plot (40.81%), weight of seed per head (8.41%), number of seeds/head (12.9%) and oil content (9.09%) (Kulkarni and Dhanorkar, 1998).

Choudhary and Kumar (1998) reported that the number of seeds/plant and seed weight increased significantly due to bee pollination (4180.3% and 1500 %, respectively) over no pollination.

Lingappa *et al.* (1999) recorded an enhanced seed yield by spraying Bee Q (12.5 g/l) twice in safflower upto 54.84 per cent over control.

In sesame two applications of Bee-Q and Bee here increased the number of pods per plant, number of seeds per pod, seed weight, yield and oil content (Viraktamath and Patil, 1999). Similar result has been obtained in sesame by Patil (1999) and Patil *et al.* (2000).

Sunflower sprayed with trionic acid gave maximum seed set (82.31seed/head), 1000 seed weight (76.78 g), yield (24.6 q/ha) and oil content (39.87%) (Sanjivan Kumar *et al.*, 2000). Sattigi (2001b) reported that Bee-Q application (12.5g/l) on niger increased the number of seeds per head (24.41 to 29.26) and also oil content (38.1%) as compared to control.

Higher dosage of Bee-Q (10.00, 12.50 and 15.00 g/l) spray significantly enhanced both qualitative and quantitative parameters in mustard crop (Murasing and Viraktamath, 2002). Similarly, Guruprasad (2001) reported that spraying of Fruit boost @ 0.5 ml /l and tuberoso floral scented water @ 10 per cent significantly enhanced yield parameters of niger.

Kalmath and Sattigi (2002) reported that application of cacambe @ 10 per cent gave significantly higher number of seeds per umbel (968.96), yield (1.46 kg/plot) and germination per cent in onion.

Sunflower sprayed with Fruit boost and Bee-Q recorded higher yield of 290.0 and 283.33 g per 10 head respectively as against 236.67 g in unsprayed control crop (Viraktamath and Patil, 2002)

Mane (2003) reported that open pollination with cacambe (10%) spray resulted in higher number of seeds/plant (191.00), 1000 seed weight (14.19 g) and highest seed yield (8.62 q/ha) in coriander as against control.

Highest yield of 18.38 q/ha, higher filled seed rows (26.02) and filled seed weight (42.61 g) was obtained from the crop sprayed with Fruit boost twice (Manjunatha, 2003).

Malerbo-Souza *et al.* (2004) reported that fruit production was 35.30 per cent greater in uncovered flowers sprayed with Bee-here with more mean fruit weight (180.2 g) than in covered flowers (168.5 g). Similarly, number of seeds per bud was higher in uncovered orange flowers sprayed with Bee-here (one seed/bud) than in covered flowers (0.8 seed/bud).

Nidagundi (2004) reported significantly more number of fruits (14.00) in the treatment with cacambe as compared to open pollinated (8.40) and caged crop without bees (5.33). Significantly highest length of fruits, seed to pulp ratio, fruit weight and yield were obtained in crop sprayed with bee attractants compared to crop caged without bees in bitter gourd.

Spray of Fruit boost recorded higher good opened bolls (26.05 /plant), number of seeds per boll (28.20), highest seed yield (9.61q/ha), lint yield (5.76q/ha), and kapas yield (15.36 q/ha) accounting for an increase of 90.8, 8.04, 10.45, 12.28 and 11.30 per cent over open pollination in MECH-184 Bt cotton, while tube rose floral scented water spray failed to produce significantly higher yield than open pollinated crop (Ganapathi, 2005).

3. MATERIAL AND METHODS

The present investigations were carried out at the Main Agricultural Research Station of the University of Agricultural Sciences (UAS), Dharwad. Dharwad is situated at 15°26' North latitude, 75°07' East longitude and at an altitude of 678 meters above mean sea level. The place is lying in the Northern Transitional Zone (Zone-VIII) of Karnataka, which receives an average annual rain fall of 700 to 800 mm. The temperature and relative humidity ranges from 12 to 37⁰ C and 40 to 85 per cent, respectively.

The materials used and techniques adopted to study the pollinator fauna, effect of bee attractants on bee visitation and yield parameters in Morden variety and KBSH-1 hybrid of sunflower, are presented in this chapter.

3.1 Studies on pollinator fauna and their relative abundance on Morden variety and KBSH-1 hybrid of sunflower during *kharif* and *rabi* season of 2007

This study was conducted on the unsprayed general crop of Morden variety of sunflower during *kharif* season while on KBSH-1 hybrid during *rabi* season of 2007. All types of pollinators other than honey bees were collected by using a hand net on alternate days from 1000 to 1100 hr and 1500 to 1600 hr throughout the flowering period of the crop. Honey bee species visiting flowers were identified in the field itself. Representative of other pollinators were collected, pinned, labeled and identified. Relative abundance of dominant species of pollinator was worked out by using the following formula after pooling all the data and expressed in percentage.

$$\text{Relative abundance of species A} = \frac{\text{Number of species, A visiting flower}}{\text{Total number of pollinators visited}} \times 100$$

3.2 Study on the influence of bee attractants on bee visitation of Morden variety and KBSH-1 hybrid of sunflower

This experiment was carried out in Morden variety of sunflower during *kharif* season and KBSH-1 hybrid during *rabi* season of 2007.

Two pheromone based attractants namely, citral E and citral Z; two plant based attractants *viz.*, *Fagara budrunga* and *Swertia densifolia* along with Fruit boost, a commercial bee attractant were selected for the present study. citral E contained *A. cerana* pheromone lure while citral Z pheromone of *A. florea*.

Samples of bee attractants *viz.* citral E, citral Z, *F. budrunga* and *S. densifolia* were obtained from Agharkar Research Institute, Pune, Maharashtra. Fruit boost was obtained from Phero-Tech Inc, Canada.

The experiment was laid out in a randomized complete block design (RCBD) in the plots of 10m x 10m with a buffer zone of 5m X 10 m between treatments and replications. Sunflower (both the Morden variety and KBSH-1 hybrid) crop was raised by following the recommended package of practices. There were seven treatments each replicated thrice. First spray was given at 10 per cent flowering of the crop while the second was applied at 50 per cent flowering. The details of treatments, which were common to both experiments as follows:

- T₁ = Spray of citral E
- T₂ = Spray of citral Z
- T₃ = Spray of *Fagara budrunga* lure
- T₄ = Spray of *Swertia densifolia* lure
- T₅ = Spray of Fruit boost lure
- T₆ = Spray of Sugar solution
- T₇ = Control (No spray)

Concentration of citral E, citral Z, *F. budrungea* and *S. densifolia* lure was 0.05 per cent in case of Morden variety during *kharif* season while it was 1.00 per cent in case of KBSH-1 hybrid sunflower during *rabi* season. Fruit boost was applied as per recommended rate of 0.05 per cent while sugar solution at 10.00 percent on both the crops. Sticker 'Samridhi' was added (0.4 ml/l of spray solution) for all types of spraying.

Each lure was added with equal quantity of emulsifier Sandovit and water, and mixed thoroughly with the help of porcelain mortar and pestle separately and then diluted to the required concentration by adding water.

Observations for visitation of different pollinators were made a day before the spray of bee attractants and one, two, three and five days after each spray. From each treatment, five flower heads were selected randomly and number of different pollinators visiting these flowers per minute was recorded at 0800 hr, 1000 hr and 1700 hr that coincided with their peak foraging activity. Means of these observations were calculated and later each mean was subjected to $\sqrt{X+1}$ transformation. The data were then subjected to ANOVA using MS Excel programme and means were separated by DMRT.

3.2.1 Average time spent by honey bees on sunflower

The time spent by one bee on an individual flower head was recorded on one day after the application of each spray. Such observations were made for three bees in each treatment during their peak active periods (1000-1100 hr) on both the crop. Following suitable transformation, the data were subjected to ANOVA and the means were ranked by DMRT.

3.3 Influence of bee attractants on yield parameters of Morden variety and KBSH-1 hybrid of sunflower

3.3.1 Head weight per plant

Twenty five heads from each treatment from Morden variety as well as from KBSH-1 hybrid were randomly harvested and sun dried separately. Weights of these dried heads were recorded with the help of digital electronic balance.

3.3.2 Number of seeds per head

From the above twenty five heads, number of seeds per head was counted separately and the mean was worked out and presented as number of seeds per head for each treatment.

3.3.3 Per cent chaffiness

Each of the 25 heads was thrashed separately and number of filled and unfilled seeds was counted by pressing them against thumb. Per cent chaffiness was then calculated by using following formula.

$$\text{Per cent chaffiness} = \frac{\text{Number of unfilled seeds / head}}{\text{Total number of seeds / head}} \times 100$$

3.3.4 100- Seed weight

Hundred filled seeds were selected randomly from each treatment and weight was recorded using electronic balance.

3.3.5 Seed yield

Each crop was harvested separately treatment wise and the total seed yield per plot was recorded. Based on this, seed yield per hectare was calculated.

3.3.6 Per cent germination

This observation was made only in seeds of Morden variety of sunflower. Germination test was carried out as per ISTA procedure (Anonymous, 1996) using paper

method. The rolled paper towels were placed at slanting position in a cabinet seed germinator maintained at a constant temperature of 25 ± 1 °C and 95 ± 1 per cent relative humidity. The number of seeds germinated was counted at the end of third day (72 hr) and expressed in percentage.

3.3.7 Shoot length

After germination test, 10 seedlings were selected randomly from each treatment and replication and then shoot length was measured from the base of primary leaf to base of hypocotyls on the seventh day. The mean shoot length was expressed in centimeter.

3.3.8 Root length

The same 10 seedlings selected for measuring shoot length were also used for measuring root length. It was measured from the tip of primary root to base of hypocotyls and mean root length was expressed in centimeters.

3.3.9 Vigour index

Seedling vigour index was computed by adopting the following formula suggested by Abdul-Baki and Anderson (1973) and expressed as number.

$$\text{Vigour Index} = \text{Germination \%} \times [\text{Root length (cm)} + \text{Shoot length (cm)}]$$

4. EXPERIMENTAL RESULTS

The results of the investigations on the pollinator fauna and their relative abundance, effect of bee attractants on bee visitation and yield parameters in Morden variety and KBSH-1 hybrid of sunflower are presented in this chapter.

4.1 Study of pollinator fauna and their relative abundance on Morden variety and KBSH-1 hybrid of sunflower at Dharwad

4.1.1 Pollinator fauna and their relative abundance on Morden variety of sunflower during *kharif* 2007

A total of eight species of pollinators were recorded on Morden variety of sunflower during *kharif* 2007 at Dharwad (Table 1). Of these, five species belonged to Hymenoptera and three species to Lepidoptera. *Apis dorsata* was the most dominant pollinator constituting 97.33 per cent of the total pollinators. Remaining pollinators altogether constituted 2.67 per cent.

4.1.2. Pollinator fauna and their relative abundance on KBSH-1 hybrid of sunflower during *rabi* 2007

Pollinator fauna and their relative abundance of KBSH-1 hybrid of sunflower during the *rabi* 2007 at Dharwad are presented in table 2.

