

EVALUATION OF INDIGENOUS BEE ATTRACTANTS IN ENHANCING THE YIELD OF SESAME AND NIGER

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1. INTRODUCTION

"India has the unique distinction to present one of the largest vegetable oil economy in the world. Oilseed crops have been the backbone of agricultural economy of India from time immemorial. It is anticipated that the demand for edible oil and oil seeds by 2009-2010 would be 19.0 million tonnes and 56 million tonnes respectively, if per capita income grows by 5 per cent. This challenging demand has to be met by increasing the production of seven annual edible oil crops viz., rapeseed and mustard, groundnut, soybean, sunflower, safflower, sesame and niger (Sengupta and Das, 2003).

Presently oilseed crops are cultivated on about 16.5 million hectares with total production of 25.5 million tonnes. This area constitutes approximately one-tenth of the total cultivated area in India. On the oilseed map of the world, India occupies a prominent position, both in acreage and production.

The Technology Mission on Oilseeds launched during 1986 envisages to create/manage conditions that would harness the best of production, processing and storage technologies to attain self-reliance in edible oils. Within a decade the Mission was able to achieve substantial progress in oil seed production and this transformation was termed as the "Yellow Revolution". The oilseed production in India is now estimated to be. India is among the top five countries of the world in oilseed production. Nine edible oilseeds are cultivated in India and sesame ranks fifth in production. The sesame seed production is estimated at about 0.8 million tonnes. The growing domestic demand for edible oil coupled with the emergence of sesame as a potential export crop, provides good opportunity for farmers to take up the cultivation of this crop and be assured of good market value. However, the gap between the potential achievable yield and the average yield of sesame is wide.

Sesame (*Sesamum indicum* L.) is one of the oldest cultivated crops in the world. In India sesame is growing in the states of Gujarat, West Bengal, Rajasthan, Tamil Nadu, Orissa, Madhya Pradesh, Andhra Pradesh, Maharashtra, Uttar Pradesh, Punjab and Karnataka.

The sesame seed is a rich source of edible oil. Its oil content generally varies from 46 to 52 per cent. Its seeds may be eaten fried, mixed with sugar or in the form of sweetmeats. Sesame is used as a cooking-oil in southern India. It is also used for anointing the body, for manufacturing perfumed oils and for medicinal purposes. Sesame-cake is a rich source of protein, carbohydrates and mineral nutrients, such as calcium and phosphorus. The cake is edible and is eaten avidly by working classes. It is also a valuable and nutritious feed for milch cattle.

Niger seed is used as a human food. The seed contains 37-47 per cent oil, which is pale yellow with nutty taste and a pleasant odour. The oil and seeds are free from any toxin and oil taste is similar to desi ghee. India is the most important country accounting for more than 50 per cent of area and production in world.

Although sesame is a self pollinated crop high level of heterosis has been reported. The flower structure of sesame facilitates cross pollination. Earlier reports show that there is 0.5 to 65 per cent natural crossing. The out crossing percentage in sesame genotypes vary from 6.1 to 20.1 per cent. The seed yield in sesame varieties could be increased concurrently from 9.52 to 39.65 per cent (Patnaik *et al.*, 2004).

Niger is self incompatible with 100 per cent entomophilous cross-pollination. Studies on effect of honey bee pollinators in increasing the yield and profit in niger during kharif and rabi seasons of 2004 revealed that the yield was reduced by 11-78 per cent in the absence of honey bee pollinators and natural pollinators. An additional income of Rs. 252 to Rs. 2125 including Rs. 1015/ha from honey was estimated through beekeeping with niger over open pollinated crops (Anon , 2005).

Bee pollination not only ensures the increase in yields of various oilseeds but also improve their quality. It ensures uniform maturity and early harvest of crops. Provision of bee colonies during the flowering period of crop is a simple but essential input. A planned bee pollination programme on national scale significantly contributes in solving the problem of edible oil shortage in the country even at the existing level of land use of oil crops (Mohana Rao *et al.*, 1981).

Honey bees are considered as the most effective and ideal pollinators. Success of pollination with help of honey bees depends on their performance to the target crop over other following plants in the vicinity. Many substances have been tested as honey bee attractants (Ambrose *et al.* 1995, Mayer *et al.* 1989, and Waller, 1970). The attractiveness of honey bee pheromones, including the worker nasonov pheromone and queen mandibular gland pheromone have been evaluated (McGurty, 1992, Mayer and Johansen, 1982). Increased numbers of honey bees in onion and apple have been recorded when citral and geraniol were used (Woyke, 1981).

Significant increased yield following applications of queen mandibular pheromone were also reported at pheromone-sprayed berry plots, but the effect lasted only 1-2 days after applications (Currie *et al.*, 1992b).

Bee attractants can be classified mainly into three categories: food based, pheromone based, and plant origin. Food based attractant mainly comprises of glucose, maltose, sucrose, lactose, protein, fat, minerals, vitamins, and gluconic acid.

Some of the commercial products are Bee-Line, Bee Lure, and Bee-Q. Pheromone based attractants are divided further into nasonov gland pheromone and queen mandibular pheromone. Studies conducted by Viraktamath and Patil (2002) have shown that Bee-Q and Fruit Boost would enhance the yield of sunflower. Field scale evaluation of Bee-Q and Fruit Boost in sunflower has been made by Manjunatha (2003) with encouraging results.

Currently all the commercial bee attractants *viz.* Bee-Q, Bee scent plus, Bee here, Fruit 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 make the bee attractants, cost prohibitive. Hence there is a need to develop indigenous bee attractants so that use of bee attractants becomes economically viable. Keeping the above in background the present investigations were made with the following objectives.

- ❑ To study the foraging behaviour of honey bees in different genotypes of sesame and niger
- ❑ Influence of bee attractants on bee visitation in sesame and niger
- ❑ Influence of bee attractants on yield parameters of sesame and niger

2. REVIEW OF LITERATURE

Review of literature pertaining to study the foraging behaviour of honey bees in three different genotypes of sesame and niger, the influence of bee attractants on bee visitation and influence of these attractants on yield parameters of sesame and niger are presented in this chapter.

Since the literature pertaining to the effect of bee attractants on sesame and niger is scanty, literature related to other crops also presented here.

2.1 Foraging behaviour of honey bees in three different genotypes of sesame and niger

Mohana Rao *et al.* (1981) conducted a study on foraging behaviour of honey bees in sesame (*Sesamum indicum* L) at Pune, and found that *Apis. cerana* bees were the most frequent visitors followed by *Apis. dorsata* and *Apis. florea* on four cultivars.

According to Panda *et al.* (1988) honey bees (*A. cerana*) were the main pollinators of sesame and niger crops with more bee visits/m²/minute in bee pollination than in open pollination.

Honey bees constituted 91.3 per cent of insect visitors observed on plots of flowering niger at Pune. *A. dorsata*, *A. cerana* and *A. florea* made up 29.5 per cent, 10.3 per cent and 51.5 per cent of the total visitors respectively (Mohana Rao and Suryanarayana, 1990).

Panda *et al.* (1993b) studied the foraging behaviour of *A. cerana*, *A. dorsata* and *A. florea* on niger cultivar IGP 72, Alasi 1, GA 10, Raichur 70 and IGP 76. *A. cerana* was the main forager. *A. dorsata* and *A. cerana* were relatively more active in the morning while *A. florea* was active in the afternoon. The bees behaved differently on the different cultivars.

Panda *et al.* (1995) studied the relative abundance and foraging behaviour of common bee species on niger in Phulbani District, Orissa. Among *Apis* species, *A. florea* was the most common, followed by *A. cerana*, and *A. dorsata*. *A. florea* was the most efficient pollinator among the *Apis* species. The largest amount of loose pollen was found on the bodies of *A. cerana* pollen collectors and *A. dorsata* nectar foragers.

According to Rakesh Kumar and Lenin, (2000) Apoidea were the predominant flower visitors (96%) of sesame. Among these, *A. mellifera* was the most abundant (44.9%) followed by *A. dorsata* (31.4%) and *A. florea* (19.7%). During foraging on sesame flowers, *A. mellifera*, *A. dorsata*, and *A. florea* spent 8.9, 8.6 and 11.2 seconds per flower and visited 8, 5 and 4 flowers per minute.

Sesame bloom attracted *A. dorsata*, *A. mellifera*, *A. cerana*, and *A. florea* at Dharwad, Karnataka. Honey bees collectively formed 96.70 per cent of total pollinators. *A. dorsata*, *A. mellifera*, *A. cerana*, *A. florea* formed 63.07, 21.28, 6.67, and 5.68 per cent respectively. The same species of honey bees were also recorded on niger at Dharwad with honey bees collectively forming 88.21 percent of total pollinators. However *A. dorsata*, *A. mellifera*, *A. cerana*, and *A. florea* constituted 45.88, 10.81, 4.71 and 27.35 per cent respectively (Viraktamath *et al.*, 2001).

The abundance and foraging behaviour of pollinators of sesame cultivar, HT-1 grown at Haryana Agricultural University, Hisar, India was studied. *A. dorsata* was more abundant (7.53 bees/m²/5 minutes) than *A. mellifera* and *A. florea*. The time spent by *A. florea* on each flower (18.33 seconds) was longer compared to *A. dorsata* (6.66 seconds) and *A. mellifera* (11.33 seconds) (Sachdeva *et al.*, 2003).

Patnaik *et al.* (2004) found that *A. cerana* predominated among the foragers in sesame crop. Peak foraging activity (5-8 bees/m²/5 min.) by *A. cerana* was observed at 50 per cent flowering of the crop (41 days after sowing). The population of *A. mellifera* was lower (3.8 bees/m²/5min).

The experiment conducted on foraging behaviour and pollination efficiency of Indian honey bee *A. cerana* on sesame at Marathwada Agricultural university revealed that honey bees were the primary pollinating agents with *A. dorsata* as predominant and constituted 74.34 per cent, while *A. cerana* and *A. florea* formed 6.7 per cent (Kulkarni, 2007).

2.2 Influence of bee attractants on bee visitation in sesame and niger

2.2.1 Influence of bee attractants on bee visitation in oilseeds

Various solutions of Bee-line were sprayed on plots of safflower. These solutions made the safflower more attractive to insects than untreated controls (Pinzauti, 1985).

Singh and Sinha (1996) studied the effects of Bee-Q on honey bee visits. There was no increase in number of honey bee visits in Bee-Q treated hybrid sunflower plots during both years.

Bee-Q at 12.5 g/liter and 4 ml Bee-here/litre had significant influence in attracting more number of pollinators (*A. dorsata*, *A. mellifera*, *A. cerana*, *A. florea* and others) up to the fifth day after first spray (10% flowering) and up to 3rd day after the second spray (50% flowering) in sesame (Viraktamath and Patil, 1999). However Bee-Q when tested at Coimbatore as an attractant for honey bees (*Apis* spp.) in hybrid sunflowers KBSH-1, there were no significant effects on bee visits in hybrid seed production (Srimathi *et al.*, 1999).

Spraying sesame plants with the bee attractants Bee-Q and Bee here was effective in attracting higher numbers of pollinators (*Apis* spp.) (Patil *et al.*, 2000).

Sanjivan Kumar *et al.* (2000) observed that maximum bees (20.74 bees/5 flower/minute) were attracted to the sugar syrup sprayed sunflower crop followed by Bee-Q (18.10 bees/5 flower/minute).

Guruprasad (2001) found that spraying of Fruit -Boost @ 0.5 ml/l and tube rose floral scented water had significant influence in attracting more number of pollinators in niger.

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.

Fruit -Boost along with *Swertia densifolia* and Citral Z enticed more bees during rabi season in sunflower (Srikanta Nath, 2008).

2.2.2. Influence of bee attractants on bee visitation in horticultural and other crops

The application of Bee-line did not increase bee visits or seed set in cucumber cultivar 'Delila' (Rapp, 1981) However the total number of insects visiting Bee-line treated fababean plants was greater than that of untreated, but the effect of Bee-line was limited to 2-3 days (Pinzauti and Corsi, 1981).

Belletti and Zani (1981) found that application of Bee-line, containing sugar and protein, at 5 kg/ha did not attract more insects or enhance pollen transfer to male sterile plants in carrot.

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

Bee-line was totally ineffective in attracting bees to the maternal parent of Delila under summer conditions in the coastal plain of Israel (Margalith *et al.*, 1984).

In 4-year trials in apple, pear, plum and cherry orchards the effects were compared of Bee scent (2 quarts/acre) or Bee scent Plus (3 quarts), applied during blossoming to 1 acre plots by helicopter or air-blast spraying in 8 and 50 gal/acre, respectively. The percentage increase in the numbers of foraging bees due to spraying was highly variable (up to 90%), and the effects lasted for 48-96 h (Mayer *et al.*, 1989).

The attractant Bee-line on kiwifruit did not significantly increase the number of visits by honey bees compared with the control (Pinzauti, 1990).

Queen mandibular pheromone (QMP) was applied by helicopter to a cranberry in Massachusetts, USA. Honey bee (*A. mellifera*) foraging activity increased significantly after

QMP application but bumble bees (*Bombus* spp.) and other native bees showed no change in activity (MacKenzie and Averill, 1992).

Bee activity on apple and pear plots sprayed with synthetic queen mandibular pheromone at concentrations of 0.1 or 10 QEQ (a.i.)/ha did not differ significantly from controls. The pheromone was most effective on the day of application and declined to the level of control plots by the third day (Currie *et al.*, 1992a).

Queen mandibular pheromone was applied to blocks of cranberry (*Vaccinium macrocarpon*) and blueberry (*Vaccinium corymbosum*) by helicopter and air-blast sprayer, respectively. Concentrations of 100 queen equivalents (QEQ)/ha of pheromone were most effective in attracting honey bees to cranberry. On blueberry, concentrations of 100 or 1000 QEQ/ha of pheromone were attractive to bees (Currie *et al.*, 1992b).

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

The efficiency of Bee here was tested in marrow plants (*Cucurbita pepo*) growing in greenhouse conditions in Almeria, Spain. The bees did not exhibit preferences for any experimental treatment, indicating that this product is ineffective as a honey bee attractant to marrow flowers (Ortiz-Sanchez, 1993).

Synthetic queen honey bee mandibular pheromone (Fruit -Boost) was applied to Anjou pear (*Pyrus communis* L) and Bing sweet cherry (*Prunus avium*) trees using air-blast sprayers. In pear, the application of 1000 queen-equivalents (q.e.)/ha did not increase the number of honey bee (*Apis mellifera*) visits compared to unsprayed controls. In cherry, the number of bee visits, were not significantly different from those on controls (Ken-Naumann *et al.*, 1994).

Schultheis *et al.* (1994) recorded increased bee visitation in cucumber when sprayed with Bee scent and Bee-line.

Bee-scent was tested on cucumbers and watermelons and Bee-line on watermelon. The attractants did not cause any significant increase in bee activity on the flower (Ambrose *et al.*, 1995).

Niera and Barriga (1995) conducted a study at Valdivia, Chile, on the efficacy of Bee-line attractant which was applied to plots of flowering raspberry at doses of 1, 3 and 5 kg/ha. Other plots were treated with extract of *Lavandula latifolia* at 60 ml/ha. On plots treated with Bee-line at the highest dose, the number of honey bee visits to flowers and average time spent on a flower were higher than on untreated plots. Lavender extract had a similar effect on some days.

Higo *et al.* (1995) observed that honey bees stayed significantly longer time and visited more flowers in queen mandibular pheromone sprayed blueberry and cranberry plots. Low queen pheromone dose was more effective than a higher dose.

Zvedenok (1996) evaluated onions with secondary attractants and concluded that they (e.g. citral, geraniol, limonene, carrot seed extract etc.) can significantly improve pollination. Citral at 0.1-0.3 per cent had the greatest effect.

Counts of bees on kiwi fruits made before and 4, 24, 72, 96 or 120 h after spraying with Bee here showed no differences from water sprayed controls. Feeding sugar syrup and weeding to remove wild plants did not seem to affect kiwifruit pollen collection (Tsirakoglou *et al.*, 1997).

Bee counts on the apple trees showed that a significantly larger number of bees visited the Bee scent treated trees compared with the control trees (Tew and Ferree, 1999).

Two applications of Bee-Q, Bee here and sugar solution enticed more number of bees (4.01 to 4.97 bees/5flowers /min) up to 5th day after first and second spray compared to unsprayed crop (3.25 to 3.59 bees/5flowers/min) on staminate flowers of *Cucumis sativa* (Viraktamath and Anagoudar, 2002).

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

Among the bee attractants, evaluated on onion bloom, cacambe attracted more *A. cerana* for 15 days after the first spray (Kalmath and Sattigi, 2004).

Sugar syrup treated gherkin plots had significantly higher foraging activity (6.0 to 6.50 bees/m²/5min) during the first two days after spraying and the normal activity continued later (Narayanan and Gavigowda, 2005).

Pateel and Sattigi (2007) observed that spraying of cacambe 10 per cent and Bee-Q 1.25 per cent attracted maximum number of bees to cucumber up to third day after first, second and third spray. Jaggery 10 per cent and sugar solution were next best treatments in attracting bees.

An experimental situation was created in which watermelon and sunflower were blooming simultaneously and competing for pollinators. The honey bee attractant Fruit -Boost was tested for its efficacy in focusing honey bees onto the target crop (watermelon) and improving pollination. Fruit -Boost did not significantly affect total number of honey bees visiting watermelon flowers (Ellis and Delaplane, 2009).

Responses of *A. mellifera* L to vapors of selected natural and synthetic materials were screened as attractants and repellents. Among the 195 formulations, four were rated as weakly to moderately attractive. Three of the more attractive materials were alcohols and one was a fatty acid having four carbon atoms (Woodrow *et al.*, 1965).

Benzene extract of the pollen, referred to as the "attractant fraction" has been reported as a source of the stimuli which attract bees to almond pollen. Pollen supplement containing benzene extract attracted 90 per cent bees compared to untreated check. Pollen with added fructose-glucose syrup was more attractive than pollen with water only, which in turn was more attractive than dry pollen. Similarly, pollen supplement plus the attractant fraction was more attractive when mixed with fructose-glucose syrup than when mixed with water alone (Doull, 1974).

Burgett and Fisher (1979) observed that no significant differences were found between number of bees on Bee-line treated red clover and untreated areas of the same fields.

According to Gellert *et al.* (1985) honey bees were attracted to both the flowers and fruits of *Evodia hupehensis*. Two compounds isolated from the fruit were identified as 2-keto-tridecan-1-yl acetate and 2-keto-tridecanol. In a field test, more honey bees were attracted to lucerne plots sprayed with a crude extract of the dried fruit than control plots.

Among five antennally perceived alfalfa volatiles only linalool appeared attractive to honey bees (Henning *et al.*, 1992).

Attractants and repellents of *A. mellifera* were investigated in vitro and on chopped sugar cane for bovine feeding. Bee here was the most attractive and citronella oil the most repellent chemicals tested (Malerbo-Souza and Nogueira-Couto, 1998).

Bhat and Sudharshan (1999) reported that after the Bee-Q spray in cardamom number of bee visits increased by 104.8 per cent.

Formulations of leaf extract of *S. densifolia* in liquid paraffin of lower concentrations were repellent, whereas those of higher concentrations were found to be attractant to *A. cerana* (Naik *et al.*, 2005).

Fruit -Boost spray on Bt cotton at 0.5 and 1.0 ml/ litre attracted significantly more number of *A. dorsata*, *A. mellifera* and *A. cerana* up to the 5th day after spray during the first and second sprays and up to the 3rd day after the third spray. Bee-Q was the next best but was effective only up to the third days after spray. Sugar solution and tube rose flower scented water was effective only for a day (Ganapathi, 2005).

Nagiri and Patnaik (2006) reported that the bee attractants like Bee-Q or sugar solution were not effective in enhancing the foraging activity of either *A. cerana* or *A. florea* under Bhubaneswar conditions.

According to Naik *et al.* (2007) formulations of the leaf extract of *Swertia densifolia* in liquid paraffin at concentrations of up to 125 mg/ml were repellent and those at higher concentrations were attractant to *A. florea*.

2.3 Influence of bee attractants on yield parameters of sesame and niger

2.3.1 Influence of bee attractants on yield parameters oil seeds

The seed yield was recorded highest on sesame plants visited by *A. dorsata* (Mohana Rao *et al.*, 1981). Both open and bee pollination treatments were effective to increase the seed yield in sesame and niger by 50-59 per cent and 22-23 per cent respectively, over that in pollination with out insects (Panda *et al.*, 1988).

Panda *et al.* (1989) observed that seed yields on plots of sesame caged with *A. cerana* was nearly two times higher than on plots caged to exclude insects. On niger plots the presence of bees made little difference to yield, although bees increased seed set.

On plots caged with *A. cerana* the yield of niger was 3 times higher than on plots without insects (Mohana Rao and Suryanarayana, 1990). According to Bhosle *et al.*, (1992) sunflower when sprayed with 2.5 per cent sucrose solution resulted in greater seed yield than control.

Significant increases in yield by bee (*A. cerana*) pollination (2.4 - 44.4%) and open pollination (33.6-81.3%), compared to without insect pollination were observed in niger at different sowing dates (Panda *et al.*, 1993).

However Singh and Sinha, (1996) reported that there was no difference in number of filled seeds/head, percentage seed setting and test weight of 1000 seeds in Bee-Q treated hybrid sunflower plots.

In sesame two applications of Bee-Q and Bee here increased the number of capsules per plant, seeds per capsule, heavier seeds, yield and oil content (Viraktamath and Patil, 1999). Similar results have been obtained by Patil (1999) and Patil *et al.* (2000).

Sunflower sprayed with trionic acid gave maximum seed set (82.31 seed/head), 1000 seed weight (76.78 g.), and oil content (39.87%) (Sanjivan Kumar *et al.*, 2000).

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

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

Maximum yield of 220.76 kg/ha was obtained in Bee-Q sprayed niger crop at 12.5 per cent which was on par with crop caged with bees, crop sprayed with jaggery 10 per cent and 10 per cent sugar solution (Sattigi *et al.*, 2004).

Nagaraj and Bhat (2006) studied the extent of dependability of niger on honey bees for cross pollination. It was found that maximum attainable seed set was 57/capitula when the capitula were kept open throughout the bloom period and minimum was one seed when the capitula was bagged throughout the bloom period.

Srikanta Nath (2008) reported that spray of *Fagara budrunga* and *S. densifolia* produced heavier heads in morden variety of sunflower. Number of seeds per head was highest in *S. densifolia*, *F. budrunga* and Citral Z treated crop. *S. densifolia* sprayed crop produced highest yield of 19.53 q/ha. Application of bee attractants had no effect on 100 seed weight, germination percentage, and root length, shoot length and vigour index.

2.3.2 Influence of bee attractants on yield parameters of horticultural and other crops

Rajotte and Fell (1982) observed that the commercial bee attractant spray had no effect on the fruit set in apple.

Maternal parent plants of the hybrid cultivar Delila treated with Bee-line and untreated plants had the same percentages of seed per fruit and thousand seed weight (Margalith *et al.*, 1984).

Mayer *et al.* (1989) found that Bee scent application increased fruit set by 23-27 per cent on cultivar Bartlett [Williams' Bon Chretien] pears, 44 per cent on Anjou pears, 12 per

cent on Van cherries, and 5-22 per cent on Red Delicious apples. Bee scent Plus increased fruit set by 44 per cent on Bartlett pears, 15 per cent on Van cherries, 88 per cent on President Plums and 6 per cent on Red Delicious apples.

Two applications of a bee attractant, Bee scent, were made to watermelon cultivars Crimson Sweet and Royal Jubilee on 5 farms in Florida. Total fruit yield was increased on one farm with treatment (3000 fruits/acre, compared with 1500 fruits/acre without treatment) and there was an apparent increase in early yield on three farms (Elmstrom and Maynard, 1990).

Honey bee attractant, Bee scent, was applied to field grown strawberries, cultivar Selva. The numbers of mis shapen fruits were fewer, the average weight was increased and more trays of marketable fruits were produced (Butts, 1991).

Pheromone application did not result in any increase in yield or fruit quality parameters in apple, but fruit diameter of pears in plots treated with 1000 QEQ/ha was significantly greater than that of pears in unsprayed control plots (Currie *et al.*, 1992a).

Maynard *et al.* (1992) studied the periodicity of watermelon fruit set and effect of bee attractants on yield, in cultivar Big Crimson watermelon treated with Bee here. The early yield and average fruit weight for the whole season were significantly higher for treated plots than control plots.

There was no significant improvement in cucumber or watermelon yield or monetary returns by spraying Bee scent and Bee-line (Schultheis *et al.*, 1994).

Fruit size was seven per cent greater on Fruit -Boost sprayed plots in pear. In cherry, fruit size and fruit set on sprayed plots were not significantly different from those on controls (Ken-Naumann *et al.*, 1994).

In the first season the best fruit set was achieved in almond with the Bee-line, Bee scent and free pollination treatments (19.5, 17.5 and 12.6%, respectively). Manually pollinated and mesh covered branches had significantly lower fruit set (5.9 and 3.9%, respectively). Similar observations were observed in the next season also (Sotomayor, 1997).

Apple fruit quality and quantity was positively influenced by Bee scent applications (Tew and Ferree, 1999).

Two applications of Bee-Q and Bee here enhanced the fruit length of cucumber by 2.36-2.43 and 1.26-1.30 times and diameter by 2.46 and 1.44-1.51 times over caged and unsprayed crop. Significantly higher yield of 206.0- 212.5q/ha as against 135.5 and 13.5 q/ha in unsprayed and caged crops was recorded in the crop receiving two sprays of Bee-Q and Bee here (Viraktamath and Anagoudar, 2002).

Malerbo-Souza *et al.* (2004) reported that orange fruit production was 35.30 per cent greater in uncovered orange flowers sprayed with Bee here and with more fruit mean weight (180.2 g) than in covered flowers (168.5 g). The number of seeds per bud was higher in the uncovered orange flowers sprayed with Bee here (1seed/bud) than in the covered treatment (0.8 seed/ bud).

Both quantitative parameters (seeds per umbel, lowest chaffy seeds, highest number of filled seeds, highest test weight) and qualitative parameters (germination %, root length and shoot length) were observed highest in 'cacambe' sprayed plots in onion (Kalmath and Sattigi, 2005).

Burgett and Fisher (1979) evaluated Bee-line as a pollinator attractant on red clover and concluded that there was no significant increase in yield levels in clover after spraying with Bee-line.

Bee-Q spray in cardamom resulted in increased fruit set by 13.0 per cent and the number of seeds/fruits by 2.7 per cent. Recovery percentage was comparatively more in the sprayed plot (21.5%) than that of the control plot (20.8%) similarly there was increased size of capsules in sprayed plot (Bhat and Sudharshan, 1999).

Spray of Fruit -Boost resulted in good opened bolls, seeds, seed yield, lint yield and kapas yield in cotton to the extent of 9.08, 8.04, 10.45, 12.28 and 11.30 per cent over the 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 Dharwad. Dharwad is located at 15°26' North latitude, 75°07' East longitudes 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 rainfall of 700-800mm. The temperature and relative humidity ranges from 12-37 °C and 40 to 85 per cent respectively.

The materials used and techniques adopted to study the foraging behaviour of honey bees in three different genotypes of sesame and niger, the influence of bee attractants on bee visitation and influence of these attractants on yield parameters of sesame and niger are presented in this chapter.

3.1 Foraging behaviour of honey bees in three different genotypes of sesame and niger

This study was conducted on the unsprayed plots of three genotypes each of sesame and niger i.e. DS-1, E-8, SSD-1 and DNC-4, RCR-18 and No: 71 respectively. Both crops were raised during kharif season of 2008 in the plots of 6 × 80 m in alternate strips. Observations were made at peak flowering stages of both the crops for ten days on every alternate day. In sesame observations were made from two days after initiation of flowering (47th day after sowing). In niger observations commenced from seven days after initiation of flowering (52 days after sowing). There were five observations for each crop. From each plot of genotype three different spots were selected, from each spot five flowers were selected randomly and number of different honey bees visiting these flowers per five minute was recorded at 8, 10, 14 and 16 hr that coincided with their peak foraging activity.

Means of these observations were calculated and later each mean was subjected to $\sqrt{x+0.5}$ transformation and Factorial RBD analysis was done. The data was then subjected to ANOVA using MS-Excel programme and means were separated by DMRT.

3.2 Influence of bee attractants on bee visitation in sesame and niger

This experiment was carried out in both sesame and niger separately during Kharif season of 2008. Two pheromone based attractants like Citral E and Citral Z and two plant based attractants viz, *Fagara budrunga* and *Swertia densifolia* along with Fruit boost, a commercial bee attractant were selected for the study. Citral E contains *A. cerana* pheromone lure while Citral Z contains pheromone of *A. florea*.

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

The experiment was laid out in a randomized block design in the plots of 10 m × 10 m with a buffer zone of 5m × 10m between treatments and replications. Sesame and niger crop were raised by following the recommended package of practices. There were seven treatments replicated thrice in both the crops. First spray was given at 10 per cent flowering while the second was applied at 50 per cent flowering in both the crops. The details of treatments which were common to both the crops are as follows.

- T1 - spray of Citral E
- T2 - spray of Citral Z
- T3- spray of *Fagara budrunga*
- T4- spray of *Swertia densifolia*
- T5- spray of Fruit Boost lure
- T6- Spray of Sugar solution
- T7- Control (water spray)

Concentration of Citral E, Citral Z, *F. budrunga*, *S. densifolia* was 1.00 per cent while sugar solution at 10.00 per cent on both the crops (Plate 1 and 2).



Plate1: Preparation of bee attractant spray



Plate 2: Bee attractant spray on sesame

The spray solution for the first four treatments was prepared by adding 30 g lure with 30g of emulsifier (Sandovit) and mixed thoroughly with the help of Porcelain mortar and pestle separately and then diluted to the required concentration by adding water, and made up to three litres to get one per cent concentration. Fruit Boost and sugar solution were sprayed by adding required quantity of water while in the control, only water was sprayed.

Observations for the bee visitation of different species were made a day before the spray of bee attractants and one, two, three and five days after each spray on both the crops. From each treatment five flower capitula were selected randomly and number of different bees visiting these flowers per minute was recorded at 8, 10, 14 and 16 hr that coincided with their peak foraging activity.

Means of these observations were calculated and later each mean was subjected to $\sqrt{x+0.5}$ transformation. The data was then subjected to ANOVA using MS- Excel programme and means were separated by DMRT.

3.3 Influence of bee attractants on yield parameters of sesame and niger

Observations on the following yield parameters were made to study the influence of bee attractants in sesame and niger separately.

3.3.1 Number of capsules or capitula per plant

Twenty five plants from each treatment of sesame and niger were selected randomly and number of capsules (in sesame) or capitula (in niger) per twenty five plants was counted and the mean was calculated and expressed as number of capsules or capitulas per plant.

3.3.2 Number of seeds per capsule or capitula

Twenty five capsules or capitula from each treatment of both the crops were selected randomly and the number of seeds per capsule/capitula was counted from each treatment separately and the mean was worked out and expressed as number of seeds per capsule or capitula.

3.3.3 1000 seed weight

One thousand seeds from both the crops were selected randomly from each treatment separately and the weight was recorded using electronic balance.

3.3.4 Seed yield

Each crop was harvested treatment wise separately and the total seed yield per net plot was recorded and then these values were converted into yield per hectare in quintals.

3.3.5 Per cent germination

These observations were made in both the seeds of niger and sesame. Germination test was carried 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 $25 \pm 1^{\circ}\text{C}$ and 95 ± 1 per cent RH. The number of seeds germinated was counted at the end of third day (72 hr) and expressed in percentage (Plate 3 and 4).

3.3.6 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.

3.3.7 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 centimeter.

3.3.8 Vigour index

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

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



Plate 3: View of sesame experimental field



Plate 4: View of niger experimental field

4. EXPERIMENTAL RESULTS

The results of the investigations on the foraging behaviour of honey bees in different genotypes of sesame and niger, the influence of bee attractants on bee visitation and yield parameters of sesame and niger are presented in this chapter.

4.1 Study on the foraging behaviour of honey bees on different genotypes of sesame and niger

4.1.1 Foraging behaviour of *Apis dorsata* in sesame genotypes

Observations pertaining to foraging behaviour of *Apis dorsata* in different genotypes of sesame are presented in Table 1.

The mean *Apis dorsata* visitation on different genotypes DS-1, E-8, and SSD-1 was 2.24, 2.63 and 2.46 bees /5 flowers /minute, respectively and the visitation did not differ significantly. However the mean bee visitation was significantly more on 4, 8, 10 and 12 days after flowering which were at par with each other (2.33 to 2.89 bees /5 flowers /minute). On the 4th day after flowering less bee visitation was recorded (1.50 bees /5 flowers /minute). The bee visitation differed significantly (1.50 to 3.33 bees /5 flowers /minute) when the interaction between genotypes and days of flowering was considered. The highest bee visitation (3.33 bees /5 flowers /minute) was recorded on SSD-1 variety at 10 days after flowering (Fig. 1, 2, Plate 5 and 6).

4.1.2 Foraging behaviour of *Apis cerana* in sesame genotypes

Apis cerana visited significantly in higher number on DS-1 and E-8 (0.82 to 0.94 bees /5 flowers /minute) followed by SSD-1 (0.53 bees /5 flowers /minute) (Table 2). On different days of flowering the mean bee visitation was significantly higher and at par on 4, 6, 10 and 12 days after flowering (0.66, 1.17, 0.66 and 0.82 bees /5 flowers /minute). However on 8th day significantly lesser number of bees (0.50 bees /5 flowers /minute) observed. When the interaction between genotypes and days of flowering was considered, the mean bee visitation was significantly different and ranged from 0.00 to 2.00 bees /5 flowers /minute (Fig. 3 and 4).

4.1.3 Foraging behaviour of *Apis florea* in sesame genotypes

A. florea visitation did not differ among the genotypes and it varied from 0.14 to 0.59 bees /5 flowers /minute (Table 3). Similarly the bee visitation days after flowering varied from 0.11 to 0.68 bees /5 flowers /minute) did not vary statistically. However the interaction between genotypes and days of flowering showed that the bee visitation was significant and varied from 0.00 to 1.83 bees /5 flowers /minute (Fig. 5 and 6).

4.1.4 Foraging behaviour of all *Apis* pollinators in sesame genotypes (pooled data of different *Apis* species)

The total number of *Apis* bee visitation was similar on all sesame genotypes and it varied from 3.35 to 3.59 bees /5 flowers /minute (Table 4). However mean bee visitation on different days was significantly different. The bee visitation was higher on 4th, 8th, 10th and 12th days after flowering (3.29 to 4.15 bees /5 flowers /minute). Significantly less number of bees were recorded on 6th day after flowering (2.78 bees /5 flowers /minute). The bees visited differently when the interaction between genotypes and days of flowering was considered (2.61 to 5.42 bees /5 flowers /minute) (Fig. 7 and 8).