The pollinator fauna included three species of honey bees namely *A. dorsata*, *A. cerana* and *A. florea*. Among these pollinators, *A. dorsata* was the most dominant constituting 96.14 per cent, while *A. florea* and *A. cerana* formed 3.35 and 0.51 per cent of the total pollinators respectively.

4.2 Study on the influence of bee attractants on bee visitation to sunflower

4.2.1 Influence of bee attractants on *A. dorsata* visitation on Morden variety of sunflower during *kharif* 2007.

First spray

A day before the spray of bee attractants, *A. dorsata* visitation varied from 5.50 to 9.83 bees per five flowers per minute (Table 3).

A day after spraying of bee attractants significantly higher number of bees was found on the crop sprayed with citral Z (13.00 bees/5 flowers/min), citral E (12.50 bees/5 flowers/min) and *F. budrunga* lure (11.00 bees/5 flowers/min). The bee visitation varied from 7.50 to 9.33 bees/5flowers/min on the crop treated with *S. densifolia* lure, Fruit boost and sugar solution which were however at par with each other and also with the control (10.00 bees/5 flowers/min).

On the second day after spray, the crop that received Fruit boost, citral E and *S. densifolia* were found significantly more attractive to the bees enticing 10.50, 10.00 and 9.00 bees/5 flowers/min, respectively. Crop sprayed with *F. budrunga* lure attracted next higher number of bees (8.00 bees/5flowers/min). Significantly lowest numbers of bees (3.50 bees/5 flowers/min) were attracted to the unsprayed crop (control).

On the third day after treatment, significantly higher number of bees was found on crops treated with citral Z (9.50 bees/5 flowers/min), Fruit boost (8.00 bees/5 flowers/min), *S. densifolia* (7.50 bees/5 flowers/min) and sugar solution (7.50 bees/5 flowers/min) which were at par with each other. *F. budrunga* was the next best treatment (6.50 bees/5 flowers/min) followed by citral E (5.33 bees/5 flowers/min). The untreated crop recorded least number of bees (3.50 bees/5 flowers/min).

Table 1. Pollinator fauna of sunflower (Morden) and their relative abundance during kharif season of 2007 at Dharwad

Sl. No	Pollinator	Systematic position	Relative abundance (% pollinators)
1.	<i>Apis dorsata</i> F.	Hymenoptera: Apidae	97.33
2.	<i>Pithitis</i> sp.	Hymenoptera: Anthophoridae	} → 2.67
3.	<i>Xylocopa fenestrata</i> (F.)	Hymenoptera: Anthophoridae	
4.	<i>Megachile lanata</i> F.	Hymenoptera: Megachilidae	
5.	<i>Megachile</i> sp.	Lepidoptera: Danaidae	
6.	<i>Danaus chrysippus</i> (L.)	Lepidoptera: Pieridae	
7.	<i>Pieris</i> sp.	Lepidoptera: Papilionidae	
8.	<i>Papilio demoleus</i> L.		

Table 2. Pollinator fauna of sunflower (KBSH-1) and their relative abundance during rabi season of 2007 at Dharwad

Sl. No	Pollinator	Systematic position	Relative abundance (% pollinators)
1.	<i>Apis dorsata</i> F.	Hymenoptera: Apidae	96.14
2.	<i>A. florea</i> F.	Hymenoptera: Apidae	3.35
3.	<i>A. cerana</i> F.	Hymenoptera: Apidae	0.51



Apis dorsata
on Morden

Apis dorsata
on Morden



Apis dorsata
on KBSH-1

Apis florea
on KBSH-1



Plate 1. Pollinator fauna of sunflower

Plate 1. Pollinator fauna of sunflower

Significantly higher numbers of bees was recorded from the crop receiving citral E (8.50 bees/5flowers/min) on the fifth day after spray. The next higher number of bees was recorded from the crop sprayed with citral Z (7.00 bees/5 flowers/min), *F. budrunga* (7.00 bees/5 flowers/min) and sugar solution (6.67 bees/5 flowers/min), which was however at par the unsprayed crop (6.00 bees/5 flowers/min).

The crop treated with Fruit boost and *S. densifolia* did not attract higher number of bees as significantly lowest number of bees was recorded on these crops (4.33 and 5.00 bees/5 flowers/min, respectively).

Second spray

One day before the second spray no bee visitation was observed in any treatments including the control.

But one day after the second spray, significantly higher number of bees was recorded from the crop receiving citral Z (8.33 bees/5 flowers/min) which was at par with the crop receiving *F. budrunga* (8.00 bees/5 flowers/min) and citral E (7.00 bees/5 flowers/min). However, significantly lower numbers of bees were recorded in the treatments with other bee attractants (2.33 to 5.00 bees/5 flowers/min) compared to the control (6.00 bees/5 flowers/min).

On the second day after treatment, significantly higher number of bees was found on the crop treated with citral Z (10.00 bees/5 flowers/min) and *S. densifolia* (9.00 bees/5 flowers/min). Treatments receiving citral E, sugar solution and Fruit boost attracted next higher number of bees (7.00, 7.00 and 6.00 bees/5 flowers/min, respectively) followed by the treatments that received *F. budrunga* (5.00 bees/5 flowers/min) and control (5.00 bees/5 flowers/min).

Fruit boost and *S. densifolia* treated plots attracted maximum number of bees (8.33 and 8.30 bees/5 flowers/min respectively) on the third day after spraying of attractants which were at par with citral E and citral Z (6.67 and 6.50 bees/5 flowers/min respectively) and followed by *F. budrunga* (4.67 bees/5 flowers/min) and sugar solution (4.50 bees/5 flowers/min). The untreated crop recorded least number of bees (2.50 bees/5 flowers/min).

On the fifth day after spray, none of the attractants were effective in attracting more bees, as the bee visitation which varied from 4.67 to 6.33 bees/5 flowers/min did not differ significantly compared to the unsprayed crop (5.00 bees/5 flowers/min).

4.2.2 Influence of bee attractants on bee visitation on KBSH-1 cultivar of sunflower during *rabi* season of 2007 at Dharwad

First spray

One day before the spray of bee attractants, *A. dorsata* visitation varied from 0.37 to 0.83 bees/5 flowers/min on KBSH-1 cultivar among the various treatments which however did not differ statistically (Table 4).

A day after application of bee attractants the bee activity was significantly more on crop sprayed with Fruit boost (2.96 bees/5 flowers/min), *S. densifolia* (2.76 bees/5 flowers/min) and citral Z (2.61 bees/5 flowers/min) as against 1.05 bees/5 flowers/min on the unsprayed (control) crop which was significantly low. Treatments that received citral E, sugar solution and *F. budrunga* were the next superior treatments attracting 1.95, 1.75 and 1.54 bees/5 flowers/min, respectively.

Two days after the application of attractants, Fruit boost and *S. densifolia* retained their superiority in attracting significantly more bees (12.25 and 10.00 bees) followed by citral Z (8.16 bees/5 flowers/min) as compared to the control (4.63 bees/5 flowers/min). The bee visitation varied from 5.33 to 7.38 bees/5 flowers/min in other treatments.

On the third day, Fruit boost continued to attract significantly more bees (11.13 bees/5 flowers/min) followed by *S. densifolia* (9.76 bees/5 flowers/min). Treatments with citral Z, citral E and *F. budrunga* attracted next higher number of bees (7.85, 7.15 and 7.03 bees/5 flowers/min) followed by sugar solution and control (5.75 and 4.50 bees/5 flowers/min).

Table 3. Influence of bee attractants on *Apis dorsata* visitation on sunflower (Morden)

Treatments	No. of bees / 5 flowers / min									
	1DBFS	1DAFS	2DAFS	3DAFS	5DAFS	1DBSS	1DASS	2DASS	3DASS	5DASS
Citral E @ 0.05 %	9.83 (3.28) a	12.50 (3.67) a	10.00 (3.31) ab	5.33 (2.51) c	8.50 (3.08) a	0.00	7.00 (2.82) ab	7.00 (2.82) b	6.67 (2.76) ab	6.33 (2.70)
Citral Z @ 0.05 %	6.33 (2.70) cd	13.00 (3.73) a	5.83 (2.61) d	9.50 (3.24) a	7.00 (2.82) b	0.00	8.33 (3.05) a	10.00 (3.32) a	6.50 (2.74) ab	5.00 (2.44)
<i>Fagara budrunga</i> @ 0.05 %	7.50 (2.91) bc	11.00 (3.46) ab	8.00 (3.00) bc	6.50 (2.73) bc	7.00 (2.83) b	0.00	8.00 (3.00) ab	5.00 (2.44) c	4.67 (2.38) bc	5.67 (2.58)
<i>Swertia densifolia</i> @ 0.05%	5.50 (2.55) d	9.33 (3.21) bc	9.00 (3.16) ab	7.50 (2.91) ab	5.00 (2.45) cd	0.00	2.33 (1.82) e	9.00 (3.16) a	8.00 (2.99) a	6.00 (2.64)
Fruit Boost @ 0.05 %	6.50 (2.74) cd	7.50 (2.91) c	10.50 (3.39) a	8.00 (2.99) ab	4.33 (2.31) d	0.00	4.00 (2.24) d	6.00 (2.64) bc	8.33 (3.05) a	5.67 (2.58)
Sugar solution @ 10 %	5.50 (2.55) d	8.50 (3.08) bc	6.50 (2.74) cd	7.50 (2.91) ab	6.67 (2.76) b	0.00	5.00 (2.45) cd	7.00 (2.83) b	4.50 (2.34) c	4.67 (2.38)
Control	9.00 (3.16) ab	10.00 (3.31)bc	3.50 (2.12) e	3.50 (2.12) d	6.00 (2.64) bc	0.00	6.00 (2.63) bc	5.00 (2.45) c	2.50 (1.87) d	5.00 (2.44)
S.Em.±	0.09	0.13	0.11	0.12	0.08	-	0.11	0.08	0.12	0.11
CD	0.29	0.40	0.35	0.36	0.24	-	0.34	0.25	0.38	NS

Figures in the parenthesis are $\sqrt{(X+1)}$ transformed values.

* 1DBSS no bee visitation was observed in any of the treatment due to continuous rain.