4.1.5 Foraging behaviour of *Apis dorsata* in niger genotypes

The mean *A. dorsata* visitation was significantly different with higher number of bees on RCR-18 and No-71 (3.29 and 2.73 bees /5 flowers /minute respectively) which were on par with each other followed by the DNC-4 (1.83 bees /5 flowers /minute) (Table 5). The mean bee visitation was higher on 11th, 15th and 17th days after flowering (2.85 to 3.75 bees /5 flowers /minute) followed by the 9th and 13th days (1.94 and 1.42 bees/5 flowers/minute). The interaction between the days and the genotypes on mean bee visitation was found to be significant. (0.42 to 6.57 bees/5 flowers/minute) (Fig. 9 and 10).

Table 1. Foraging behaviour of *Apis dorsata* in sesame genotypes

Days after flowering	Number of <i>A. dorsata</i> / 5 flowers /min in genotypes			Mean
	DS-1	E-8	SSD-1	
4 DAF	2.33 (1.68) ^{cd}	2.67 (1.78) ^{abc}	2.00 (1.58) ^d	2.33 (1.68) ^a
6 DAF	1.50 (1.41) ^e	1.50 (1.41) ^e	1.50 (1.41) ^e	1.50 (1.41) ^b
8 DAF	2.42 (1.71) ^{bcd}	3.00 (1.87) ^{ab}	3.13 (1.90) ^a	2.85 (1.83) ^a
10 DAF	2.17 (1.63) ^{cd}	3.17 (1.91) ^a	3.33 (1.95) ^a	2.89 (1.83) ^a
12DAF	2.78 (1.81) ^{abc}	2.83 (1.82) ^{abc}	2.33 (1.68) ^{cd}	2.65 (1.77) ^a
Mean	2.24 (1.65) ^a	2.63 (1.76) ^a	2.46 (1.71) ^a	
	S.Em.±		CD	
Genotypes (G)	0.02		NS	
Days (D)	0.01		0.03	
G x D	0.03		0.09	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

DAF – Days after flowering

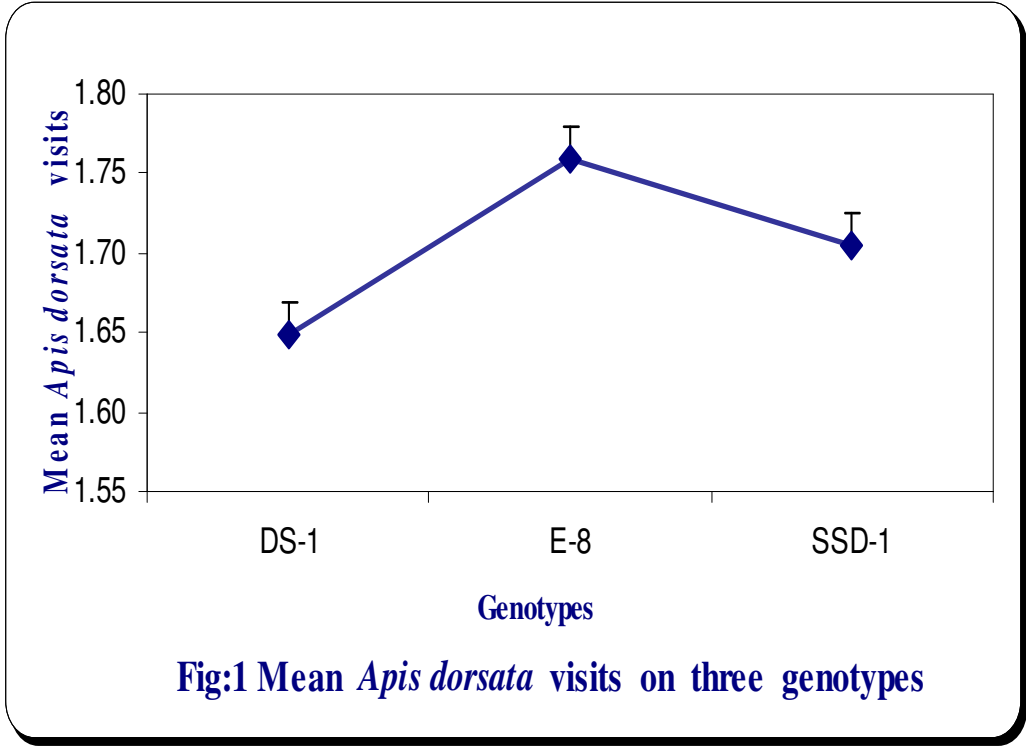


Fig.1: Mean *Apis dorsata* visits on three genotypes

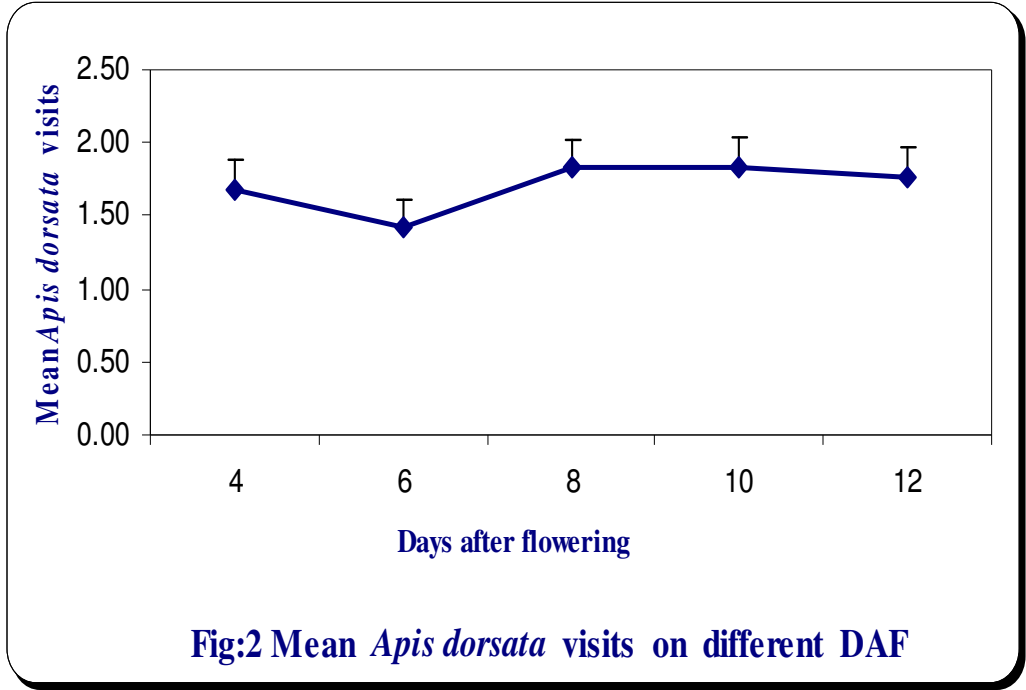


Fig.2: Mean *apis dorsata* visits on different DAF

Table 2. Foraging behaviour of *Apis cerana* in sesame genotypes

Days after flowering	Number of <i>A. cerana</i> / 5 flowers /min in genotypes			Mean
	DS-1	E-8	SSD-1	
4 DAF	1.33 (1.35) ^b	0.33 (0.91) ^d	0.33 (0.91) ^d	0.66 (1.06) ^{ab}
6 DAF	2.00 (1.58) ^a	1.50 (1.41) ^b	0.00 (0.71) ^e	1.17 (1.23) ^a
8 DAF	0.38 (0.93) ^{cd}	0.38 (0.93) ^{cd}	0.75 (1.11) ^c	0.50 (0.99) ^b
10 DAF	0.33 (0.91) ^d	1.33 (1.35) ^b	0.33 (0.91) ^d	0.66 (1.06) ^{ab}
12DAF	0.66 (1.08) ^{cd}	0.55 (1.02) ^{cd}	1.25 (1.32) ^b	0.82 (1.14) ^{ab}
Mean	0.94 (1.17) ^a	0.82 (1.13) ^{ab}	0.53 (0.99) ^b	
	S.Em.±		CD	
Genotypes (G)	0.03		0.07	
Days (D)	0.03		0.10	
G×D	0.02		0.07	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values
 DAF – Days after flowering

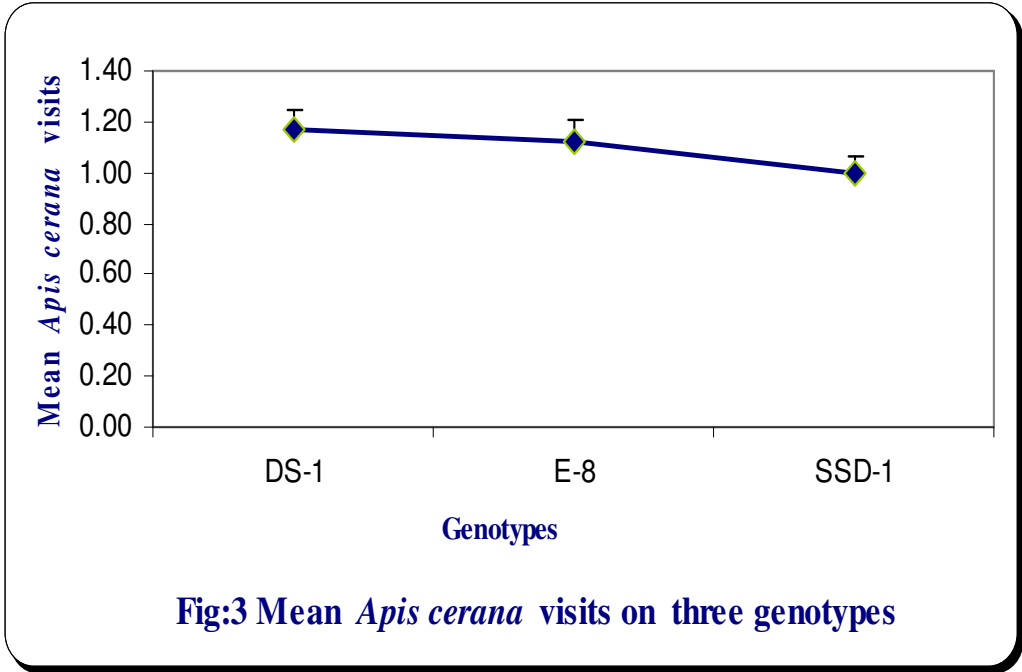


Fig.3: Mean *Apis cerana* visits on three genotypes

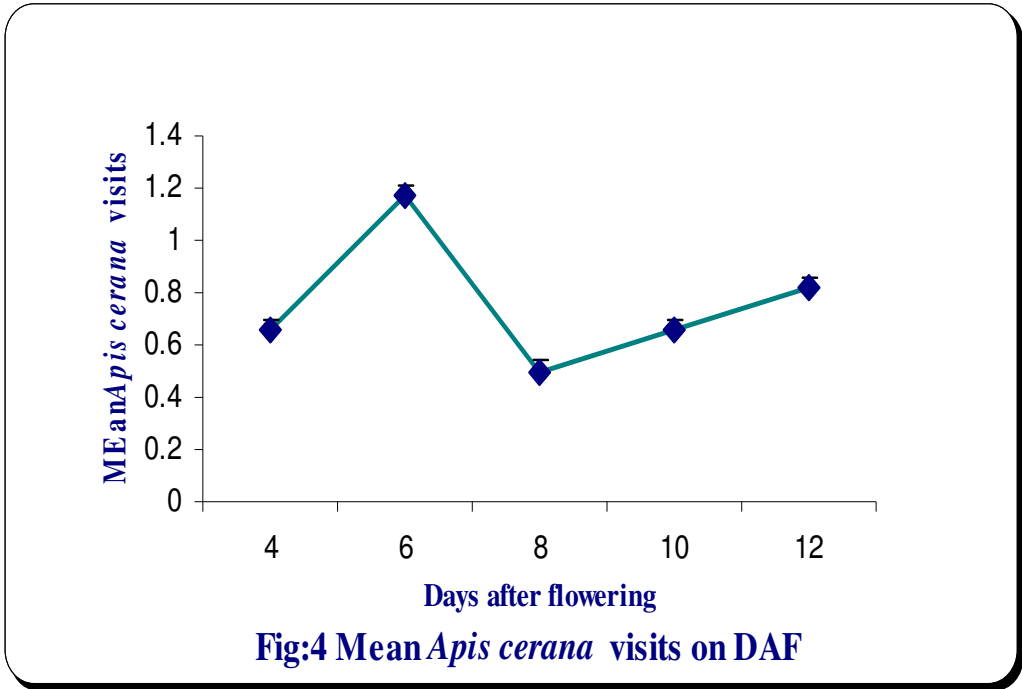


Fig.4: Mean *Apis cerana* visits on DAF



Plate 5: *Apis dorsata* on sesame flower



Plate 6: *Apsi dorsata* on niger flower

Table 3. Foraging behaviour of *Apis florea* in sesame genotypes

Days after flowering	Number of <i>A. florea</i> / 5 flowers /min in genotypes			Mean
	DS-1	E-8	SSD-1	
4 DAF	0.44 (0.95) ^{bc}	0.11 (0.78) ^{bc}	0.33 (0.91) ^{bc}	0.29 (0.88) ^a
6 DAF	0.33 (0.90) ^{bc}	0.00 (0.71) ^c	0.00 (0.71) ^c	0.11 (0.77) ^a
8 DAF	0.00 (0.71) ^c	0.17 (0.81) ^{bc}	0.58 (1.03) ^b	0.25 (0.85) ^a
10 DAF	0.11 (0.78) ^{bc}	0.22 (0.84) ^{bc}	0.22 (0.84) ^{bc}	0.18 (0.82) ^a
12DAF	0.00 (0.71) ^c	0.22 (0.84) ^{bc}	1.83 (1.50) ^a	0.68 (1.02) ^a
Mean	0.18 (0.81) ^a	0.14 (0.80) ^a	0.59 (1.00) ^a	
	S.Em.±		CD	
Genotypes (G)	0.04		NS	
Days (D)	0.05		NS	
G×D	0.08		0.24	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

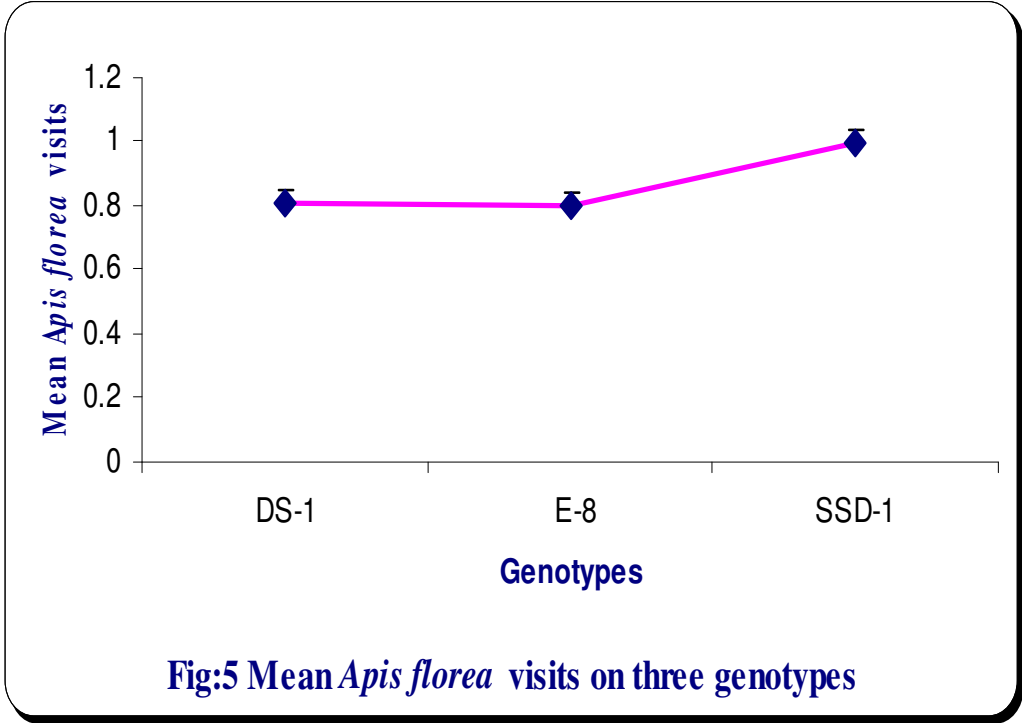


Fig.5: Mean Apis flrea visits on three genotypes

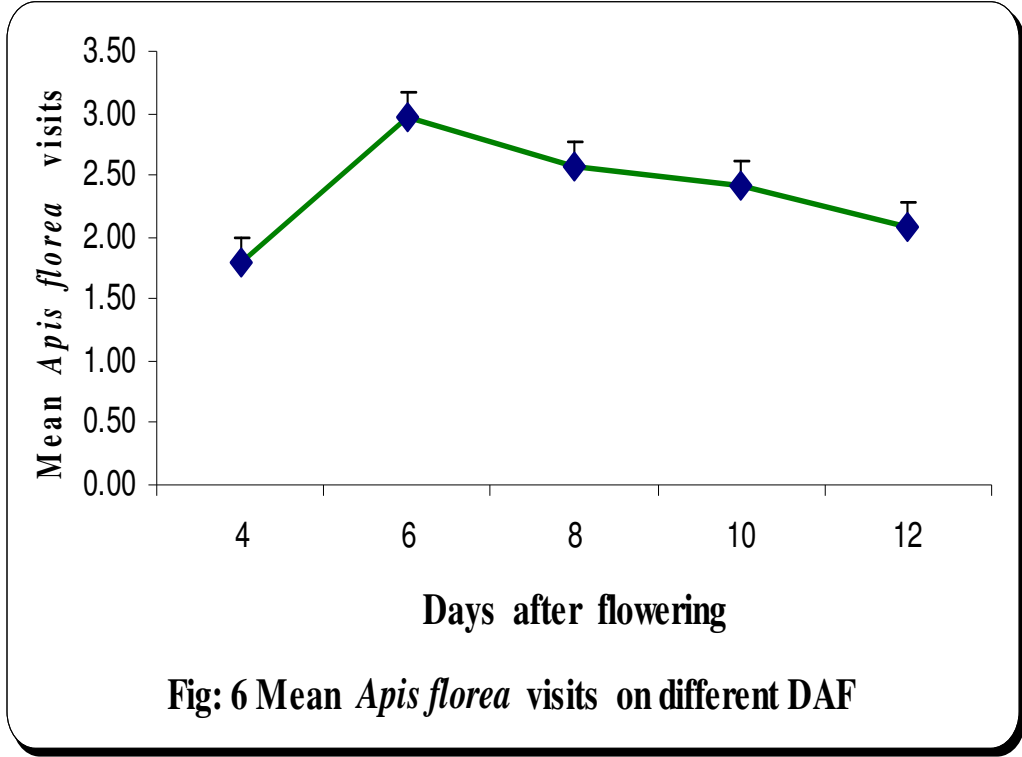


Fig.6: Mean Apis florae visits on different DAF

Table 4. Foraging behaviour of all *Apis* pollinators in sesame genotypes (pooled data of three *Apis* species)

Days after flowering	Number of total <i>Apis</i> bees / 5 flowers /min in genotypes			Mean
	DS-1	E-8	SSD-1	
4 DAF	4.10 (2.14) ^{bcd}	3.11 (1.90) ^{def}	2.66 (1.78) ^f	3.29 (1.94) ^{ab}
6 DAF	3.83 (2.08) ^{bcde}	3.00 (1.87) ^{def}	1.50 (1.41) ^g	2.78 (1.79) ^b
8 DAF	2.79 (1.81) ^{ef}	3.54 (2.01) ^{cde}	4.46 (2.22) ^{abc}	3.60 (2.02) ^{ab}
10 DAF	2.61 (1.76) ^f	4.72 (2.28) ^{ab}	3.88 (2.08) ^{bc}	3.73 (2.04) ^{ab}
12DAF	3.44 (1.98) ^{cde}	3.60 (2.02) ^{bc}	5.42 (2.42) ^a	4.15 (2.14) ^a
Mean	3.35 (1.96) ^a	3.59 (2.02) ^a	3.58 (1.98) ^a	
	S.Em.±		CD	
Genotypes (G)	0.03		NS	
Days (D)	0.04		0.13	
G×D	0.08		0.22	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values
 DAF – Days after flowering

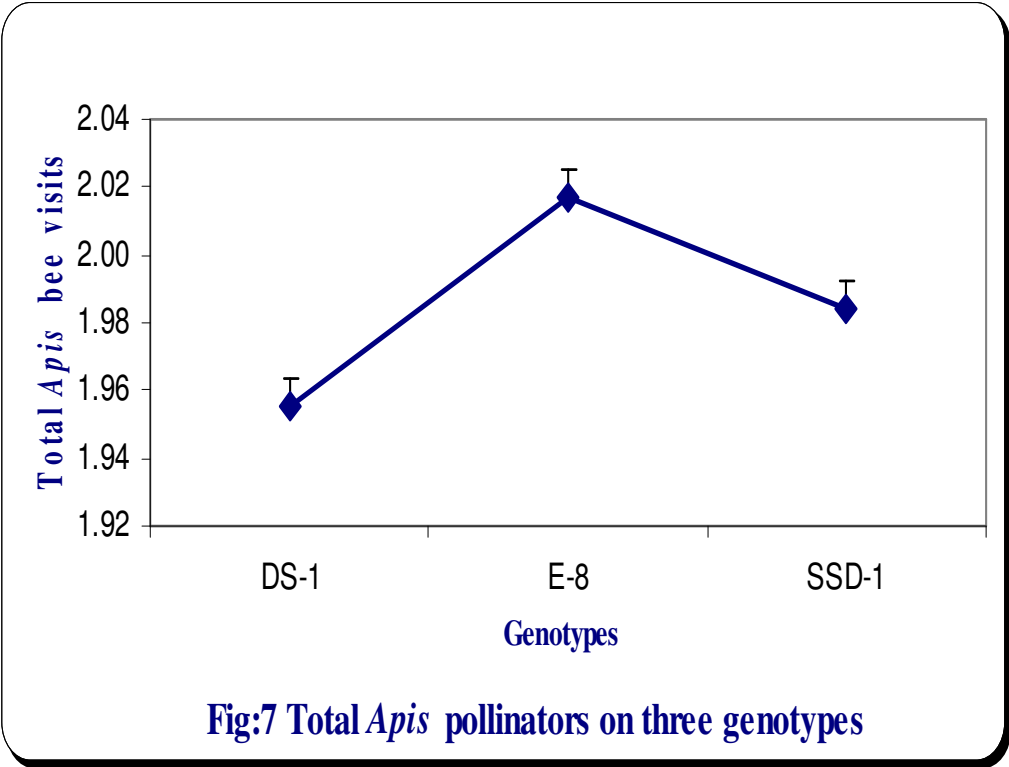


Fig.7: Total Apis pollinators on three genotypes

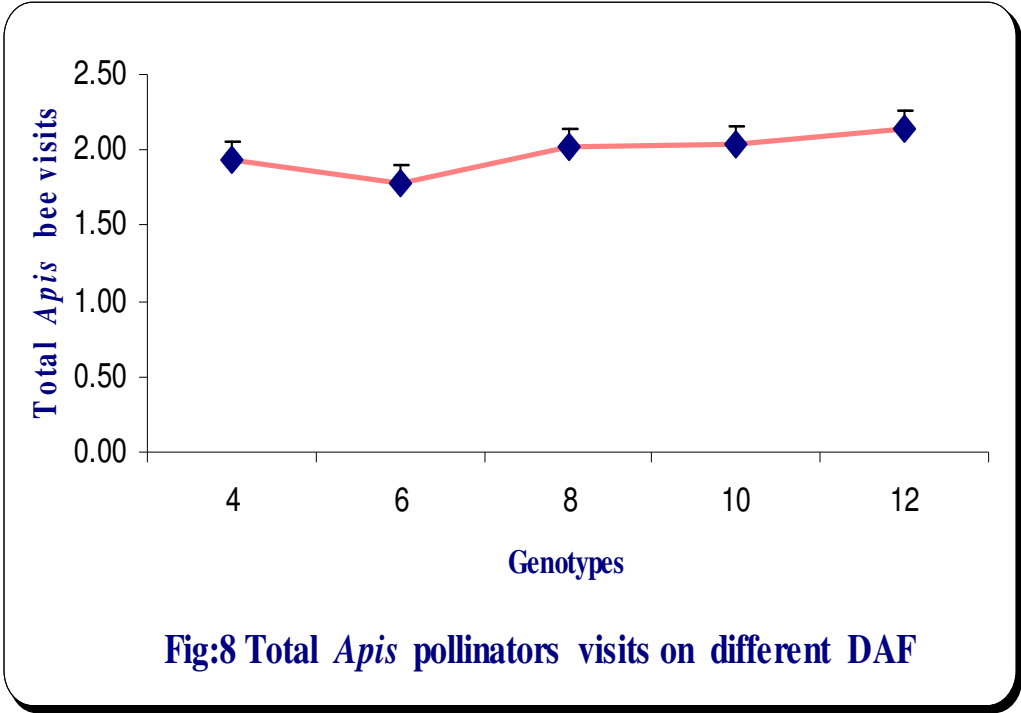


Fig.8: Total Apis pollinators visits on different DAF

Table 5. Foraging behaviour of *Apis dorsata* in three genotypes of niger

Days after flowering	Number of <i>A. dorsata</i> / 5 flowers /min in genotypes			Mean
	DNC-4	RCR-18	NO-71	
9 DAF	0.42 (0.96) ⁱ	1.46 (1.40) ^{gh}	3.96 (2.11) ^{bc}	1.94 (1.49) ^b
11 DAF	1.25 (1.32) ^{gh}	6.57 (2.66) ^a	1.57 (1.43) ^{fgh}	3.13 (1.81) ^a
13 DAF	1.87 (1.53) ^{efg}	1.57 (1.43) ^{fgh}	0.84 (1.15) ^{hi}	1.42 (1.37) ^b
15 DAF	2.50 (1.73) ^{def}	3.13 (1.89) ^{cd}	2.92 (1.83) ^{cde}	2.85 (1.81) ^a
17 DAF	3.13 (1.90) ^{bcd}	3.75 (2.06) ^{bc}	4.38 (2.21) ^b	3.75 (2.06) ^a
Mean	1.83 (1.49) ^b	3.29 (1.89) ^a	2.73 (1.74) ^{ab}	
	S.Em.±		CD	
Genotypes (G)	0.01		0.03	
Days (D)	0.02		0.05	
G×D	0.05		0.16	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values
 DAF – Days after flowering

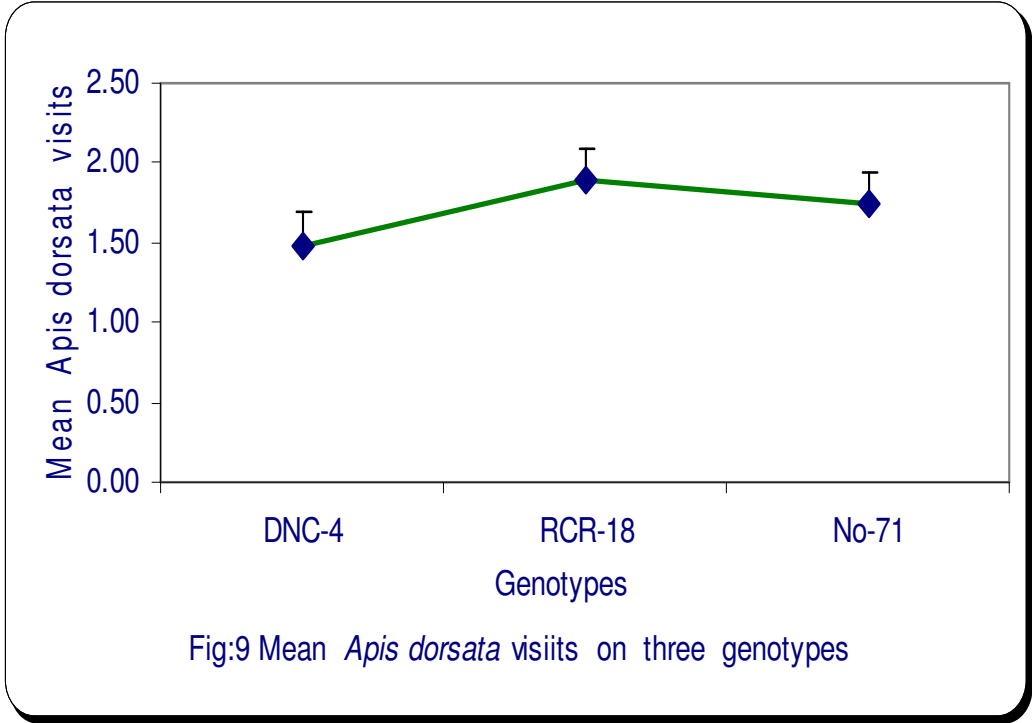


Fig.9: Mean *Apis dorsata* visits on three genotypes

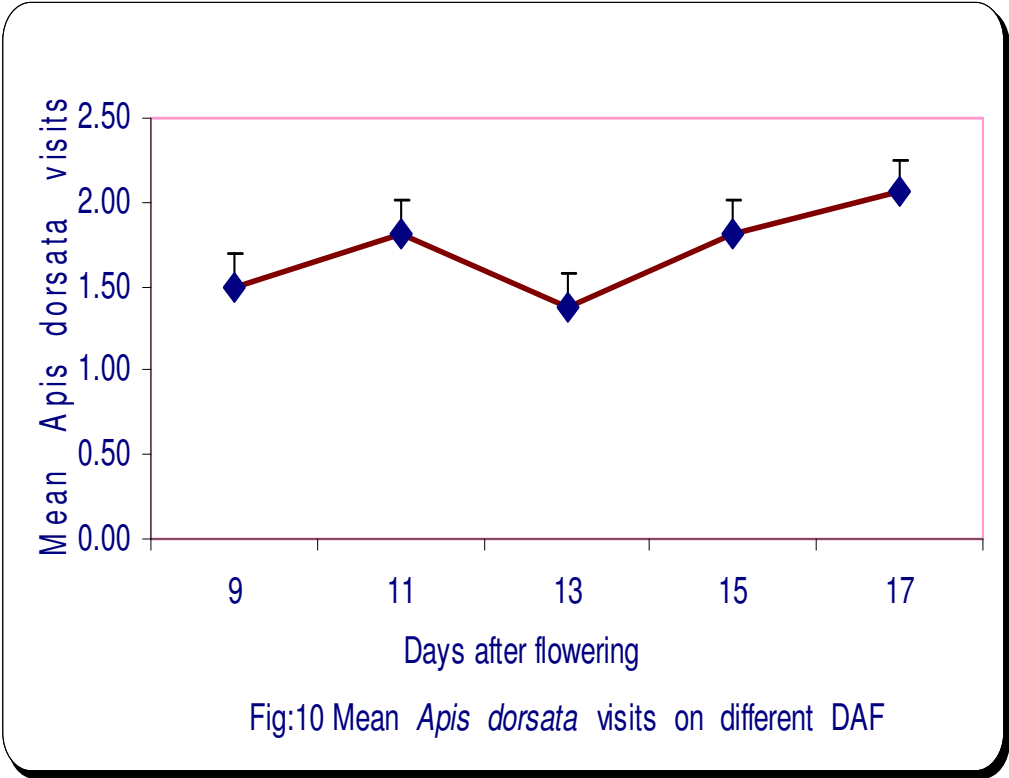


Fig.10: Mean *Apis dorsata* visits on different DAF

Table 6. Foraging behaviour of *Apis cerana* in three genotypes of niger

Days after flowering	Number of <i>A. cerana</i> / 5 flowers /min in genotypes			Mean
	DNC-4	RCR-18	NO-71	
9 DAF	2.07 (1.60) ^{de}	2.09 (1.60) ^{de}	1.25 (1.32) ^{fg}	1.80 (1.51) ^{bc}
11 DAF	2.82 (1.81) ^{cd}	3.13 (1.91) ^c	1.67 (1.47) ^{ef}	2.54 (1.73) ^{ab}
13 DAF	0.25 (0.87) ^h	1.88 (1.54) ^{ef}	5.00 (2.35) ^b	2.38 (1.58) ^{bc}
15 DAF	0.83 (1.15) ^g	2.08 (1.60) ^{de}	2.22 (1.64) ^{de}	1.71 (1.47) ^c
17 DAF	1.67 (1.46) ^{ef}	2.50 (1.73) ^{cde}	6.88 (2.70) ^a	3.68 (1.96) ^a
Mean	1.53 (1.38) ^b	2.34 (1.68) ^a	3.40 (1.90) ^a	
	S.Em.±		CD	
Genotypes (G)	0.01		0.03	
Days (D)	0.05		0.14	
G×D	0.09		0.25	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values
 DAF – Days after flowering