Means followed by same letter in a column do not differ significantly by DMRT (P = 0.05)

DBFS = Days before first spray

DAFS = Days after first spray

DBSS = Days before second spray

DASS = Days after second spray

Table 4. Influence of bee attractants on *Apis dorsata* visitation on sunflower (KBSH-1)

Treatments	No. of bees / 5 flowers / min.									
	1DBFS	1DAFS	2DAFS	3DAFS	5DAFS	1DBSS	1DASS	2DASS	3DASS	5DASS
Citral E @ 1.00 %	0.74 (1.32)	1.95 (1.72) b	7.38 (2.89) cd	7.15 (2.85) c	7.12 (2.85) b	6.78 (2.79)	8.58 (3.09) bc	5.33 (2.51) ab	3.59 (2.14)	1.30 (1.48)
Citral Z @ 1.00 %	0.37 (1.17)	2.61 (1.90) a	8.16 (3.03) bc	7.85 (2.97) c	7.50 (2.92) b	7.10 (2.84)	9.71 (3.27) ab	5.52 (2.55) ab	4.05 (2.25)	1.50 (1.56)
<i>Fagara budrunga</i> @ 1.00 %	0.69 (1.29)	1.54 (1.59) bc	7.25 (2.87) cd	7.03 (2.83) c	6.99 (2.83) b	6.64 (2.76)	8.59 (3.10) bc	5.41 (2.53) a	5.27 (2.50)	1.51 (1.53)
<i>Swertia densifolia</i> @ 1.00%	0.61 (1.26)	2.76 (1.94) a	10.00 (3.32) ab	9.76 (3.28) b	8.33 (3.05) ab	6.69 (2.77)	9.66 (3.26) ab	6.01 (2.64) a	5.30 (2.50)	1.88 (1.70)
Fruit Boost @ 0.05 %	0.67 (1.29)	2.96 (1.99) a	12.25 (3.64) a	11.13 (3.48) a	9.72 (3.27) a	7.18 (2.86)	10.14 (3.34) a	6.63 (2.76) a	6.16 (2.67)	2.05 (1.73)
Sugar solution @ 10 %	0.57 (1.25)	1.75 (1.65) b	5.33 (2.52) de	5.75 (2.60) d	5.27 (2.50) c	6.98 (2.82)	8.23 (3.04) c	5.53 (2.55) ab	4.96 (2.44)	1.20 (1.46)
Control	0.83 (1.34)	1.05 (1.43) c	4.63 (2.37) e	4.50 (2.34) e	4.42 (2.33) c	6.28 (2.70)	6.42 (2.72) d	4.37 (2.31) b	4.18 (2.27)	1.79 (1.62)
S.Em.±	0.08	0.05	0.12	0.04	0.08	0.05	0.06	0.10	0.03	0.22
CD	NS	0.17	0.38	0.14	0.26	NS	0.19	0.31	NS	NS

Means followed by the same letter in a column do not differ significantly by DMRT (P = 0.05)

Figures in the parenthesis are $\sqrt{(X+1)}$ transformed values.

DBFS = Days before first spray

DAFS = Days after first spray

DBSS = Days before second spray

DASS = Days after second spray

On the fifth day also, Fruit boost and *S. densifolia* spray were highly efficient in attracting more bees with 9.72 and 8.33 bees/5 flowers/min followed by citral Z, citral E and *F. budrunga* (6.99 to 7.50 bees/5 flowers/min). Application of sugar solution was as good as the unsprayed crop (4.42 to 5.27 bees/5 flowers/min).

Second spray

All the treatments were at par with each other in attracting bees a day before the second spray. The bee visitation varied from 6.28 to 7.18 bees/5 flowers/min.

One day after spray, treatments with Fruit boost (10.14 bees/5 flowers/min), citral Z (9.71 bees/5 flowers/min) and *S. densifolia* (9.66 bees/5 flowers/min) proved to be significantly more but equally effective in enticing bees. Next best treatments were *F. budrunga*, citral E. and sugar solution (8.23 to 8.59 bees/5 flowers/min). Significantly least number of bees was attracted to untreated crop (6.42 bees/5 flowers/min).

On the second day, though significantly higher numbers of bees were attracted to Fruit boost sprayed plot (6.33 bees/5 flowers/min) than control (4.37 bees/5 flowers/min), it was at par with all other treatments.

A. dorsata did not show any preference to either treated or untreated crop after third (3.59 to 6.16 bees) and fifth day (1.30 to 2.50 bees) as all the treatments were at par with each other.

4.2.3 Influence of bee attractants on time spent by *A. dorsata* on Morden variety of sunflower during *kharif* 2007

Data on time spent by *A. dorsata* bees in gathering pollen or nectar are presented in table 5. The bees preferred to spend as much as 92.51 sec/3 bees on the crop sprayed with citral E which was significantly higher than all the remaining treatments. This accounted 97.75 per cent more time than the unsprayed crop. The next preferred treatment was the crop treated with sugar solution (68.41 sec / 3 bees) which was at par with *F. budrunga* (56.67 sec / 3 bees). This accounted for 46.24 and 21.14% increase over unsprayed crop. However, the bees remained for shorter time on the crop sprayed with other attractants (26.66 to 43.33 sec / 3 bees) compared with the unsprayed crop (46.78 sec / 3 bees).

4.2.4 Influence of bee attractants on time spent by *A. dorsata* on KBSH-1 hybrid of sunflower during *rabi* 2007

Observations on average time spent by bees on KBSH-1 cultivar of sunflower during *rabi* season of 2007 at Dharwad are presented in table 6.

A. dorsata stayed significantly for longer duration on the crop receiving Fruit boost (95.00 sec / 3 bees), *F. budrunga* (94.67 sec / 3 bees), *S. densifolia* (89.00 sec / 3 bees) and citral Z (85.67 sec / 3 bees) which were however at par with each other. This accounted for 28.19 to 42.15 per cent more time than the control crop on which the bees spent significantly least time (66.83 sec / 3 bees). The bees spent 72.00 to 79.67 sec/ 3 bees flowers in other treatments.

4.3 Influence of bee attractants on yield parameters of sunflower

4.3.1.1 Study on the influence of bee attractants on quantitative yield parameters of Morden cultivar of sunflower during *kharif* 2007

Observations on the effect of attractants on quantitative parameters, viz., head weight, 100 seed weight, per cent chaffiness, number of seeds per head and yield are presented in the table 7.

4.3.1.1.1 Head weight

Significantly heavier heads were recorded from the crop sprayed with *F. budrunga* (55.38 g) and *S. densifolia* (54.51 g) accounting 15.45 and 13.43 per cent increase in head weight over control (47.97 g). Fruit boost treated crop produced next heavier heads (49.37 g) which accounted for 2.92 per cent increase over the control. Treatments with citral E and citral Z failed to produce heavier heads than the control.



Plate 2. Field view of Morden variety of sunflower during *kharif* 2007



Before flowering



After flowering

Plate 3. Field view of KBSH-1 hybrid sunflower during *rabi* 2007

Plate 3. Field view of KBSH-1 hybrid sunflower during *rabi* 2007

Table 5. Influence of bee attractants on time spent by *Apis dorsata* on sunflower (Morden)

Treatments	Time spent (sec)/ 3 bees	% increase / decrease over control
Citral E @ 0.05 %	92.51 (9.68) a	97.75
Citral Z @ 0.05 %	43.33 (6.62) cd	- 7.37
<i>Fagara budrunga</i> @ 0.05 %	56.67 (7.56) bc	21.14
<i>Swertia densifolia</i> @ 0.05%	26.66 (5.23) d	- 43.01
Fruit Boost @ 0.05 %	42.50 (6.56) cd	- 9.15
Sugar solution @ 10 %	68.41 (8.33) b	46.24
Control	46.78 (6.91) c	
S.Em.±		0.44
CD		1.34

Means followed by the same letter in a column do not differ significantly by DMRT (P = 0.05)
 Figures in the parenthesis are $\sqrt{(X+1)}$ transformed values.

Table 6. Influence of bee attractants on time spent by *Apis dorsata* on sunflower (KBSH-1)

Treatments	Time spent (sec) /3 bees	% increase over control
Citral E @ 1.00 %	79.67 (8.98) bc	19.21
Citral Z @ 1.00 %	85.67 (9.31) ab	28.19
<i>Fagara budrunga</i> @ 1.00 %	94.67 (9.78) a	41.66
<i>Swertia densifolia</i> @ 1.00%	89.00 (9.49) a	33.17
Fruit Boost @ 0.05 %	95.00 (9.80) a	42.15
Sugar solution @ 10 %	72.00 (8.54) cd	7.74
Control	66.83 (8.23) d	
S.Em.±	0.16	
CD	0.48	

Means followed by the same letter in a column do not differ significantly by DMRT (P = 0.05)
 Figures in the parenthesis are $\sqrt{(X+1)}$ transformed values.

4.3.1.1.2 Per cent chaffiness

Lowest percentage of chaffiness was found in sugar solution treated crop (4.33 %) which was however at par with the crop treated with *F. budrunga* (5.00 %). This accounted for 48.02 and 39.98 per cent reduction in chaffiness over control. However, all other treatments did not differ statistically from each other as well as control, with chaffiness varying from 8.00 to 10.00 per cent chaffiness.

4.3.1.1.3 100-seed weight

The hundred seed weight varied from 4.21 (citral Z) to 5.02 g (Fruit boost) among the various treatments. However, this variation was not significant.

4.3.1.1.4 Number of seeds per head

Application of *F. budrunga*, *S. densifolia*, citral Z spray resulted in significantly higher number of seeds per head (429.33, 426.17 and 399.90 seeds/head, respectively) which was however at par with the application of sugar solution (468.83 seeds/head). This accounted for an increase of 45.37 to 70.42 per cent more seeds over control. Treatment with citral E resulted in next higher number of seeds (313.90 seeds/head) followed by Fruit boost which was at par with the control.

4.3.1.1.5 Seed yield

Crop treated with *S. densifolia* produced significantly higher yield of 19.53 q/ha. This resulted in 50.81 per cent increase in the yield over control. Remaining all the treatments failed to increase the seed yield of sunflower (Morden) compared to control (12.95 to 13.74 q/ha).

4.3.1.2 Study on the influence of bee attractants on qualitative yield parameters of Morden variety of sunflower during *kharif* 2007

The observations related to the effect of bee attractants on qualitative parameters of Morden variety of sunflower *viz.*, per cent germination, root length, shoot length and vigour index is presented in table 8.

4.3.1.1.6 Per cent germination

Per cent germination of the seeds produced from the crop receiving various bee attractants varied from 90.67 to 93.33 per cent, which was not significantly different from the control (92.33 %).

4.3.1.1.7 Root length

Root length of the seedlings varied from 11.15 to 12.97 cm in various treatments which however, was statistically at par with the root length produced by the seeds from unsprayed crop (12.92 cm).

4.3.1.1.8 Shoot length

The shoot length of the seedlings from the crop receiving attractant spray varied from 12.14 to 13.86 cm, which was as good as the shoot length of the seedlings from the unsprayed crop (13.24 cm).

4.3.1.1.9 Vigour index

The vigour index of the seedlings was as high as 2486.33 in *S. densifolia* treated plots and as low as 2216.33 in sugar solution treated crop. However, these variations were not statistically different from the unsprayed crop (2405.67).

4.3.2 Study on the influence of bee attractants on quantitative yield parameters of KBSH-1 hybrid of sunflower during *rabi* 2007

Data on the effect of bee attractants on quantitative parameters of KBSH-1 hybrid of sunflower *viz.*, head weight, per cent chaffiness, 100 seed weight, number of seeds per head and yield during *rabi* 2007, are presented in the table 9.

Table 7. Influence of bee attractants on quantitative yield parameters of sunflower (Morden)

Treatments	Head weight (g)	%increase/ decrease over control	% Chaffiness	% increase/ decrease over control	100 seed weight (g)	No of seeds per head	% increase / decrease over control	Yield (q/ha)	% increase over control
Citral E @ 0.05 %	41.64 (6.53) d	- 13.20	10.00 (18.41) a	38.06	4.64 (2.37)	313.90 (17.74) b	14.10	13.74 (3.84) b	6.1
Citral Z @ 0.05 %	41.29 (6.50) d	- 13.93	8.00 (16.29) a	-3.96	4.21 (2.28)	399.90 (19.98) a	45.37	13.20 (3.76) b	1.93
<i>Fagara budrunga</i> @ 0.05 %	55.38 (7.51) a	15.45	5.00 (12.87) b	- 31.93	4.66 (2.38)	429.33 (20.73) a	56.06	13.44 (3.80) b	3.78
<i>Swertia densifolia</i> @ 0.05%	54.41 (7.44) a	13.43	8.67 (17.00) a	4.08	4.66 (2.38)	426.17 (20.67) a	54.91	19.53 (4.53) a	50.81
Fruit Boost @ 0.05 %	49.37 (7.09) b	2.92	8.00 (16.40) a	- 12.00	5.02 (2.45)	274.25 (16.59)bc	- 0.31	13.16 (3.76) b	1.62
Sugar solution @ 10 %	45.54 (6.82) c	- 5.07	4.33 (11.99) b	- 51.98	4.94 (2.43)	468.83 (21.67) a	70.42	13.08 (3.75) b	1.00
Control	47.97 (7.00) bc		8.33 (16.73) a		4.46 (2.34)	275.10 (16.61) bc		12.95 (3.73) b	
S.Em.±	0.09		0.80		0.05	0.51		0.08	
CD	0.27		2.45		NS	1.59		0.26	

Means followed by the letter in a column do not differ significantly by DMRT (P = 0.05)

Figures in the parenthesis are $\sqrt{(X+1)}$ transformed values (except per cent chaffiness which are arc sin transformed values)

Table 8. Influence of bee attractants on qualitative yield parameters of sunflower (Morden)

Treatments	Percent germination	Root length (cm)	Shoot length (cm)	Vigour index
Citral E @ 0.05 %	91.00 (72.53)	12.19 (3.63)	12.29 (3.64)	2228.00 (47.21)
Citral Z @ 0.05 %	91.33 (72.89)	11.15 (3.48)	13.15 (3.76)	2218.33 (47.11)
<i>Fagara budrunga</i> @ 0.05 %	93.33 (75.07)	12.48 (3.66)	13.57 (3.82)	2414.00 (49.09)
<i>Swertia densifolia</i> @ 0.05%	92.67 (74.31)	12.97 (3.74)	13.86 (3.85)	2486.33 (49.85)
Fruit Boost @ 0.05 %	90.67 (72.26)	12.42 (3.66)	13.21 (3.77)	2323.67 (48.20)
Sugar solution @ 10 %	91.67 (73.22)	12.04 (3.61)	12.14 (3.62)	2216.33 (47.07)
Control	92.33 (73.99)	12.92 (3.73)	13.24 (3.77)	2405.67 (49.02)
S.Em.±	0.93	0.10	0.10	0.02
CD	NS	NS	NS	NS

Figures in the parenthesis are $\sqrt{(X+1)}$ transformed values

Table 9. Influence of bee attractants on quantitative yield parameters of sunflower (KBSH-1)

Treatments	Head weight (g)	% Chaffiness	100 seed weight (g)	% increase over control	No of seeds per head	% increase / decrease over control	Yield (q /ha)	% increase over control
Citral E @ 1.00 %	43.28 (6.65)	1.67 (5.76)	5.13 (2.48) bc	14.51	128.75 (11.39) c	- 1.9	11.80 (3.58) a	51.87
Citral Z @ 1.00 %	41.57 (6.52)	3.33 (8.44)	5.44 (2.54) ab	21.43	179.75 (13.44) b	36.95	12.30 (3.64) a	58.30
<i>Fagara budrunga</i> @ 1.00 %	43.51 (6.57)	1.33 (3.84)	5.11 (2.47) bc	14.06	278.75 (16.67) a	112.38	11.15 (3.49) a	43.50
<i>Swertia densifolia</i> @ 1.00%	39.64 (6.37)	1.67 (6.03)	5.46 (2.54) ab	21.88	103.25 (10.21) c	- 21.33	12.15 (3.62) a	56.37
Fruit Boost @ 0.05 %	41.99 (6.56)	4.00 (11.28)	5.72 (2.59) a	27.68	244.17 (15.59)a	86.03	12.90 (3.73) a	66.02
Sugar solution @ 10 %	42.82 (6.62)	2.67 (8.93)	4.70 (2.39) cd	4.91	101.25 (10.11) c	- 22.86	11.05 (3.47) a	42.21
Control	40.98 (6.48)	1.67 (6.03)	4.48 (2.34) d		131.25 (11.50)c		7.77 (2.96) b	
S.Em.±	0.11	2.56	0.031		0.54		0.09	
CD	NS	NS	0.096		1.68		0.27	

Means followed by the same letter in a column do not differ significantly by DMRT (P = 0.05)

Figures in the parenthesis are $\sqrt{X+}$ transformed values (except per cent chaffiness, which are arc sin transformed values)

4.3.2.1 Head weight

Weight of the sunflower head from crop that received the spray of attractants varied from 39.64 g (*S. densifolia*) to 43.51 g (*F. budrunga*). However, the weight of the sunflower head that did not receive any spray of attractant was also statistically at par (40.98 g).

4.3.2.2 Per cent chaffiness

Chaffiness of the seeds in various treatments though varied from 1.33 (*F. budrunga*) to 4.00 per cent (Fruit boost), but was statistically at par with each other as well as with the control (1.67 per cent).

4.3.2.3 100-seed weight

Significantly higher test weight was registered in the treatments that received spray of Fruit boost (5.72 g), *S. densifolia* (5.46 g) and citral Z (5.44 g). The next higher seed weight was recorded in the treatment receiving spray of citra E (5.13 g) and *F. budrunga* (5.11 g). The test weight was significantly lower in the treatment that received the spray of sugar solution (4.70 g) which was as good as the unsprayed treatment (4.48 g).

4.3.2.4 Number of seeds per head

A maximum of 278.75 seeds/head was recorded from crop treated with *F. budrunga* which was statistically at par with the treatment receiving Fruit boost (244.17 seeds/head). The next higher number of seeds was recorded in the treatment with citral Z (179.75 seeds/head). However, the number of seeds which varied from 101.25 to 128.75 seeds/head in the remaining treatments was at par with the control (131.25 seeds/head).

4.3.2.5 Seed yield

Crop treated with Fruit boost produced significantly higher yield of 12.90 q/ha which was also at par with the crop that received citral Z (12.30 q/ha), *S. densifolia* (12.15 q/ha), citral E (11.80 q/ha), *F. budrunga* (11.15 q/ha) and sugar solution (11.05 q/ha). Thus there was an increase in the yield to the extent of 42.21 to 66.02 per cent over control. The unsprayed crop produced significantly lower yield of (7.77 q/ha).

5. DISCUSSION

The present study was conducted to evaluate the efficiency of two pheromone based attractants namely, citral E and citral Z; two plant based attractants viz., *Fagara budrunga* and *Swertia densifolia* along with Fruit boost, a commercial bee attractant on Morden variety and KBSH-1 hybrid of sunflower during *kharif* and *rabi* 2007 at Dharwad. citral E contains *A. cerana* pheromone lure while citral Z is a lure based on *A. florea* pheromone.

S. densifolia lure is a leaf extract from medicinal plant, *Swertia densifolia* (Gentianaceae) commonly known as Chirayata and which has already been proved to have attractant properties towards *A. cerana* (Naik *et al.*, 2005) and *A. florea* under laboratory conditions (Naik *et al.*, 2007). On the other hand *F. budrunga* lure is a fruit extract from another medicinal plant *Fagara budrunga* (Rutaceae), commonly known as Mullilam. This product is also known for its attractant property towards *A. cerana* under laboratory conditions (Naik *et al.*, 2003). The results of these experiments have been discussed in this chapter.

5.1 Study of pollinator fauna and their relative abundance on two genotypes of sunflower at Dharwad

The present study revealed that during *kharif* 2007 a total of five species of Hymenoptera and three species of Lepidoptera foraged on Morden variety at Dharwad. Hymenoptera was the predominant group of pollinators. *A. dorsata* was the most dominant pollinator which constituted 97.33 per cent of the total pollinators. Similar dominance of *A. dorsata* on Morden variety of sunflower has also been reported by Manjunatha (2003) at Dharwad.

In contrast, only honey bees namely, *A. dorsata*, *A. cerana* and *A. florea* were found pollinating KBSH-1 hybrid of sunflower during *rabi* 2007. Among these different bees, *A. dorsata* was the most dominant forming 96.14 per cent of the pollinators followed by *A. florea* (3.35 per cent) and *A. cerana* (0.51%). These findings once again confirm that honey bees are the predominant pollinators of sunflower.

Absence of other pollinators on KBSH-1 hybrid was mainly due to change in the crop environment surrounding the experimental field. The Morden variety of sunflower during *kharif* season was surrounded by niger which is known to attract many species of insects other than honey bees. However, during *rabi* season, no attractive crop was present except cotton around KBSH-1 hybrid sunflower.

Findings of the present study strongly corroborate the earlier reports of Deodikar (1975), Vaish *et al.* (1978) and Viraktamath *et al.* (2001) who have reported *A. dorsata* as the most dominant pollinator of sunflower. *Apis* species and Hymenoptera formed the dominant group of pollinators of sunflower as reported by Goyal and Atwal (1973), Freund and Furgula (1982), Satyanarayana and Seetharam (1982), Ortiz-Sanchez and Tinaut-Ranera (1987), Ahmed *et al.* (1988), Dimitrov *et al.* (1992), Ajantha and Rathore (1998), Mahavir Gupta (1999), and Singh *et al.* (2000).

Rahoo *et al.* (1985), Butignol (1990) and Abrol (1996) also reported Hymenoptera constituting the major pollinator among various groups of insects visiting sunflower.

5.2 Study on the influence of bee attractants on bee visitation to sunflower

5.2.1 Influence of bee attractants on *A. dorsata* visitation on Morden variety of sunflower during *kharif* 2007

The bee visitation on Morden variety was not uniform and varied from 5.50 to 9.83 bees /5 flowers / min (Table 3) on the previous day of application of the first spray of bee attractants (10 % flowering) as it happened to be a rainy day.

One day after the first spray citral Z, citral E and *F. budrunga* sprayed crop enticed maximum number of bees (11.00 to 13.00 bees /5 flowers / min). On the second day along with citral E, Fruit boost and *S. densifolia* treatment was found to attract higher number of bees (9.00 to 10.50 bees / 5 flowers / min). Fruit boost and *S. densifolia* treated crops

retained their attractiveness along with citral Z and sugar solution on the third day also (7.50 to 9.50 bees / 5 flowers / min). Maximum number of bees was recorded on citral E (8.50 bees / 5 flowers / min) followed by citral Z (7.00 bees / 5 flowers / min), *F. budrunga* (7.00 bees / 5 flowers / min) and sugar solution (6.67 bees / 5 flowers / min) sprayed crops which was as good as control (6.00 bees / 5 flowers / min) on the fifth day after spraying.