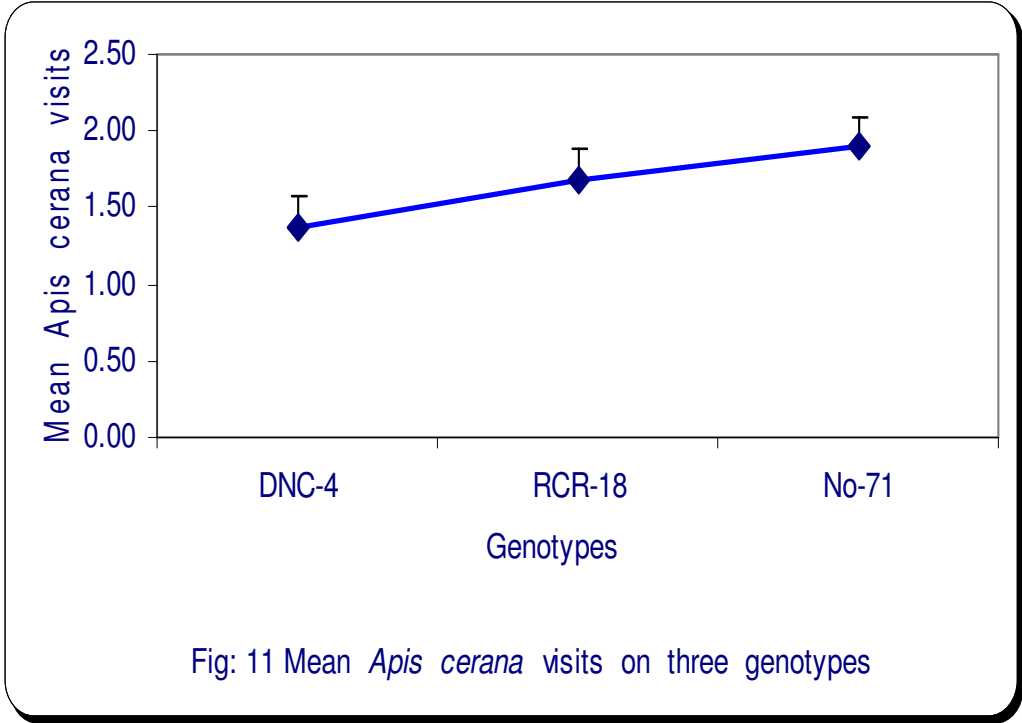


Fig.11: Mean *Apis cerana* visits on three genotypes

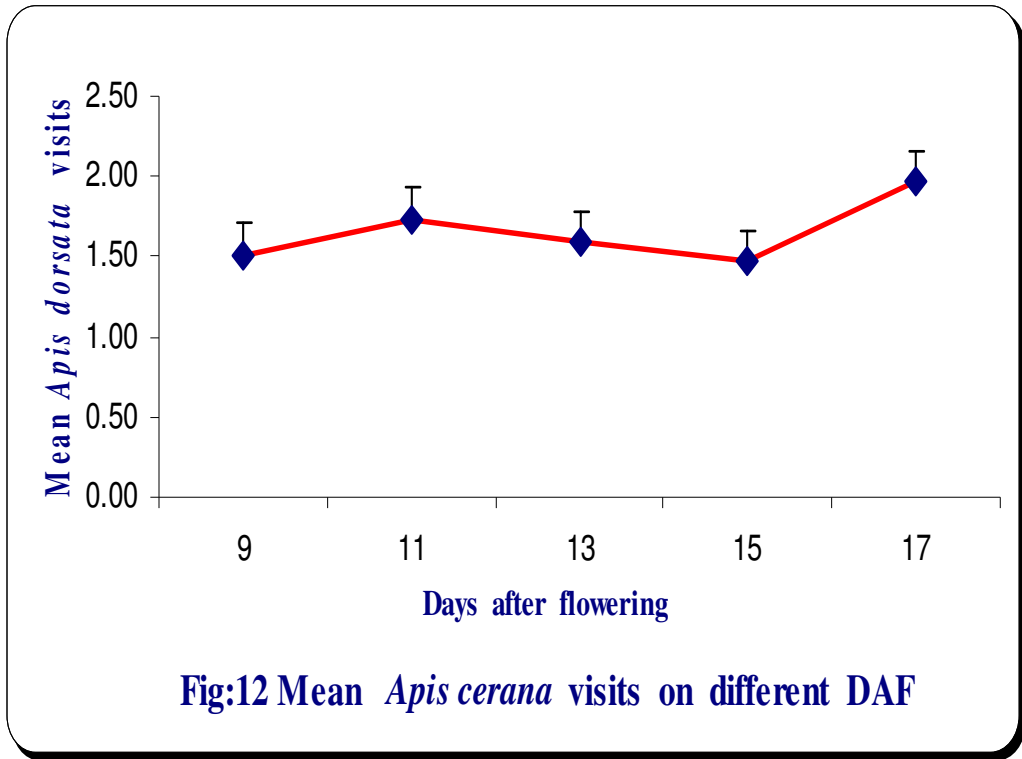


Fig.12: Mean *Apis cerana* visits on different DAF

4.1.6 Foraging behaviour of *Apis cerana* in niger genotypes

Apis cerana visitation was significantly higher on RCR-18 and NO-71 with 2.34 and 3.40 bees /5 flowers /minute which were on par with each other (Table 6 and Fig. 11). DNC-4 recorded the least number of bees (1.53 bees /5 flowers /minute). Higher number of *A. cerana* bee visits was recorded on 11th and 17th day after flowering. (2.54 and 3.68 bees /5 flowers /minute) followed by 9th and 13th (1.80 and 2.38 bees /5 flowers /minute) and least number of bees was recorded on 15th day after flowering which was however on par with the bee visits on 9th and 13th days after flowering. Mean bee visitation that ranged (0.25 to 6.88 bees /5 flowers /minute) was found to be significant when the interaction between genotypes and days of flowering was considered (Fig. 12).

4.1.7 Foraging behaviour of *Apis florea* in niger genotypes

A. florea had equal preference to different genotypes of niger though the bee visitation varied from 4.33 to 5.97 bees /5 flowers /minute (Table 7). However on different days its behaviour was different with higher number of bees on 11th day after flowering (8.37 bees /5 flowers /minute) followed by 13th and 15th day after flowering (6.45 to 5.32 bees /5 flowers /minute) and the least on 9th and 17th day (2.82 and 3.82 bees /5 flowers /minute). Interaction effect between days after flowering and the genotypes was found significant on *A. florea* visitation (Fig. 13 and 14).

4.1.8 Foraging behaviour of all *Apis* pollinators in niger genotypes (pooled data of different *Apis* species)

Total number of *Apis* bee visitation was on par on different genotypes with 9.13 to 11.60 bees /5 flowers /minute (Table 8). Higher mean bee visitation was recorded on 11th day after flowering (14.04 bees /5 flowers /minute) followed by 13th, 15th and 17th day after flowering i.e. 10.25, 9.88 and 11.25 bees /5 flowers /minute respectively which were on par with each other. On the 9th day after flowering least number of bees was recorded (6.57 bees /5 flowers /minute). The interaction between days after flowering and the genotypes on total bee visitation was significant and ranged from 5.21 to 18.87 bees /5 flowers /minute. Highest number of bees were visited on 11th days after flowering in RCR-18 interestingly on the same variety lowest number of bees were visited on 9 days after flowering (Fig. 15 and 16).

4.2 Study on the influence of bee attractants on bee visitation in sesame and niger

4.2.1 Influence of bee attractants on bee visitation in sesame

First spray

A day before the spray bee visitation was similar in all the treatments which varied from 0.5 to 1.38 bees /5 flowers /minute (Table 9).

A day after spraying significantly higher number of bees was recorded on the crop sprayed with Citral E (2.49 bees /5 flowers /minute) and *F. budrunga* (2.18 bees /5 flowers /minute). The bee visitation varied from 1.86 to 2.05 bees /5 flowers /minute on the crop treated with Fruit Boost, *S. densifolia* and Citral Z which were on par with each other. The crop sprayed with sugar solution was the next best treatment (1.66 bees /5 flowers /minute) followed by control which recorded 1.15 bees /5 flowers /minute.

Second day after spray, significantly higher number of bees was recorded on plots treated with Fruit Boost (2.55 bees /5 flowers /minute) and *S. densifolia* (2.34 bees /5 flowers /minute) sprayed plots. *F. budrunga* attracted next higher number of bees (1.88 bees /5 flowers /minute) followed by Citral E (1.19 bees /5 flowers /minute), Citral Z (0.62 bees /5 flowers /minute) and sugar solution (0.69 bees /5 flowers /minute) which were on par with each other.

On third day after spray *F. budrunga* (1.79 bees /5 flowers /minute) and *S. densifolia* (1.75 bees /5 flowers /minute) treated plots recorded significantly higher bee visits. Citral E (0.76 bees /5 flowers /minute), Citral Z (0.74 bees /5 flowers /minute), Fruit Boost (1.10 bees /5 flowers /minute) and sugar solution (0.64 bees /5 flowers /minute) were the next best attractants and were on par with each other.

Table 7. Foraging behaviour of *A. florea* in three genotypes of niger

Days after flowering	Number of total <i>A. florea</i> / 5 flowers /min in genotypes			Mean
	DNC-4	RCR-18	NO-71	
9 DAF	3.75 (2.06) ^{de}	1.67 (1.47) ^f	3.05 (1.86) ^e	2.82 (1.80) ^c
11 DAF	9.38 (3.14) ^a	9.17 (3.11) ^a	6.56 (2.66) ^b	8.37 (2.97) ^a
13 DAF	6.57 (2.66) ^b	10.03 (3.24) ^a	2.75 (1.80) ^e	6.45 (2.57) ^b
15 DAF	5.42 (2.43) ^{bc}	5.83 (2.51) ^{bc}	4.72 (2.28) ^{cd}	5.32 (2.41) ^b
17 DAF	3.75 (2.06) ^{de}	3.13 (1.90) ^e	4.58 (2.25) ^{cd}	3.82 (2.07) ^c
Mean	5.77 (2.47) ^a	5.97 (2.44) ^a	4.33 (2.17) ^a	
	S.Em.±		CD	
Genotypes (G)	0.05		NS	
Days (D)	0.06		0.17	
G×D	0.10		0.29	

Figures in the parenthesis are $\sqrt{(X+0.5)}$ transformed values

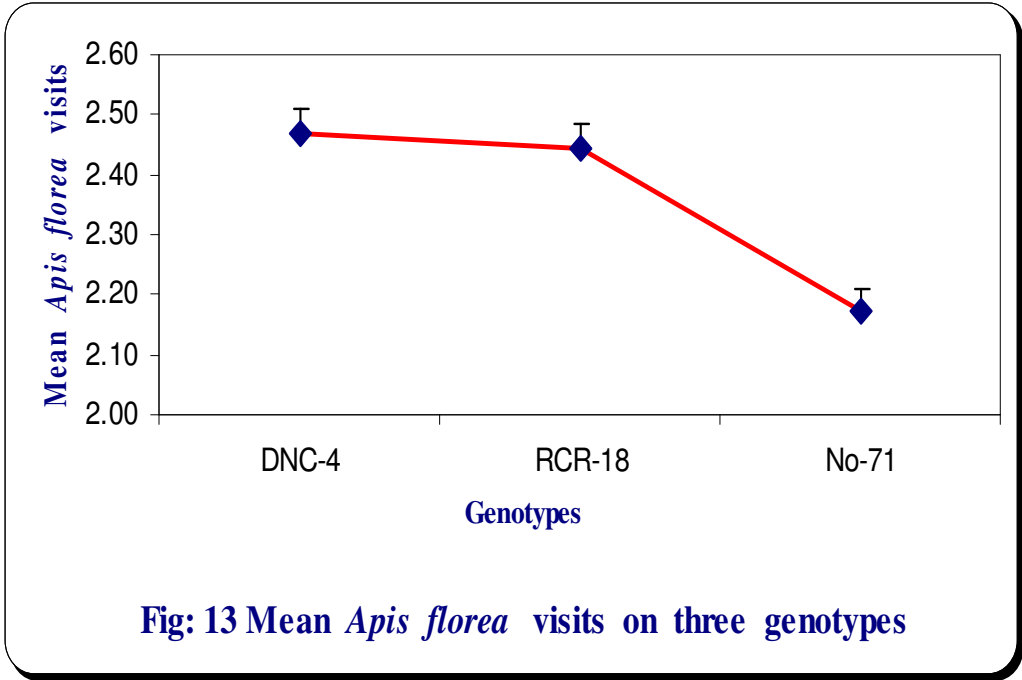


Fig.13: Mean *Apis florea* visits on three genotypes

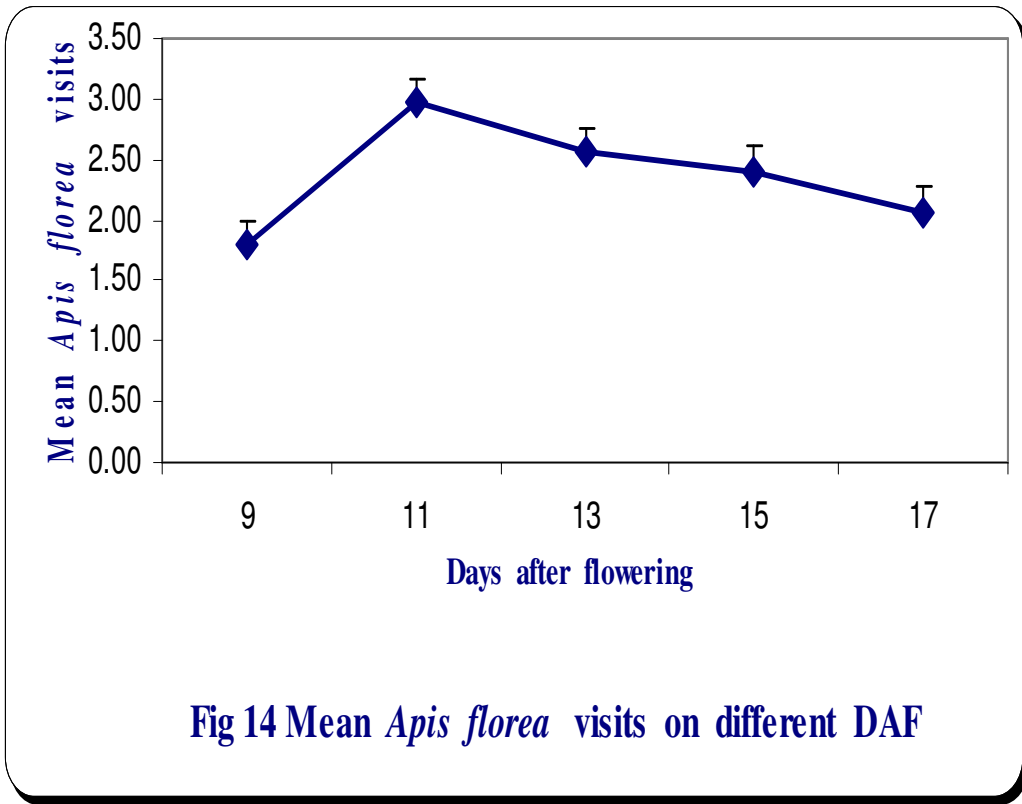


Fig.14: Mean *Apis florea* visits on different DAF

Table 8. Foraging behaviour of all *Apis* pollinators in three genotypes of niger (pooled data of three *Apis* species)

Days after flowering	Number of total <i>Apis</i> bees / 5 flowers /min in genotypes			Mean
	DNC-4	RCR-18	NO-71	
9 DAF	6.24 (2.60) ^f	5.21 (2.39) ^f	8.26 (2.95) ^e	6.57 (2.65) ^c
11 DAF	13.45 (3.73) ^{bc}	18.87 (4.40) ^a	9.80 (3.21) ^{de}	14.04 (3.78) ^a
13 DAF	8.69 (3.03) ^{de}	13.48 (3.73) ^{bc}	8.59 (3.01) ^{de}	10.25 (3.26) ^b
15 DAF	8.75 (3.04) ^{de}	11.04 (3.39) ^{cd}	9.86 (3.21) ^{de}	9.88 (3.21) ^b
17 DAF	8.54 (3.01) ^{de}	9.38 (3.14) ^{de}	15.83 (4.04) ^b	11.25 (3.39) ^b
Mean	9.13 (3.08) ^a	11.60 (3.41) ^a	10.47 (3.28) ^a	
	S.Em.±			CD
Genotypes (G)	0.05			0.06
Days (D)	0.06			0.19
G×D	0.11			0.32

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values
 DAF – Days after flowering