The day before imposing second treatment (50 % flowering) no bees were recorded from any of the treatment as it was raining continuously throughout the day. But one day after the spray, citral Z, *F. budrunga* and citral E enticed maximum bees (7.00 to 8.33 bees / 5 flowers / min). Citral Z continued to be attractive even on the second day along with *S. densifolia* (10.00 and 9.00 bees / 5 flowers / min). On the third day after second spray, both *S. densifolia* and citral Z retained their efficacy along with Fruit boost and citral E attracting more bees (6.50 to 8.33 bees / 5 flowers / min). However, on the fifth day after second spray all the treatments lost their effectiveness in attracting more bees as bee visitation was at par with control varying from 4.67 to 6.33 bees / 5 flowers / min.

Results of present investigation indicated that none of the bee attractants showed consistency in attracting the honey bees. This was perhaps due to the overcast weather condition and frequent rain during the entire experimental period. There were as many as seven rainy days during experimental period, which lasted for 12 days (including two days of spraying). Hence, though all the bee attractants have shown indications of attracting bees, the present results may not reflect about their true potentiality in enticing more bees.

5.2.2 Influence of bee attractants on *A. dorsata* visitation on KBSH-1 hybrid of sunflower during *rabi* 2007

A. dorsata visitation which varied from 0.37 to 0.83 bees / 5 flowers / min) did not differ statistically a day before the spray of attractants indicating uniform activity of the bees (Table 4). However, significant increase in bee visitation was noticed on treatments sprayed with bee attractants a day after the first spray (10% flowering) as well as second spray (50 % flowering). Fruit boost, *S. densifolia* and citral Z were equally effective enticing 2.61 to 2.96 bees / 5 flowers / min on the first day after spray. Citral Z was superior only for the one day after treatment in first spray. While citral E was second best on 1st and 5th day after spray and third best on second and third day. *S. densifolia* was superior on 1st, 2nd and 5th day after first spray (2.76, 10.00 and 8.33 bees / 5 flowers / min). Whereas, *F. budrunga* was next best to the control during first and second spray. But Fruit boost retained its effectiveness right from the 1st day after spray up to 5th day (2.96 to 9.72 bees / 5 flowers / min).

One day before the second spray *A. dorsata* did not show any preference towards treated or untreated crop for foraging as the number varied from 6.28 to 7.18 bees / 5 flowers / min. But one day after second spray *A. dorsata* activity on treatments receiving Fruit boost, *S. densifolia* and citral Z again proved to be most attractive for bees (9.66 to 10.14 bees / 5 flowers / min). Similar trend continued up to second day after treatment. Remaining treatments namely sugar solution, citral E and *F. budrunga* recorded more number of bees than control on second day (5.33 to 6.63 bees / 5 flowers / min). On the third and fifth day after spray all the attractants failed to entice more bees than control (3.59 to 6.16 and 1.30 to 2.05 bees / 5 flowers / min, respectively).

Results of present investigation clearly indicate equal and higher efficiency of citral Z, *S. densifolia* and Fruit boost in enticing more pollinators. The reduction of attractiveness after 2nd day in *S. densifolia* and lower efficiency of *F. budrunga* could be attributed to the fact that the products were plant based and in open field condition may not retain their effectiveness after two days. Similar short efficacy of botanicals namely tuberose floral scented water and cinnamon leaf extract have been reported by Murasing and Viraktamath (2002), Guruprasad (2001) and Ganapathi (2005) on niger, mustard and cotton, respectively. In the present study *F. budrunga* did not show clearly about its attractiveness under field conditions which needs to be further investigated.

Efficacy of Fruit boost in attracting higher pollinators to sunflower could be attributed to the presence of queen mandibular gland pheromone (QMP) that stimulates the foraging activity of workers (Winston and Slessor, 1993). Increased recruitment induced by QMP sprays on crop could operate by heightening perceptions of foragers by way of an increase number of dance circuits resulting ultimately in longer waggle dance (Higo *et al.* 1995).

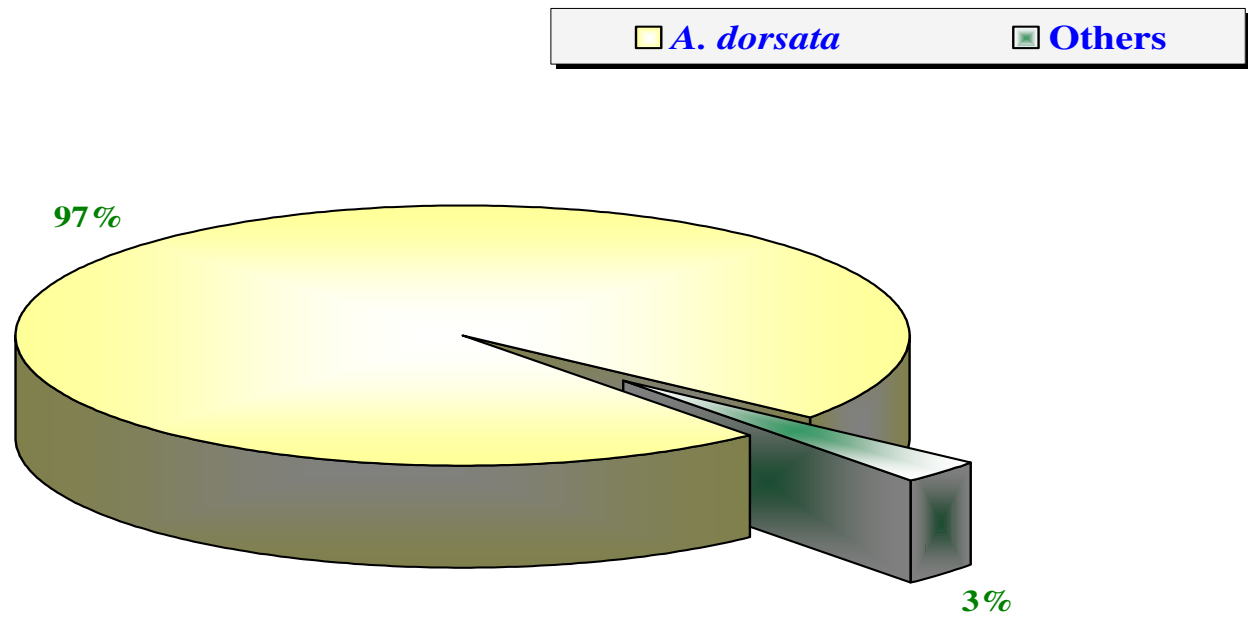


Fig. 1. Relative abundance of pollinator fauna on Morden variety of sunflower during *kharif* 2007 at Dharwad

Fig. 1. Relative abundance of pollinator fauna on Morden variety of sunflower during kharif 2007 at Dharwad

■ *A.dorsata* ■ *A.florea* ■ *A. cerana*

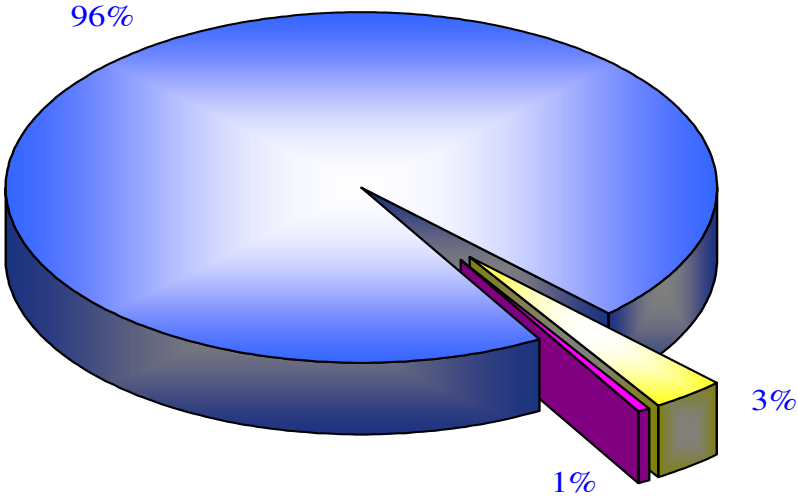


Fig. 2. Relative abundance of pollinators on KBSH-1 hybrid sunflower during *rabi* 2007 at Dharwad

Fig. 2. Relative abundance of pollinators on KBSH-1 hybrid sunflower during *rabi* 2007 at Dharwad

Present findings strengthen results of Manjunatha (2003) who reported significant effect of Fruit boost spray on bee visitation on Morden variety and Agsun® hybrid of sunflower. Viraktamath and Patil (2002) also confirmed the impact of Fruit boost on sunflower upto fifth day.

Higo *et al.* (1995), Niera and Barriga (1995) reported increased number of honey bee visits to attractant treated plots on blooming crop and raspberry, respectively. Similar increased bee visitation on the crops sprayed with attractants are reported in apple and pear (Currie *et al.*, 1992 b) berry crops (Currie *et al.*, 1992 a), watermelon (Elmstrom and Maynard, 1991) apple, pear and plum (Mayer *et al.*, 1989) cardamom (Bhat and Sudarshan, 1999) sunflower (Sanjivan Kumar, 2000), cucumber (Viraktamath and Anagoudar, 2002), mustard (Murasing and Viraktamath, 2002), sesame (Patil, 1999 and Viraktamath and Patil, 1999), niger (Guruprasad, 2001, Sattigi *et al.*, 2001b) and onion (Kalmath, 2002).

5.2.3 Influence of bee attractants on time spent by *A. dorsata* on Morden variety and KBSH-1 hybrid sunflower

A. dorsata stayed significantly for longer time consequent to the application of citral E (92.51 sec / 3 bees) followed by sugar solution and *F. budruna* (68.41 and 56.67 sec /3 bees) (Table 6) on Morden variety during *Kharif* 2007.

However, on KBSH-1 hybrid, *A. dorsata* foraged significantly for longer duration on crop treated with Fruit boost, *F. budruna*, *S. densifolia* and citral Z (85.67 to 95.00 sec / 3 bees) during *rabi* 2007.

The variation of the results between *kharif* and *rabi* season was obviously due to the highly varying weather conditions prevailing during these periods. The results of the *kharif* season may not represent the true efficacy of the bee attractants because of the overcast weather and more rainy days.

Present results with respect to Fruit boost are similar to the findings of Manjunatha (2003) who reported that higher time was spent by bees on attractants treated Morden variety and Agsun® hybrid of sunflower. Similarly Niera and Barriga (1995) and Higo *et al.* (1995) concluded that the beneficial effects of bee attractants was mainly due to the longer time that bees would spend on the sprayed bloom.