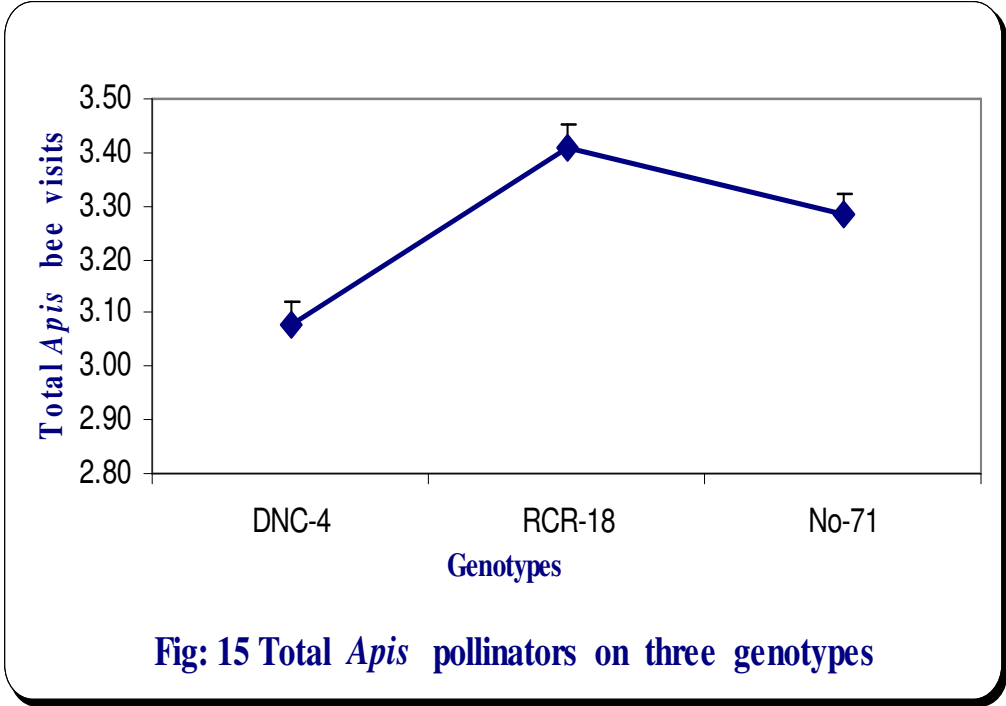


Fig.15: Total Apis pollinators on three genotypes

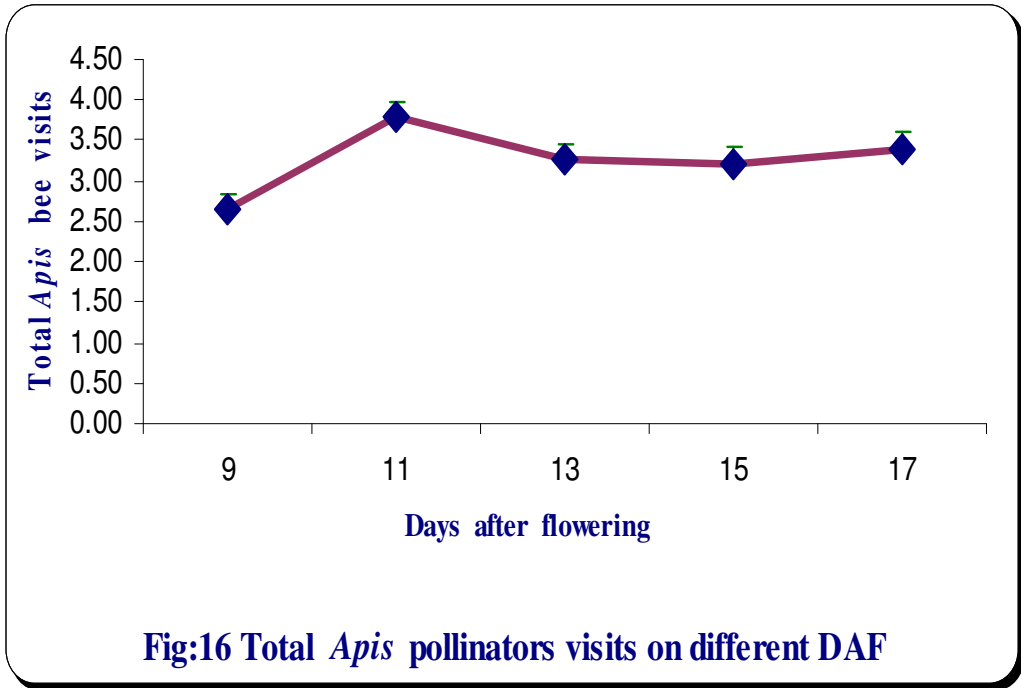


Fig.16: Total Apis pollinators visits on different DAF

Table 9. Influence of bee attractants on bee visitation in sesame - First spray

Treatments	Number of bees / 5 flowers / min						
	1DBFS	1DAFS	2DAFS	3DAFS	4DAFS	5DAFS	Mean
Citral E @ 1%	0.50 (0.98)	2.49 (1.73) ^a	1.19 (1.30) ^c	0.76 (1.12) ^b	2.89 (1.84) ^{ab}	3.83 (2.08) ^a	2.23 (1.61) ^a
Citral Z @ 1%	0.67 (1.07)	2.05 (1.60) ^b	0.62 (1.06) ^d	0.74 (1.11) ^b	3.28 (1.94) ^{ab}	3.91 (2.10) ^a	2.12 (1.56) ^{ab}
<i>Fagara budrunga</i> @1%	0.92 (1.10)	2.18 (1.64) ^{ab}	1.88 (1.54) ^b	1.79 (1.51) ^a	2.74 (1.80) ^b	2.82 (1.82) ^b	2.28 (1.66) ^a
<i>Swertia densifolia</i> @ 1%	1.00 (1.19)	1.93 (1.56) ^{bc}	2.34 (1.69) ^a	1.75 (1.49) ^a	3.50 (2.00) ^a	2.71 (1.78) ^{bc}	2.45 (1.70) ^a
Fruit boost @ 1%	1.11 (1.24)	1.86 (1.54) ^{bc}	2.55 (1.75) ^a	1.10 (1.26) ^b	2.87 (1.84) ^{ab}	2.25 (1.63) ^{bc}	2.13 (1.60) ^a
Sugar solution @ 10%	1.38 (1.36)	1.66 (1.47) ^c	0.69 (1.09) ^d	0.64 (1.07) ^b	2.66 (1.78) ^b	1.88 (1.54) ^c	1.51 (1.39) ^{bc}
Control	0.93 (1.19)	1.15 (1.28) ^d	0.41 (0.95) ^e	0.20 (0.83) ^c	2.57 (1.75) ^b	1.88 (1.54) ^c	1.24 (1.27) ^c
S.Em.±	0.19	0.04	0.04	0.06	0.05	0.08	0.05
CD	NS	0.12	0.12	0.20	0.15	0.26	0.17

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

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

DBFS = Day before first spray

DAFS = Days after first spraying

Table 10. Influence of bee attractants on bee visitation in sesame – Second spray

Treatments	Number of bees / 5 flowers / min						
	1DBBS	1DASS	2DASS	3DASS	4DASS	5DASS	Mean
Citral E @ 1%	1.42 (1.37)	2.65 (1.77) ^c	2.15 (1.61) ^{ab}	4.00 (2.12) ^b	3.96 (2.11) ^{bc}	6.96 (2.73) ^a	3.94 (2.07) ^{ab}
Citral Z @ 1%	1.46 (1.38)	2.76 (1.81) ^c	3.20 (1.92) ^a	4.70 (2.28) ^a	4.54 (2.24) ^{ab}	5.94 (2.54) ^b	4.23 (2.16) ^a
<i>Fagara budrunga</i> @1%	1.33 (1.33)	4.38 (2.21) ^a	2.51 (1.73) ^a	3.58 (2.02) ^c	2.25 (1.66) ^d	4.28 (2.19) ^c	3.40 (1.96) ^{bc}
<i>Swertia densifolia</i> @ 1%	1.42 (1.37)	2.03 (1.59) ^e	2.58 (1.71) ^a	3.03 (1.88) ^d	3.76 (2.06) ^c	5.00 (2.33) ^c	3.28 (1.91) ^c
Fruit boost @ 1%	1.36 (1.35)	3.34 (1.96) ^b	2.42 (1.69) ^a	4.12 (2.15) ^b	4.85 (2.31) ^a	4.85 (2.31) ^c	3.92 (2.08) ^{ab}
Sugar solution @ 10%	1.39 (1.35)	2.35 (1.69) ^d	1.72 (1.49) ^{ab}	2.69 (1.79) ^{de}	3.75 (2.06) ^c	4.79 (2.30) ^c	3.06 (1.87) ^c
Control	1.43 (1.38)	1.23 (1.32) ^f	0.94 (1.18) ^b	2.48 (1.72) ^e	2.50 (1.73) ^d	2.82 (1.82) ^d	1.99 (1.55) ^d
S.Em.±	0.15	0.02	0.16	0.01	0.05	0.06	
CD	NS	0.07	0.49	0.03	0.16	0.18	

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

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

DBSS = Day before second spray

DASS = Days after second spraying

S. densifolia (3.50 bees /5 flowers /minute), Citral Z (3.28 bees /5 flowers /minute), Citral E (2.89 bees /5 flowers /minute) and Fruit Boost (2.87 bees /5 flowers /minute) recorded maximum number of bee visits and were on par with each other on the fourth day after spraying. *F. budrunga* (2.74 bees /5 flowers /minute) and sugar solution (2.66 bees /5 flowers /minute) were as good as control (2.57 bees /5 flowers /minute).

On the fifth day after spraying, maximum number of bee visits were found in Citral Z (3.91 bees /5 flowers /minute) and Citral E (3.83 bees /5 flowers /minute) received plots followed by the remaining treatments which were on par with each other. Sugar solution and untreated control plots were on par with each other and recorded least number of bees (1.88 bees /5 flowers /minute).

The overall mean bee visitation was significantly more and at par in the treatments that received Citral E, Citral Z, *F. budrunga*, *S. densifolia*, and Fruit Boost which attracted 2.12 to 2.45 bees /5 flowers /minute. Sugar solution treatment attracted 1.51 bees /5 flowers /minute which was at par with unsprayed crop.

Second spray

A day before the application of attractants bee visitation which varied from 1.33 to 1.46 bees /5 flowers /minute did not differ significantly among the treatments. (Table 10)

After one day of spraying, maximum number of bees was noticed in *F. budrunga* (4.38 bees /5 flowers /minute) treated plots. The second best treatment was Fruit Boost sprayed plots (3.34 bees /5 flowers /minute) followed by Citral E (2.65 bees /5 flowers /minute) and Citral Z (2.76 bees /5 flowers /minute) applied plots which were however on par with each other. Sugar solution received plots attracted 2.35 bees /5 flowers /minute followed by *S. densifolia* and the control.

On second day after spraying bee visitation was treated significantly higher (1.72 to 3.20 bees /5 flowers /minute) in all bee attractant treated plots over the control.

On third day after spraying, Citral Z (4.70 bees /5 flowers /minute) enticed highest number of bee visitation followed by Citral E (4.00 bees /5 flowers /minute) and Fruit Boost (4.12 bees /5 flowers /minute). *F. budrunga* was the next best attractant followed by *S. densifolia* and sugar solution, which were on par with each other.

Fruit Boost (4.85 bees /5 flowers /minute) Citral Z (4.54 bees /5 flowers /minute) attracted higher number of bees after four days of spraying followed by Citral E (3.96 bees /5 flowers /minute). Next best treatments were *S. densifolia* and sugar solution followed by *F. budrunga*.

Five days after spraying, Citral E (6.96 bees /5 flowers /minute) treated crop recorded significantly higher number of bee visits followed by Citral Z (5.94 bees /5 flowers /minute). The remaining treatments attracted 4.28 to 5.00 bees /5 flowers /minute followed by the control.

Means of bee visitation of all the five days showed that Citral E, Citral Z, and Fruit boost (3.94, 4.23 and 3.92 bees /5 flowers /minute) were the best treatments followed by *F. budrunga* (3.40 bees /5 flowers /minute). Next best treatment was *S. densifolia* (3.28 bees /5 flowers /minute) which was on par with the sugar solution sprayed crop. Least number of bees was recorded in untreated control (1.99 bees /5 flowers /minute).

4.2.2 Influence of bee attractants on bee visitation in niger

First spray

One day before spray the number of bees visiting niger flowers varied from 2.08 to 3.63 bees/5 flowers/minute but this variation did not differ significantly among the treatments. (Table 11)

Following one day after the spray Citral E attracted significantly more number of bees (19.48 bees/5 flowers/minute). Spraying with Citral Z and *F. budrunga* were the next best attractants with 15.40 bees/5 flowers/minute) and 13.75 bees/5 flowers/minute bee visitation respectively. Similarly *S. densifolia* and Fruit Boost sprayed treatments were on par with each other attracting next higher number of bees (13.34 and 13.12 bees/5 flowers/minute).

Table 11. Influence of bee attractants on *Apis* bee visitation in niger during the first spray

Treatments	Number of bees / 5 flowers / min				
	1DBFS	1DAFS	2DAFS	3DAFS	Mean
Citral E @ 1%	2.92 (1.82)	19.48 (4.47) ^a	12.60 (3.62) ^b	13.96 (3.80) ^a	15.34 (3.97) ^a
Citral Z @ 1%	2.92 (1.80)	15.40 (3.99) ^b	12.21 (3.56) ^{bc}	11.25 (3.42) ^b	12.95 (3.66) ^b
<i>Fagara budrunga</i> @1%	3.42 (1.96)	13.75 (3.77) ^{bc}	15.61 (4.01) ^a	8.75 (3.04) ^c	12.70 (3.63) ^b
<i>Swertia densifolia</i> @ 1%	2.08 (1.57)	13.34 (3.72) ^c	12.55 (3.61) ^b	7.92 (2.90) ^c	11.27 (3.43) ^b
Fruit boost @ 1%	3.63 (2.01)	13.12 (3.68) ^c	11.09 (3.40) ^c	12.08 (3.55) ^b	12.09 (3.54) ^b
Sugar solution @ 10%	2.78 (1.76)	8.75 (3.04) ^d	13.25 (3.71) ^b	8.54 (3.00) ^c	10.18 (3.26) ^c
Control	2.75 (1.75)	8.67 (3.03) ^d	11.06 (3.40) ^c	8.33 (2.97) ^c	9.35 (3.13) ^c
S.Em.±	0.2	0.09	0.07	0.07	0.07
CD	NS	0.28	0.20	0.22	0.23

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

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

DBFS = Day before first spray

DAFS = Days after first spraying

Significantly less number of bees were noticed in sugar solution sprayed (8.75 bees/5 flowers/minute) and control (8.67 bees/5 flowers/minute) plots.

On the second day after spraying significantly higher number of bees were noticed in *F. budrunga* treated plots (15.61 bees/5 flowers/minute) which was followed by sugar solution (13.25 bees/5 flowers/minute) Citral E (12.60 bees/5 flowers/minute), *S. densifolia*, (12.55 bees/5 flowers/minute) and Citral Z (12.21 bees/5 flowers/minute) sprayed crops respectively. Fruit Boost and control were on par with each other in attracting bees (11.07 and 11.06 bees/5 flowers/minute) respectively.

Significantly higher number of bees were noticed in Citral E treated plots (13.96 bees/5 flowers/minute) on the third day after spraying. Fruit Boost and Citral Z were equally effective and attracted next higher number of bees (12.08 and 11.25 bees/5 flowers/minute). All other treatments including control were on par with each other in bee attraction.

The mean bee visitation of all the different days showed that Citral E attracted more bees (15.34 bees/5 flowers/minute) followed by and Citral Z, *F. budrunga*, *S. densifolia* and Fruit Boost (12.95 to 11.27 bees/5 flowers/minute). Sugar solution and control attracted lowest number of bees.

Second spray

One day before the application of bee attractants, bee visitation varied from 3.50 to 4.53 bees /5 flowers /minute which was found non significant among the treatments. (Table12)

On first day after second spraying Citral E, Citral Z, *F. budrunga*, *S. densifolia* and Fruit Boost attracted significantly more bees (12.50 to 10.08 bees/5 flowers/minute) followed by sugar solution (9.00 bees/5 flowers/minute) and control (7.50 bees/5 flowers/minute).

The treatment with Citral E (12.82 bees /5 flowers /minute), Citral Z (12.00 bees /5 flowers /minute) and *F. budrunga* (10.63 bees /5 flowers /minute) were superior in attracting more bees on the second day after spray. The second best attractants were *S. densifolia* (8.75 bees /5 flowers /minute) and Fruit Boost (8.88 bees /5 flowers /minute). Both sugar solution (7.92 bees /5 flowers /minute) and control treated plots attracted bees at par with each other (7.92 to 7.50 bees /5 flowers /minute) respectively.

After third day of spraying all the bee attractant sprayed treatments *viz* Citral E, Citral Z, *F. budrunga*, *S. densifolia*, Fruit Boost and sugar solution attracted 5.00, 6.25, 8.13, 4.38, 8.33, and 9.00 bees/5 flowers/minute respectively which were on par with each other and superior over the control.

On the fourth day after spraying Citral Z, *F. budrunga*, *S. densifolia*, Fruit Boost and sugar solution attracted higher number of bees 7.5, 6.88, 8.13, 7.19 and 8.75 bees/5 flowers/minute, respectively followed by Citral E (5.83 bees /5 flowers /minute) and control.

Fruit Boost (14.24 bees /5 flowers /minute), Citral E (10.67 bees /5 flowers /minute), Citral Z (11.25 bees /5 flowers /minute) and *S. densifolia* (11.38 bees /5 flowers /minute) attracted significantly more number of bees on the fifth day. Remaining treatments *F. budrunga* and sugar solution attracted 8.05 to 7.08 bees /5 flowers /minute which were as good as the unsprayed treatment (7.08 bees /5 flowers /minute).

All the bee attractants *viz*, Citral E, Citral Z, *F. budrunga*, *S. densifolia*, Fruit Boost and sugar solution sprayed crops were equally effective in attracting higher number of bees when the mean of all the five days were considered (7.77 to 9.85 bees /5 flowers /minute) followed by untreated control.(5.29 bees /5 flowers /minute)

4.3 Influence of bee attractants on yield parameters of sesame and niger

4.3.1 Influence of bee attractants on quantitative parameters of sesame

Observations on the effect of attractants on quantitative Parameters *viz*, Number of capsules/ plant, number of seeds per capsule, 1000 seed weight, and yield per plot are presented in (Table 13, Fig. 17 and 18).