5.3 Influence of bee attractants on yield parameters in Morden variety and KBSH-1 hybrid sunflower

5.3.1 Study on the effect of bee attractants on quantitative yield parameters of Morden variety and KBSH-1 hybrid sunflower during *kharif* and *rabi* 2007, respectively

5.3.1.1 Head weight

During *kharif* season, the Morden variety sprayed with *F. budruna* and *S. densifolia* produced significant heavier heads (54.41 and 55.38 g, respectively) than the control (47.97 g). Thus the spray of bee attractants enhanced the head weight by 13.43 and 15.45 per cent, respectively (Table 7).

While during *rabi* season, application of bee attractants to the hybrid KBSH-1 crop did not enhance the head weight over the control (Table 9).

These results perhaps indicate that head weight is more of a genetic character in hybrids than in varieties of sunflower.

Present findings are partially in line with the report of Manjunatha (2003) who reported significant increase in the head weight of Morden variety as well as Agsun® hybrid of sunflower due to spray of Fruit boost. Similar increase in weight of watermelon with application of Bee-Q was reported by Lingappa *et al.* (1999) and Sattigi *et al.* (2001a).

5.3.1.2 Per cent chaffiness

Significantly lower chaffiness was noticed in sugar solution treated crop of Morden variety (4.33 %) which was however at par with the crop treated with *F. budruna* (5.00%) during *kharif* 2007 (Table 7). This accounted for 48.02 and 39.98 per cent reduction in

chaffiness over control (8.33 %). However, all other treatments were at par with each other as well as control (8.00 to 10.00 per cent).

But there was no variation in per cent chaffiness among the various treatments as well as control (Table 9) during *rabi* season of 2007 on KBSH-1 hybrid of sunflower (1.33 to 4.00 %).

Significant difference in per cent chaffiness in case of Morden variety was attributed to the fact that variety would respond better to the bee pollination. During *rabi* season, KBSH-1 hybrid crop showed no significant variation among treatments which was perhaps due to the hybrid cultivar used in the study. In hybrid, chaffiness appears to be of genetic character.

Present findings corroborate the earlier studies by Manjunatha (2003) who also reported significant difference in per cent chaffiness when Morden cultivar was sprayed with different bee attractants, while non-significant differences in per cent chaffiness with hybrid variety Agsun®.

5.3.1.3 Hundred seed weight

Hundred seed weight of different attractant sprayed crop was statistically as good as untreated crops (control) in Morden variety of sunflower during *kharif* 2007.

But in KBSH-1 hybrid of sunflower during *rabi* 2007, the crop sprayed with Fruit boost, *S. densifolia* and citral Z produced heavier seeds (5.72, 5.46 and 5.44 g, respectively). Thus there was an increase from 21.43 to 27.68 per cent in the seed weight over control.

The increase in seed weight in treatments was attributed to the increased pollinator attraction towards the KBSH-1 hybrid crop and also more time spent by bees. As a result vigorous pollen received by such heads ultimately increased the weight of seeds.

Similar results were also obtained by Manjunatha (2003) in Morden variety and Agsun® hybrid of sunflower when the crop was sprayed with Fruit boost. Seed weight was also enhanced due to application of bee attractants in other oilseeds like niger (Sattigi *et al.*, 2001b; Guruprasad, 2001), sesame (Viraktamath and Patil, 1998), Patil (2000), mustard (Murasing and Viraktamath, 2002) and coriander (Anonymous, 2000).

5.3.1.4 Number of seeds per head

Significantly higher number of seeds per head was produced by *F. budrunga*, *S. densifolia*, citral Z sprayed crops (429.33, 426.17 and 399.90 seeds/head, respectively) in Morden variety which was however as good as sugar solution treated crop (468.83 seeds/head). Thus, application of bee attractants resulted in an increase of 45.37 to 70.42 per cent more seeds over control. The next best treatment with higher number of seeds per head was citral E with 313.90 seeds/head, followed by Fruit boost, which was at par with the control.

But in KBSH-1 hybrid, crop that received *F. budrunga* and Fruit boost spray yielded a maximum of 278.75 and 244.17 seeds/head, accounting an increase of 112.38 and 86.03 per cent over unsprayed crop. Citral Z (179.75 seeds/head) spray was the next best treatment resulting an increase of 36.95 per cent over control.

The increase in the number of seeds per head is attributed to the increase bee visitation to the target crop which was very much evident in case of citral Z, *S. densifolia* treated Morden variety crops and Fruit boost treated KBSH-1 hybrid crops, but however not much obvious about other chemicals.

The present findings substantiate the report by Manjunatha (2003) who also recorded significantly high filled seed rows per head from Fruit boost treated crops in Morden variety of sunflower. Viraktamath and Patil (1999) and Patil (1999) also reported significantly higher numbers of seed when crop was sprayed with Bee-here and Bee-Q. Similar increase in the seeds was also recorded in watermelon due to spray of attractants (Elmstrom and Maynard, 1991). Bee pollination also resulted in four time increased seeds/pod in mustard (Singh and Singh, 1992) and 12.9 to 4180.3 per cent increase in niger (Choudhary and Kumar, 1998; Kulkarni and Dhanorkar, 1998).

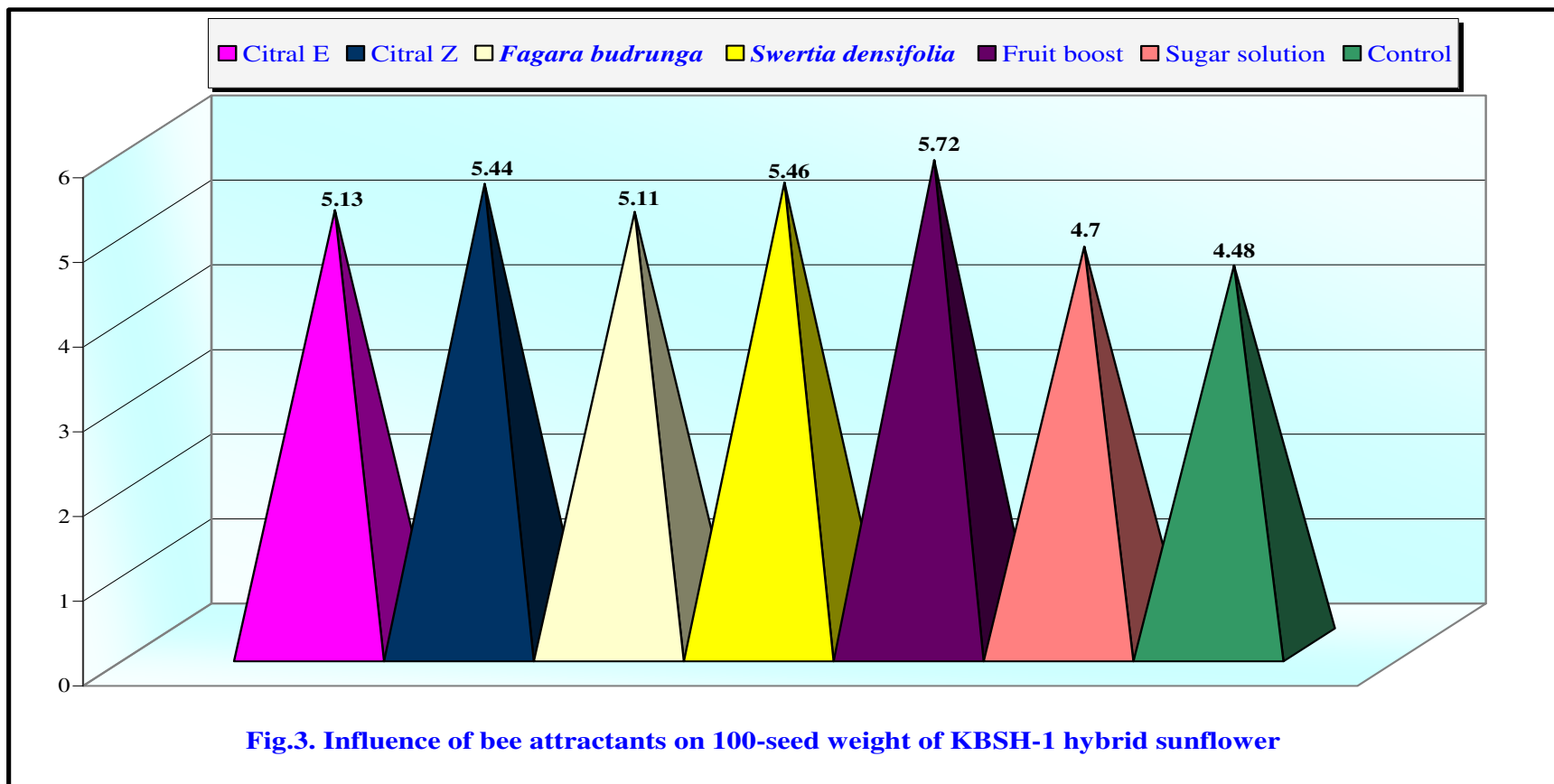


Fig.3. Influence of bee attractants on 100-seed weight of KBSH-1 hybrid sunflower

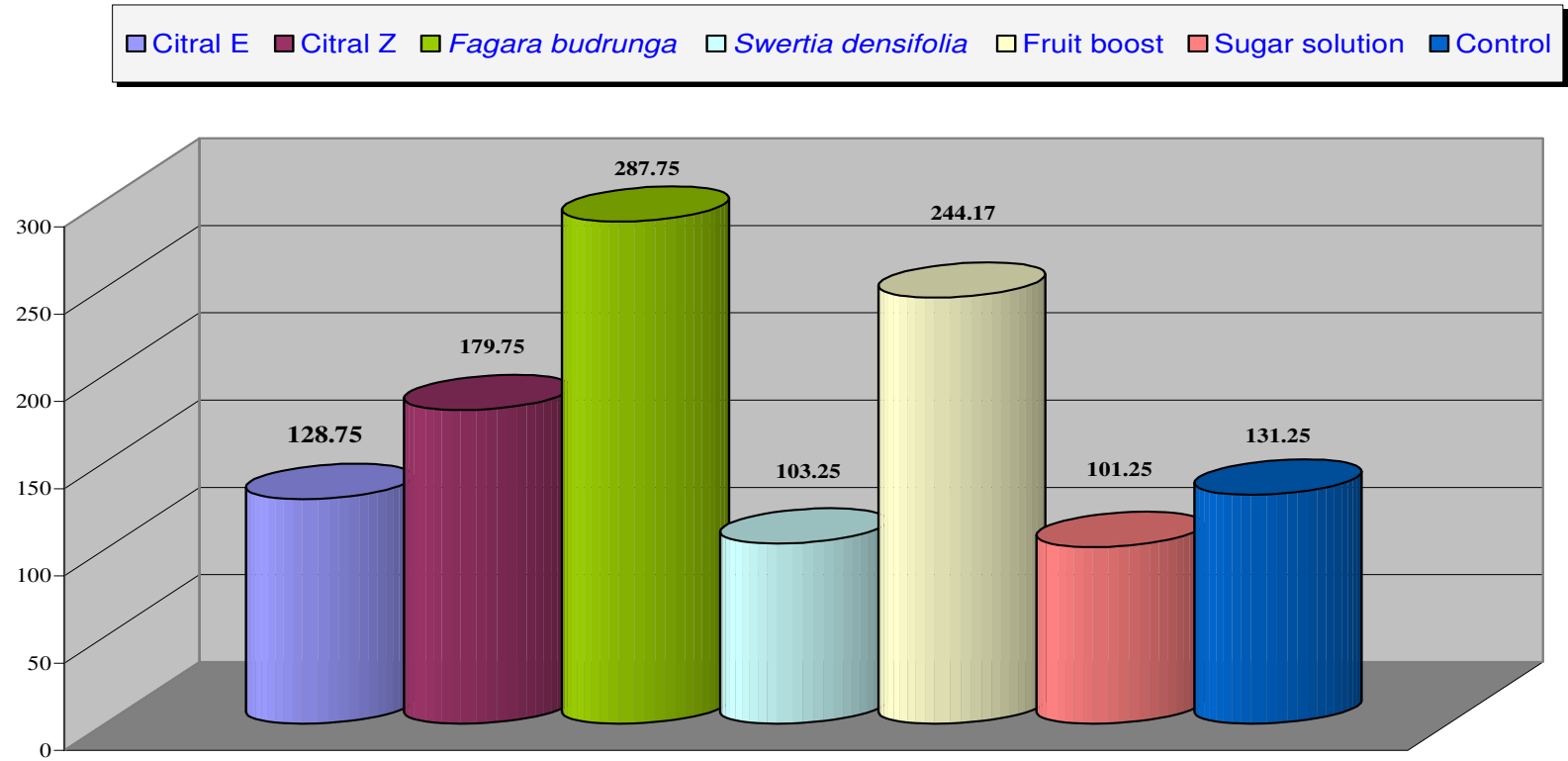


Fig. 4. Influence of bee attractants on number of seeds/head in KBSH-1 hybrid sunflower

Fig. 4. Influence of bee attractants on number of seeds/head in KBSH-1 hybrid sunflower

5.3.1.5 Seed yield

Morden variety of sunflower sprayed with *S. densifolia* produced significantly higher yield of 19.53 q/ha, accounting for an increase of 50.81 per cent over control during *kharif* 2007. Remaining attractants were as good as the unsprayed crop.

During *rabi* 2007, crop treated with Fruit boost (12.90 q/ha), citral Z (12.30 q/ha), *S. densifolia* (12.15 q/ha), citral E (11.80 q/ha), *F. budrunga* (11.15 q/ha) and sugar solution (11.05 q/ha) produced significant increase in seed yield of KBSH-1 hybrid. Thus, bee attractant spray was beneficial in increasing the seed yield to the extent of 42.21 to 66.02 per cent over control. The unsprayed crop produced significantly lower yield of 7.77 q/ha.

The impact of application of bee attractants on Morden variety was not apparent except *S. densifolia*. However, during the *rabi* season all bee attractants proved to be superior compared to the unsprayed crop in enhancing the yield of KBSH-1 hybrid. This variation was perhaps due to the rainy weather that prevailed during the flowering period of Morden variety of sunflower during *kharif*. This resulted in varying bee visitation which might have affected the pollination of the crop. However, during *rabi* season, the weather was quite conducive for the bee visitation which was significantly more on the crops sprayed with bee attractants. This has ensured the optimum pollination resulting in the improvement of the yield.

The result of the present investigation ratify earlier report by Manjunatha (2003) who reported 31.48 and 25.14 per cent enhancement of yield of Morden variety and Agsun@ hybrid of sunflower due to application of Fruit boost.

Bee attractants are reported as yield increasing factor in sunflower (Bhosle *et al.*, 1992; Sanjivan Kumar *et al.*, 2000; Viraktamath and Patil, 2002), niger (Panda *et al.*, 1998; Mohana Rao and Suryanarayana, 1990; Choudhary and Kumar, 1998; Kulkarni and Dhanorkar, 1998; Guruprasad, 2001; Sattigi *et al.*, 2001b), sesame (Viraktamath and Patil, 1998; Patil, 1999; Patil *et al.*, 2000), mustard (Murasing and Viraktamath, 2002; Viraktamath *et al.*, 2001), watermelon (Elmstrom and Maynard, 1991; Maynard *et al.* 1992; Winston and Slessor, 1993; Schulthesis *et al.*, 1994; Lingappa *et al.*, 1999, Sattigi *et al.*, 2001a), apple (Rajotte and Fell, 1982; Winston and Slessor, 1993), pear (Mayer *et al.*, 1989), Ken-Naumann *et al.*, 1994), berry crops (Currie *et al.*, 1992a), cardamom (Bhat and Sudarshan, 1999), cucumber (Schulthesis *et al.*, 1994; Viraktamath and Anagoudar, 2002), onion (Kalmath, 2002) and safflower (Lingappa *et al.*, 1999).

5.3.2 Study on the influence of bee attractants on qualitative yield parameters of Morden variety of sunflower during *kharif* 2007

5.3.2.1 Germination percentage

Germination percentage of the seeds produced from various bee attractant treated crop did not differ significantly from the seeds of unsprayed (control) crop. The germination percentage varied from 90.67 to 93.33 per cent (Table 8). Similar results have been reported from Morden variety of sunflower by Manjunatha (2003). These results are also in agreement with Sattigi *et al.* (2001b) who reported that the bee pollination did not influence the germination percentage in niger.

However, Patil (1999) recorded higher germination when sesame was sprayed with Bee here and Bee-Q. Murasing and Viraktamath (2002) also recorded higher germination percentage in mustard crop when sprayed with Bee-Q and sugar solution. Similarly Guruprasad (2001) obtained higher germination in Fruit boost and floral scented water treatments.

5.3.2.2 Root length

The root length (11.15 to 12.97 cm) of the germinated seeds from the crop that received various attractant sprays was statistically at par with the root length of germinated seeds from the control crop (12.92 cm). In contrast, Manjunatha (2003) obtained significant variation in the root length of seedlings obtained from the sprayed and unsprayed sunflower. Similarly Patil (1999) and Patil *et al.* (2000) reported beneficial effects of attractant in enhancing root length in sesame, which is also in agreement with findings of Sattigi *et al.* (2001b), and Guruprasad (2001) in niger.

■ Citral E ■ Citral Z ■ *Fagara budrunga* ■ *Swertia densifolia* ■ Fruit boost ■ Sugar solution ■ Control