Table 12. Influence of bee attractants on *Apis* bee visitation in niger during the second spray

Treatments	Number of bees / 5 flowers / min						
	1DBBS	1DASS	2DASS	3DASS	4DASS	5DASS	Mean
Citral E @ 1%	4.53 (2.22)	12.50 (3.60) ^a	12.82 (3.64) ^a	5.00 (2.34) ^a	5.83 (2.51) ^{bc}	10.67 (3.34) ^{ab}	9.36 (3.14) ^a
Citral Z @ 1%	3.66 (2.03)	12.16 (3.56) ^a	12.00 (3.53) ^a	6.25 (2.59) ^a	7.50 (2.82) ^{ab}	11.25 (3.42) ^{ab}	9.83 (3.21) ^a
<i>Fagara budrunga</i> @1%	3.83 (2.08)	11.25 (3.42) ^a	10.63 (3.33) ^{ab}	8.13 (2.93) ^a	6.88 (2.71) ^{ab}	8.05 (2.92) ^b	8.99 (3.08) ^a
<i>Swertia densifolia</i> @ 1%	4.08 (2.14)	10.08 (3.22) ^{ab}	8.75 (3.04) ^{bc}	4.38 (2.21) ^a	8.13 (2.93) ^a	11.38 (3.40) ^{ab}	8.54 (2.96) ^a
Fruit boost @ 1%	3.50 (2.00)	10.62 (3.33) ^a	8.88 (3.05) ^{bc}	8.33 (2.94) ^a	7.19 (2.76) ^{ab}	14.24 (3.84) ^a	9.85 (3.18) ^a
Sugar solution @ 10%	4.05 (2.12)	9.00 (3.07) ^b	7.92 (2.90) ^c	5.83 (2.46) ^a	8.75 (3.04) ^a	7.33 (2.77) ^b	7.77 (2.85) ^a
Control	3.63 (2.02)	7.50 (2.83) ^b	7.50 (2.83) ^c	0.00 (0.71) ^b	4.38 (2.21) ^c	7.08 (2.75) ^b	5.29 (2.27) ^b
S.Em.±	0.14	0.15	0.10	0.25	0.11	0.23	0.16
CD	NS	0.46	0.31	0.76	0.35	0.71	0.51

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

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

DBFS = Day before first spray

DAFS = Days after first spraying

Table 13. Influence of bee attractants on the quantitative parameters of sesame seed

Treatments	No. of capsules per plant	% increase over control	No. of seeds per capsule	1000 seed weight (g)	% increase /decrease over control	Yield (q/ha)	% increase over control
Citral E @ 1%	42.50 ^{ab}	23.18	55.34	2.80 (1.82) ^b	11.11	1.41 (4.10) ^a	48.42
Citral Z @ 1%	43.07 ^{ab}	24.84	60.40	3.02 (1.88) ^a	19.84	1.50 (4.26) ^a	57.89
<i>Fagara budrunga</i> @1%	37.47 ^b	8.61	57.41	2.73 (1.80) ^b	8.33	1.22 (3.85) ^b	28.42
<i>Swertia densifolia</i> @ 1%	35.59 ^c	3.15	60.62	2.68 (1.78) ^b	6.35	1.21 (3.82) ^b	27.37
Fruit boost @ 1%	42.32 ^{ab}	22.66	58.02	2.85 (1.83) ^{ab}	13.09	1.51 (4.26) ^a	58.94
Sugar solution @ 10%	47.12 ^a	36.57	59.72	2.44 (1.72) ^d	-8.00	1.01 (3.51) ^c	6.31
Control	34.50 ^d		59.24	2.52 (1.74) ^{cd}		0.95 (3.41) ^c	
S.Em.±	0.15		0.11	0.02		0.06	
CD	0.46		NS	0.05		0.18	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

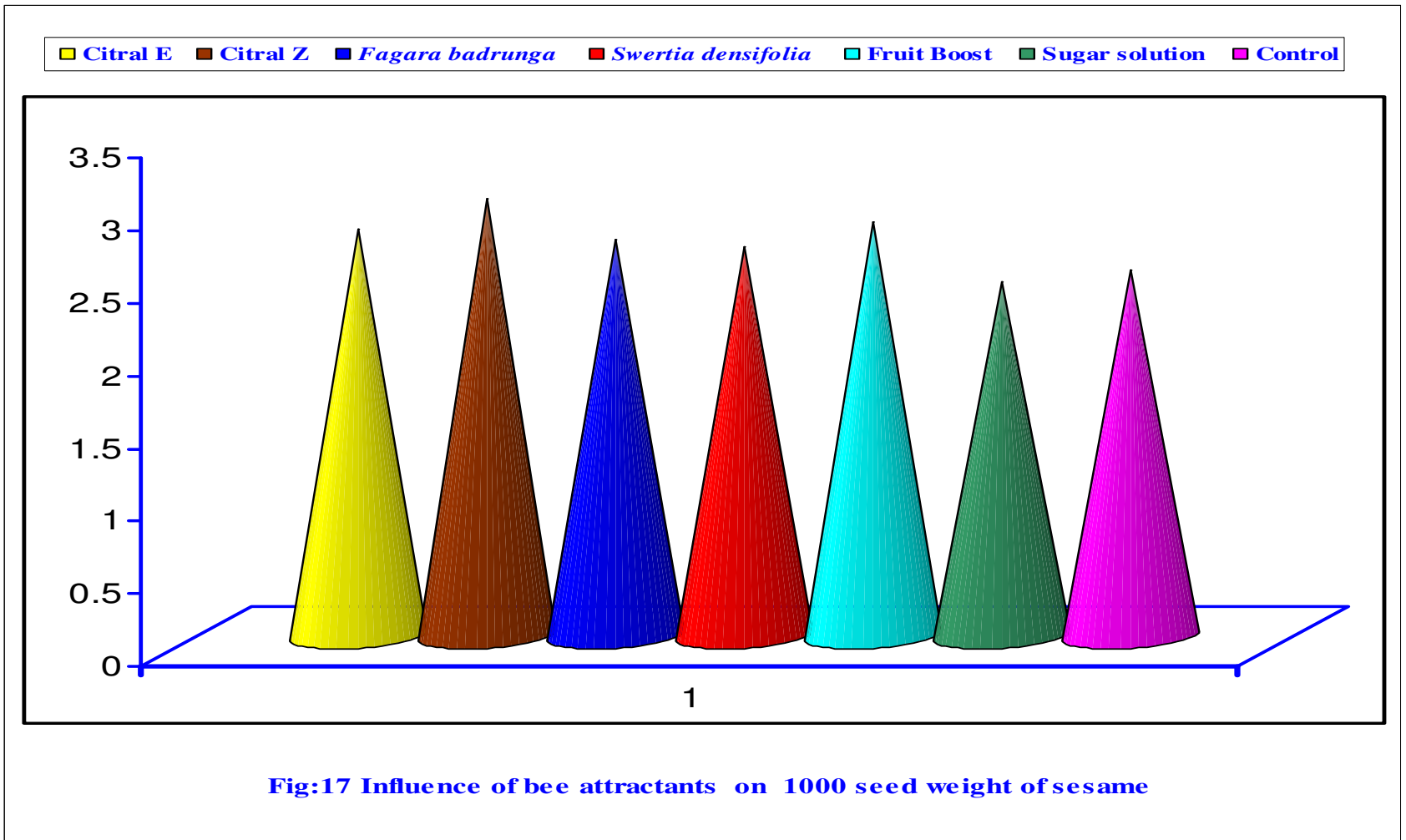


Fig.17 : Influence of bee attractants on 1000 seed weight of sesame

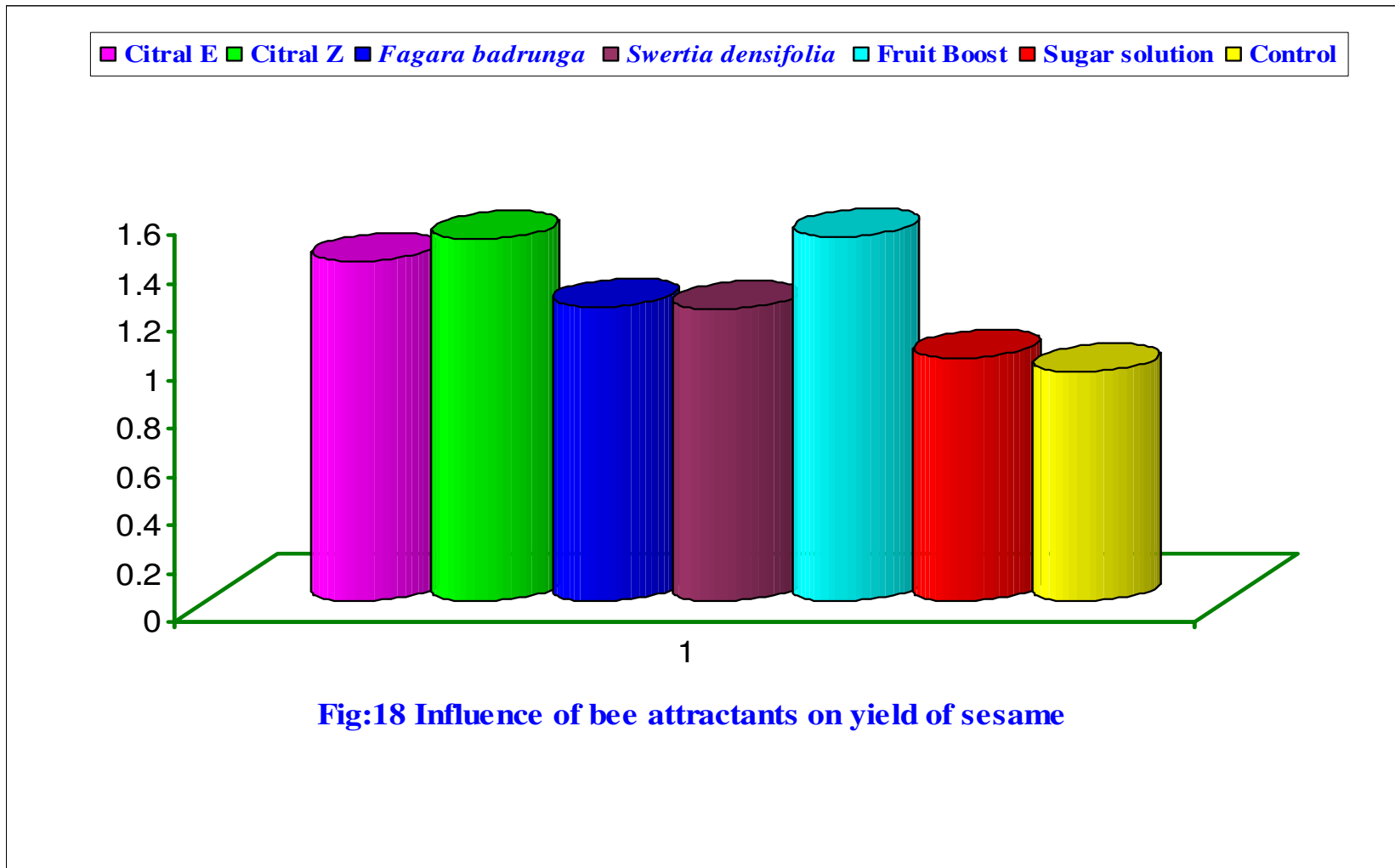


Fig.18: Influence of bee attractants on yield of sesame

4.3.1.1 Number of capsules/ plant

Significantly higher number of capsules/ plant was recorded on Citral Z (43.07), Citral E (42.50), Fruit Boost (42.32) and sugar solution (47.12), treated plots and were on par with each other accounting for 23.18 to 36.57 per cent increase over control. Next higher number of capsules was produced in *F. budrunga* (37.47 capsules per plant) treated plots followed by *S. densifolia* (35.59 capsules per plant) which accounted for 8.61 to 3.15 per cent increase over control.

4.3.1.2 Number of seeds per capsule

Number of seeds produced per capsule varied from 55.34 (Citral E) to 60.62 (*S. densifolia*) in the crop sprayed with different attractants however statistically the variation was non significant.

4.3.1.3 1000 seed weight

Seed weight was higher in the crop treated with Citral Z (3.02 g) and Fruit Boost (2.85 g) followed by Citral E, *F. budrunga* and *S. densifolia* (2.80, 2.73, and 2.68g) which were on par with each other and accounted for 6.35 to 19.84 per cent more seed weight over control. The crop treated with sugar solution produced lighter seeds (2.44 g) which was as good as the unsprayed crop.

4.3.1.4 Yield

Higher seed yield was obtained from the crop sprayed with Citral Z (1.50 q/ha) and Citral E (1.41 q/ha) which were on par with Fruit Boost (1.51 q/ha) resulting an increase in yield of 48.42 to 58.94 per cent higher than the control. *F. budrunga* (1.22 q/ha) and *S. densifolia* (1.21 q/ha) treated crops recorded the next higher yield. From the crop applied with sugar and untreated plots lower yield of 1.01 and 0.95 q/ha was recorded.

4.3.2 Influence of bee attractants on qualitative parameters of sesame

Effect of attractants on qualitative parameters of sesame like per cent germination, root length, shoot length and vigour index is presented in (Table 14 and Fig. 19).

4.3.2.1 Per cent germination

Per cent germination of seeds ranged from 80 to 93.33 among the various treatments but this variation was in significant.

4.3.2.2 Shoot length

Shoot length ranging from 5.41 to 6.21 cm and showed non significant differences between the treatments.

4.3.2.3 Root length

Seeds from the crop applied with Fruit Boost produced significantly longer roots (8.55 cm) however the seeds from the other treatments produced as long roots as the control (6.22 to 8.55 cm).

4.3.2.4 Vigour index

Vigour index of the seedling was found higher in Fruit Boost (1251.70), *S. densifolia* (1198.00) and Citral E (1177.90) treated plots and it accounted for an increase of 16.35 to 23.87 per cent over control. Next higher vigour index was recorded in the treatments with Citral Z (1063.27), *F. budrunga* (1065.45) and sugar solution (1075.05) which were at par with the control (1012.35).

4.3.3 Influence of bee attractants on quantitative parameters of niger

Effect of attractants on quantitative yield parameters viz, number of capitulas per plant, number of seeds per capitula, 1000 seed weight, and yield is presented in (Table 15).

4.3.3.1 Number of capitulas per plant

Capitulums per plant ranged from 41.63 to 44.59 and did not differ significantly among different treatments.

Table 14. Influence of bee attractants on the qualitative parameters of sesame seed

Treatments	Germination * (%)	Shoot length(cm)	Root length(cm)	Vigour index	% increase over control
Citral E @ 1%	86.67 (68.56)	6.21	6.95 ^b	1177.90 ^{ab}	16.35
Citral Z @ 1%	90.00 (71.54)	5.50	6.63 ^b	1063.27 ^{bc}	5.02
<i>Fagara budrunga</i> @1%	90.00 (71.54)	5.41	6.46 ^b	1065.45 ^{bc}	5.24
<i>Swertia densifolia</i> @ 1%	93.33 (75.00)	5.84	7.11 ^b	1198.00 ^{ab}	18.33
Fruit boost @ 1%	86.67 (68.56)	6.17	8.55 ^a	1251.70 ^a	23.87
Sugar solution @ 10%	90.00 (71.54)	5.72	6.22 ^b	1075.05 ^{bc}	6.19
Control	80.00 (63.41)	5.81	6.83 ^b	1012.35 ^c	
S.Em.±	0.16	0.04	0.07	0.75	
CD	NS	NS	0.20	2.31	

*Figures in the parenthesis are arcsine transformed values

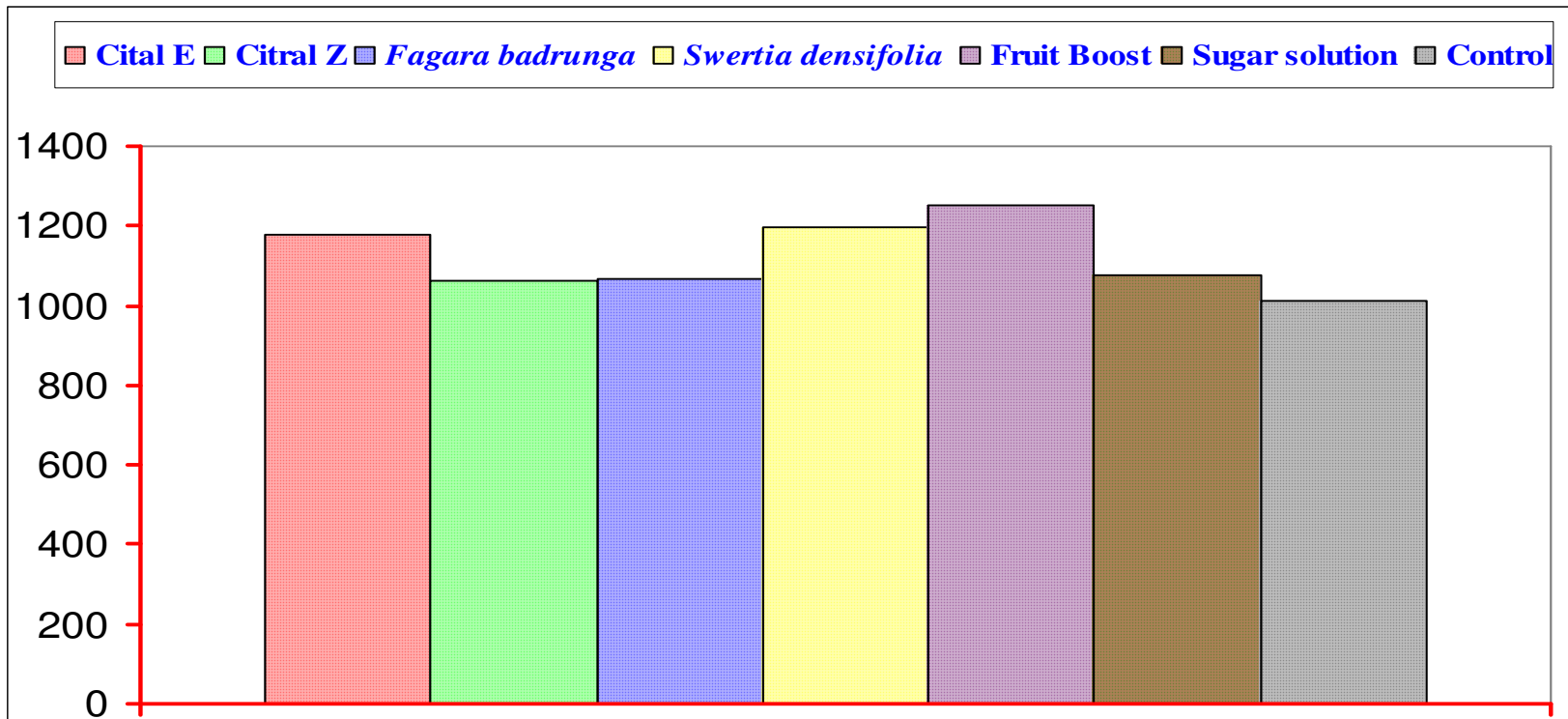


Fig:19 Influence of bee attractants on quantitative parameters of sesame (Vigour index)

Fig.19: Influence of bee attractants on quantitative parameters of sesame (Vigour index)

Table 15. Influence of bee attractants on the quantitative parameters of niger seed

Treatments	No. of capitulum per plant	No. of seeds per head	1000 seed weight (g)	% increase over control	Yield (q/ha)	% increase over control
Citral E @ 1%	42.52	36	4.64 ^a	31.44	1.01 ^a	62.90
Citral Z @ 1%	42.01	33.33	4.29 ^{ab}	21.53	0.91 ^{ab}	46.77
<i>Fagara budrunga</i> @1%	44.29	37.84	4.13 ^{ab}	16.99	0.83 ^b	33.87
<i>Swertia densifolia</i> @ 1%	44.59	38.41	4.08 ^{ab}	15.58	0.85 ^b	37.11
Fruit boost @ 1%	42.20	40.28	4.53 ^a	28.33	0.89 ^{ab}	43.55
Sugar solution @ 10%	41.63	41.91	3.64 ^b	3.12	0.63 ^c	1.61
Control	41.80	33.09	3.53 ^b		0.62	
S.Em.±	0.15		0.06		0.78	
CD	NS	NS	0.18		2.40	