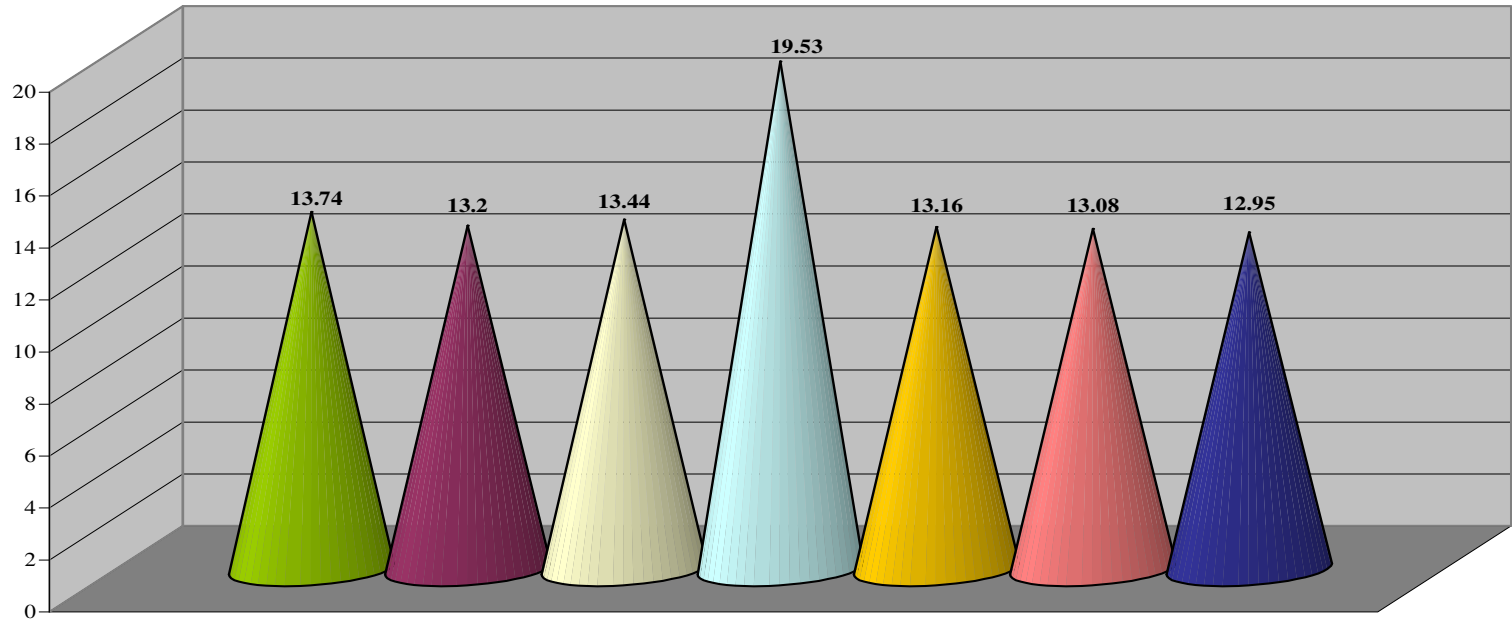


Fig.5. Effect of bee attractants on yield of Morden variety of sunflower

Fig.5. Effect of bee attractants on yield of Morden variety of sunflower

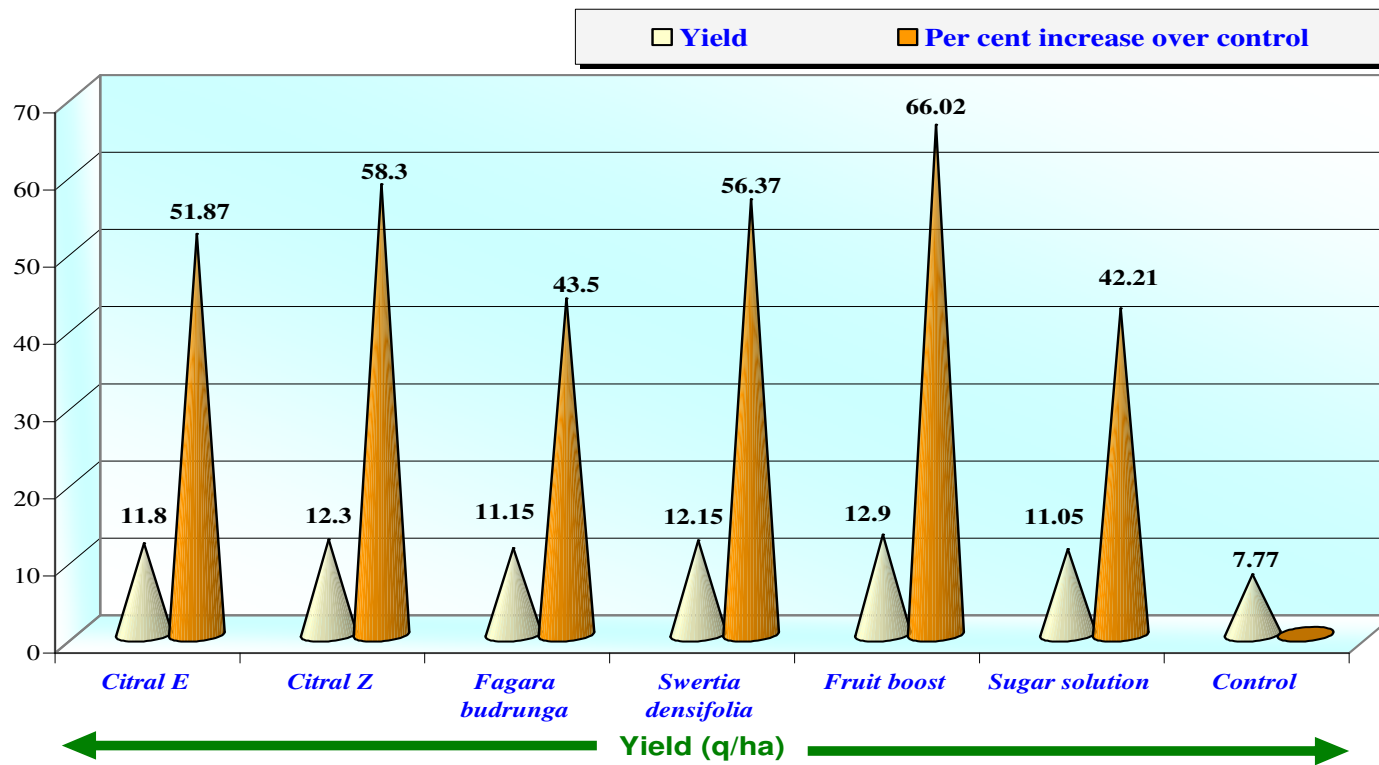


Fig.6. Influence of bee attractants on yield of KBSH-1 sunflower

Fig.6. Influence of bee attractants on yield of KBSH-1 sunflower

5.3.2.3 Shoot length

Application of bee attractants had no positive effect in increasing shoot length of the seedlings which varied from 12.14 to 13.86 cm.

Sattigi *et al.* (2000b) also opined that application of bee attractants has no influence on shoot length in niger. However, Manjunatha (2003) recorded significant increase in shoot length in the Morden variety of sunflower. Similarly, higher shoots length was observed in niger (Guruprasad, 2001), sesame (Patil, 1999; Patil *et al.*, 2000) and mustard (Murasing and Viraktamath, 2002) due to application of bee attractants.

5.3.2.4 Vigour index

Vigour index of the seedlings which varied from 2486.33 to 2216.33 remained unaffected inspite of application of bee attractants. Vigour index is a result of cumulative effect of per cent germination, root and shoot length. As all these parameters were found statistically at par with unsprayed crop, the vigour index of these seedlings automatically followed the same trend.

However, Manjunatha (2003) found higher vigour index in Morden variety of sunflower) due to Fruit boost. Similarly Lingappa *et al.*, (1999) recorded enhanced seedling vigour of safflower due to bee pollination.

6. SUMMARY AND CONCLUSIONS

Salient findings of the investigation carried out during *kharif* and *rabi* season of 2007 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, on pollinator fauna and their relative abundance, influence of bee attractants on bee visitation and yield parameters of Morden (variety) and KBSH-1 (hybrid) genotypes of sunflower are summarized below.

Pollinator fauna of Morden variety of sunflower at Dharwad constituted five species of Hymenoptera and three species of Lepidoptera during *kharif* season of 2007. Hymenopterans were the predominant and frequent visitors of sunflower. Among the pollinators, *A. dorsata* was the most dominant constituting 97.33 per cent of all pollinators. Other pollinators (*Pithitis* sp., *Xylocopa fenestrata*, *Pieris* sp., *Danaus chrysippus* etc.) constituted remaining 2.67 per cent. While during *rabi* season, three species of honey bees were recorded as pollinator fauna of KBSH-1. *A. dorsata* constituted 96.14 per cent of the total pollinators and was the most dominant followed by *A. florea* (3.35%) and *A. cerana* (0.51%).

Spraying of bee attractants had significant influence in attracting bees to the target crop. During *kharif* season, none of the attractant showed consistency throughout the flowering season, however during *rabi* season Fruit boost along with *S. densifolia* and citral Z enticed more number of bees compared to other treatments and also against control. However, the effects of these attractants lasted for two to five days.

Average time spent by *A. dorsata* was influenced by the application of different attractants. They foraged for longer time (92.51 sec) in citral E treated crops on Morden variety followed by sugar solution and *F. budrunga* treated plots (68.41 and 56.67 sec). However, on KBSH-1 hybrid, *A. dorsata* foraged significantly longer on crops treated with Fruit boost, *F. budrunga*, *S. densifolia* and citral Z (85.67 to 95.00 sec / 3 bees) during *rabi* 2007.

Application of attractants enhanced yield and also yield components of Morden variety of sunflower during *kharif* 2007. Spray of *F. budrunga* and *S. densifolia* recorded heavier heads (55.38 and 54.41 g) followed by Fruit boost (49.37 g).

Per cent chaffiness was least in sugar solution and *F. budrunga* treated crops (4.33 and 5.00 %) while number of seeds per head was highest in *S. densifolia*, *F. budrunga* and citral Z treated crops.

S. densifolia sprayed crop produced highest yield of 19.53 q/ha in case of Morden variety of sunflower accounting for an increase of 50.81 per cent over control.

Application of bee attractants had no effect on 100-seed weight, germination percentage, root length, shoot length and vigour index to the treated crop. However, during *rabi* season of 2007 in KBSH-1 hybrid, higher 100-seed weight was recorded from Fruit boost (5.72 g), *S. densifolia* (5.46 g) and citral Z (5.44 g) sprayed crop followed by citral E and *F. budrunga* sprayed crop (5.13 and 5.11 g respectively).

The crops that received *F. budrunga*, and Fruit boost spray produced higher number of seeds/head (278.75 and 244.17 seeds/head) resulting in 112.38 and 86.03 per cent more seeds/head over control. Citral Z (179.75 seeds/head) with 36.95 per cent increase over control (131.25 seeds/head) was the next best treatment.

Beneficial influence of attractant was very much evident as Fruit boost (12.90 q/ha), citral Z (12.30 q/ha), *S. densifolia* (12.15 q/ha), citral E (11.80 q/ha), *F. budrunga* (11.15 q/ha) and sugar solution (11.05 q/ha) sprayed crops produced significantly higher yield as against the crops that did not receive any attractant spray (7.77 q/ha), resulting in an increased seed yield of 42.21 to 66.02 per cent as against unsprayed control.

Application of attractants failed to improve head weight per plant and reduce per cent chaffiness in KBSH-1 crop as there was no statistical difference between treated and unsprayed crops.

- Hymenopterans were the most dominant pollinators and *A. dorsata* constituted 97.33 per cent of the total pollinators in Morden variety of sunflower during *kharif* 2007. Only honey bees were recorded in KBSH-1 hybrid with *A. dorsata* forming 96.14% during *rabi* 2007 at Dharwad.
- In Morden variety the bee attractants did not show consistency in their attracting property through out the flowering season mainly due to adverse climatic condition, hence no conclusion can be inferred. However, *S. densifolia*, citral E and citral Z showed indications of attracting more bees. In KBSH-1 hybrid sunflower, Fruit boost and *S. densifolia* spray attracted significantly higher numbers of bees.
- *S. densifolia* sprayed crop produced highest yield of 19.53 q/ha accounting 50.81 per cent increased yield over control in Morden variety of sunflower, which however needs confirmation. Fruit boost (12.90 q/ha), citral Z (12.30 q/ha), *S. densifolia* (12.15 q/ha), citral E (11.80 q/ha), *F. budrunga* (11.15 q/ha) along with sugar solution (11.05 q/ha) were effective in enhancing yield of KBSH-1 hybrid sunflower thus increasing the yield from 42.21 to 66.02 per cent over unsprayed crop.

Future line of work

1. Bee attractants should be tested for efficacy by conducting large field scale experiments
2. Suitable commercial formulations for these bee attractants need to be developed and tested

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APPENDIX-1

Monthly Meteorological data for the year 2007 of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)
		Mean maximum	Mean minimum	
January	Trace	30.4	14.0	72
February	0.0	31.9	15.7	67
March	12.8	35.3	19.7	49
April	86.4	36.7	21.4	55
May	65.0	34.6	21.3	61
June	220.1	29.7	21.3	80
July	211.2	27.0	21.1	85
August	176.0	27.1	20.5	85
September	18.8	27.2	20.3	83
October	74.8	29.7	19.4	68
November	54.0	29.5	15.1	53
December	Trace	29.0	14.6	65
Total	919.10	-	-	-
Average	76.59	30.68	18.7	-

EVALUATION OF INDIGENOUS BEE ATTRACTANTS IN SUNFLOWER

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ABSTRACT

Studies on the pollinator fauna of sunflower, impact of indigenous bee attractants on bee visitation and yield parameters in Morden variety and KBSH-1 hybrid sunflower were carried out in 2007 at Main Agricultural Research Station, Dharwad. Hymenopterans were the most dominant pollinators and *Apis dorsata* constituted 97.33 per cent of the total pollinators in Morden variety and 96.14% in KBSH-1 hybrid.

Attractants did not show uniform efficacy in Morden variety during *kharif* season due to inclement weather. However during *rabi* season Fruit boost along with *Swertia densifolia* and citral Z enticed more bees. The bees spent significantly more time on sprayed crop.

Spray of *Fagara budrunga* and *S. densifolia* recorded heavier heads (55.38 and 54.41 g) in Morden variety of sunflower. Per cent chaffiness was least in sugar solution and *F. budrunga* treated crop (4.33 and 5.00 %) while number of seeds per head was highest in *S. densifolia*, *F. budrunga* and citral Z treated crop. *Swertia densifolia* sprayed crop produced highest yield of 19.53 q/ha. Application of bee attractants had no effect on 100-seed weight, germination percentage, root length, shoot length and vigour index to the treated crop.

In KBSH-1 hybrid sunflower, higher 100-seed weight was recorded from Fruit boost (5.72 g), *S. densifolia* (5.46 g) and citral Z (5.44 g) sprayed crop. *Fagara budrunga* and Fruit boost sprayed crops produced higher number of seeds/head (278.75 and 244.17 seeds/head). Fruit boost (12.90 q/ha), citral Z (12.30 q/ha), *S. densifolia* (12.15 q/ha), citral E (11.80 q/ha), *F. budrunga* (11.15 q/ha) and sugar solution (11.05 q/ha) sprayed crops produced significantly higher yield as against control (7.77 q/ha). Application of attractants failed to improve head weight per plant and reduce per cent chaffiness in KBSH-1 crop.