Figures in the parenthesis are $\sqrt{(X + 0.5)}$ transformed values

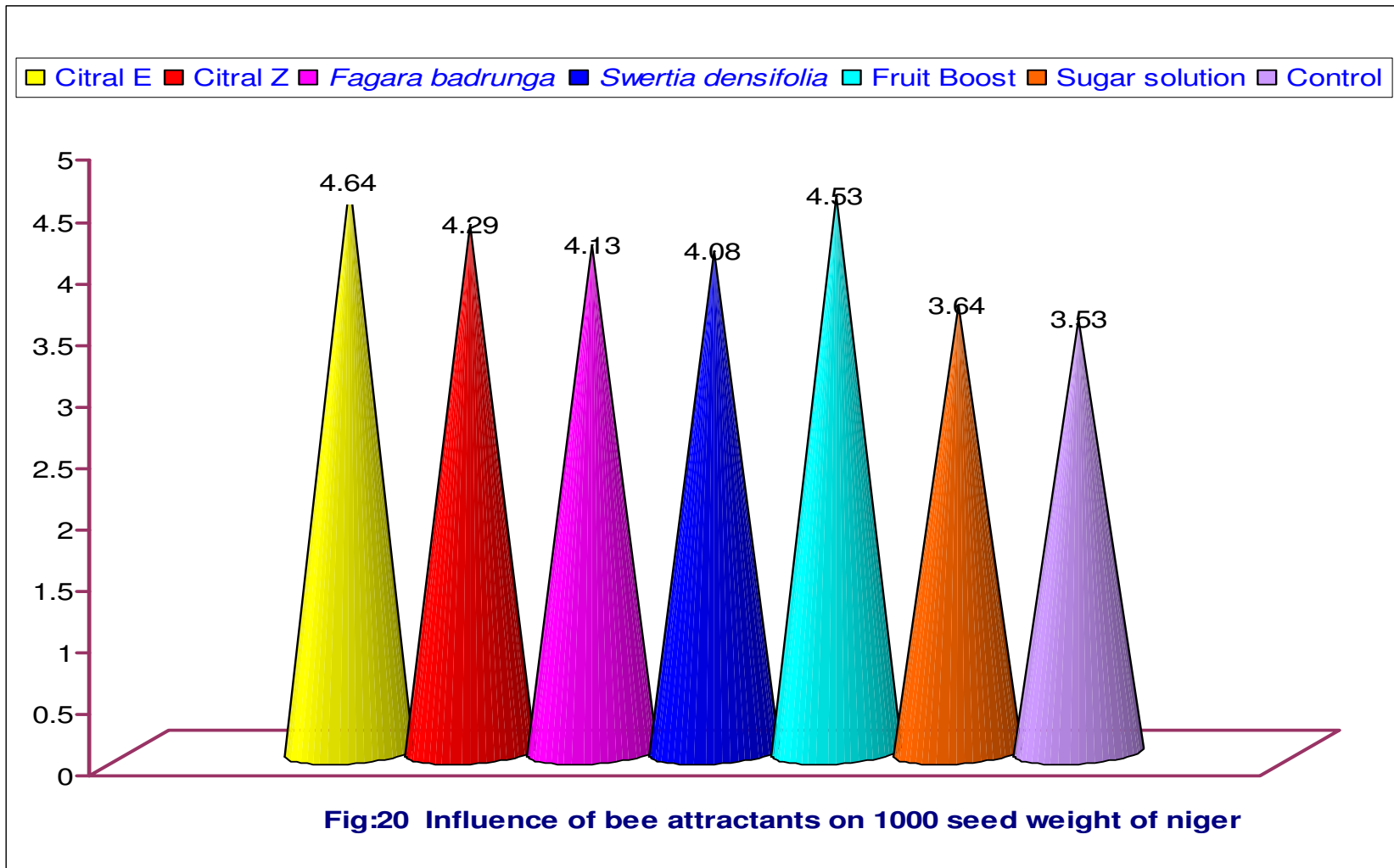


Fig.20: Influence of bee attractants on 1000 seed weight of niger

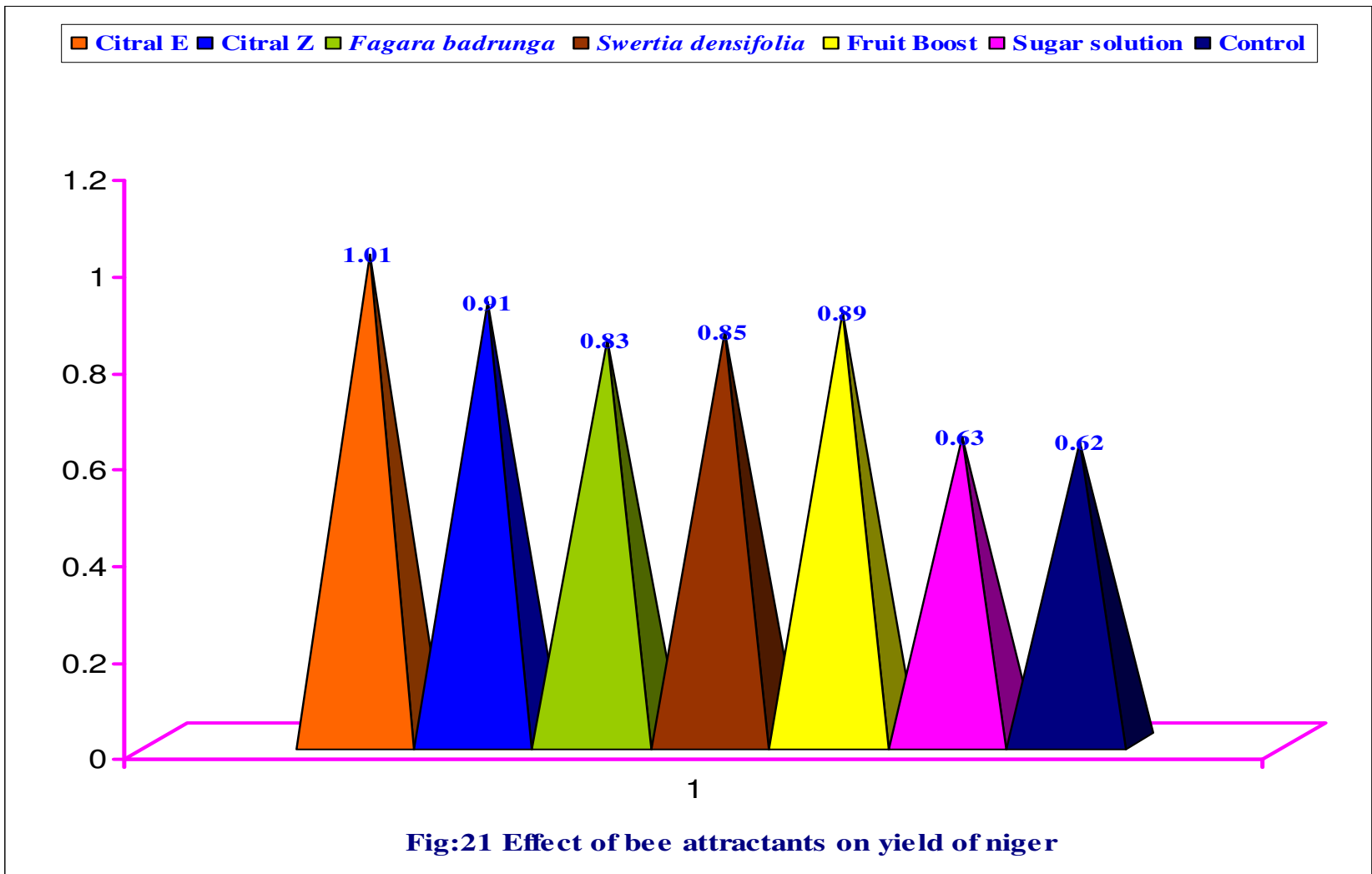


Fig.21: Effect of bee attractants on yield of niger

4.3.3.2 Number of seeds per capitulum

Number of seeds per capitulum also showed non significant differences among the treatments and ranged from 33.09 to 41.91 seeds per capitulum in different treatments.

4.3.3.3 1000 seed weight

Seeds from the treatments Citral E (4.64g), Fruit Boost (4.53 g), Citral Z (4.29 g), *F. budrunga* (4.13g), and *S. densifolia* (4.08 g) were significantly heavier and resulted in an increase of 15.58 to 31.44 per cent. The sugar solution accounted for an increase of 3.12 per cent over untreated control (3.53 g) (Fig. 20).

4.3.3.4 Yield

Significantly higher seed yield (1.01 q /ha) was obtained in Citral E received crop which was on par with Citral Z (0.91 q/ha) and Fruit Boost (0.89 q /ha) treated plots and accounted for an increase of 43.55 to 62.90 per cent. *F. budrunga* and *S. densifolia* applied crops produced statistically similar and next higher yield of 0.83 q/ha and 0.85 q /ha respectively and resulted in increase of 33.87 and 37.11 per cent. Sugar solution and untreated control were on par with each other in producing yield of 0.63 and 0.62 q /ha respectively (Fig. 21).

4.3.4 Influence of bee attractants on qualitative parameters of niger

Effect of attractants on qualitative parameters of niger like per cent germination, root length, shoot length and vigour index is presented in (Table 16).

4.3.4.1 Per cent germination

Per cent germination varied from 56.67 to 70.00 but the difference among various treatments was statistically non significant.

4.3.4.2 Shoot length

Shoot length of seedlings was higher in Citral E (10.04 cm), *S. densifolia* (9.72 cm), Fruit Boost (8.57 cm) and sugar solution (8.98 cm). Next best treatments were Citral Z (8.04 cm) and *F. budrunga* (7.77 cm) which were statistically similar.

4.3.4.3 Root length

Seeds from the crop treated with *S. densifolia* (9.7 cm), sugar solution (8.81 cm), Citral Z (8.6 cm) and Fruit Boost (8.78 cm) produced longer roots followed by Citral E (8.15 cm) and control (7.64 cm).

4.3.4.4 Vigour index

Vigour index was found maximum in Fruit Boost received plots (1415.78) followed by Citral E, Citral Z, *S. densifolia* and sugar solution which accounted for 16.74 to 49.81 per cent increase over control. *F. budrunga* and untreated control were on par with each other (Fig. 22).

Table 16. Influence of bee attractants on the qualitative parameters of niger seed

Treatments	Germination (%)*	Shoot length (cm)	Root length (cm)	Vigour index	% increase over control
Citral E @ 1%	60.00 (50.75)	10.04 ^a	8.15 ^{bc}	1220.70 ^b	29.17
Citral Z @ 1%	70.00 (56.77)	8.04 ^b	8.6 ^{ab}	1103.20 ^{bc}	16.74
<i>Fagara budrunga</i> @1%	66.67 (54.72)	7.77 ^b	7.66 ^c	995.20 ^{cd}	5.31
<i>Swertia densifolia</i> @ 1%	60.00 (50.75)	9.72 ^a	9.7 ^a	1139.63 ^b	20.59
Fruit boost @ 1%	70.00 (56.77)	8.57 ^{ab}	8.78 ^{ab}	1415.78 ^a	49.81
Sugar solution @ 10%	56.67 (48.81)	8.98 ^{ab}	8.81 ^{ab}	1136.55 ^b	20.21
Control	63.33 (52.71)	8.89 ^c	7.64 ^c	945.00 ^d	
S.Em.±		0.07	0.05	0.66	
CD	NS	0.22	0.16	2.04	

* Figures in the parenthesis are arcsine transformed values

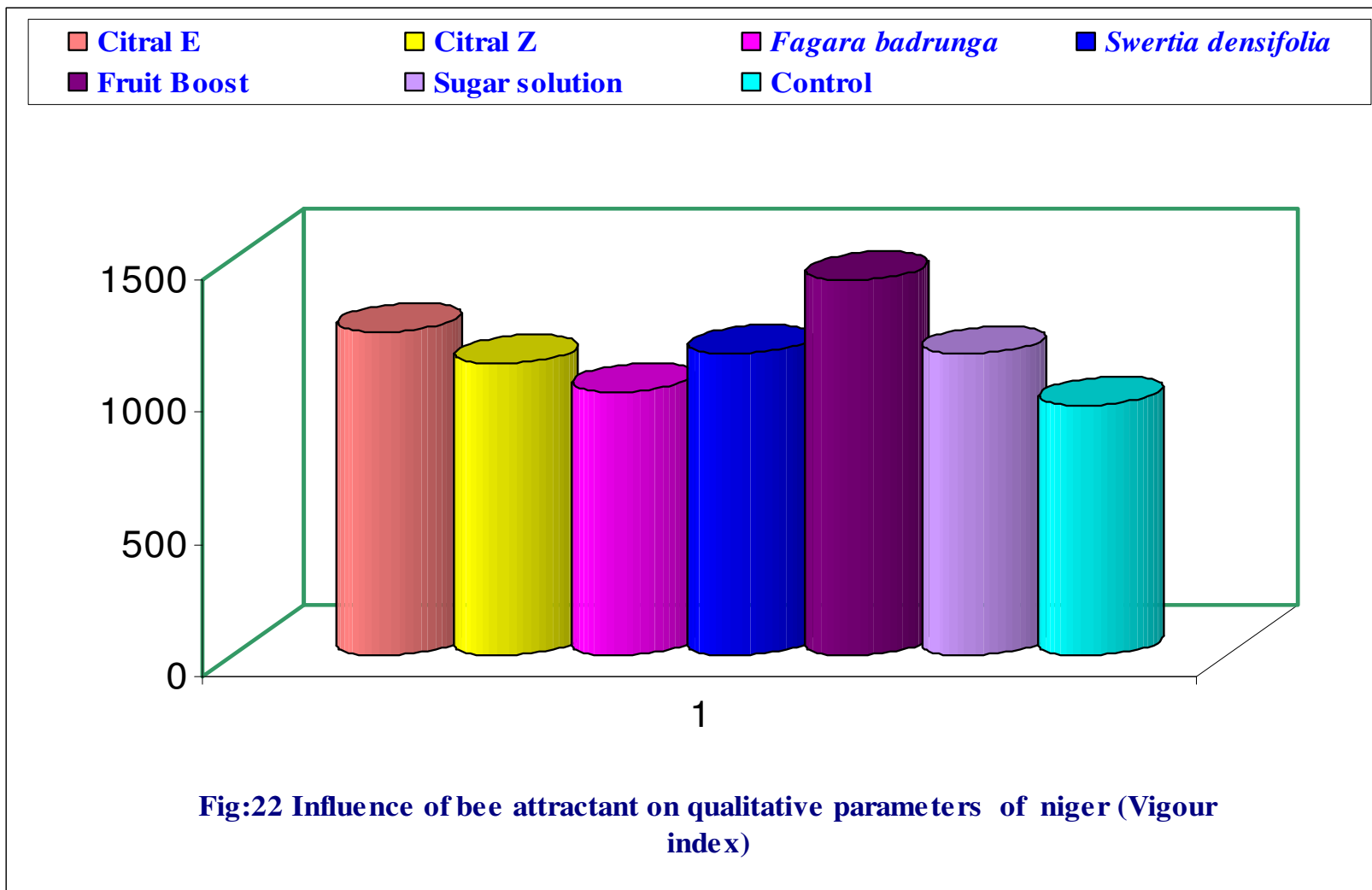


Fig.22; influence of bee attractants on qualitative parameters of niger (Vigour index)

5. DISCUSSION

The investigations conducted to study the foraging behaviour of honey bees in of sesame and niger genotypes, the influence of bee attractants on bee visitation and influence of these attractants on yield parameters of sesame and niger are discussed in this chapter.

Two pheromone based attractants namely, Citral E, and Citral Z; two plant based attractants viz., *F. budrunga* and *S. densifolia* along with Fruit Boost, a commercial bee attractant on sesame and niger at Dharwad were studied. Citral E contains *A. cerana* pheromone lure while Citral Z is a lure based on *A. florea* pheromone.

Swertia 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 Foraging behaviour of honey bees in sesame and niger genotypes

In sesame *Apis dorsata* and *A. florea* mean visitation did not differ significantly among the three genotypes, but *A. cerana* visitation differed with higher number of bees on DS-1 and E-8 genotypes followed by SSD-1 in sesame. Total number of *Apis* species visitation also did not differ among the genotypes which varied from 3.35 to 3.59 bees/5 flowers/minute. These results indicate no special preference to any particular genotype of sesame by the honey bees. Contrarily, Sachdeva *et al.* (2003) reported that *A. dorsata* was more abundant on HT-1 cultivar of sesame. However on different days after flowering mean *A. dorsata* and *A. cerana* bee visitation was significantly different but *A. florea* visitation did not differ on different days, similarly the total number of mean *Apis* visitation was also similar on different days.

The mean *Apis dorsata*, *A. cerana*, *A. florea* and total *Apis* visitation differed significantly when the interaction between the genotypes and days after flowering was considered.

In niger, the mean *A. dorsata* and *A. cerana* visitation was significantly different with higher number of bees visiting on RCR-18 and No.71 followed by DNC-4. *A. florea* visitation did not differ among the genotypes. These results perhaps indicate that *A. dorsata* and *A. cerana* may get more rewards in terms of nectar and pollen by visiting RCR-18 and No.71 genotypes of niger. Present results endorse the finding of Panda *et al.* (1993) who reported that *Apis* bees visitation differed in various cultivars of niger (Plate 7 and 8).

A. dorsata and *A. cerana* visitation differed on different days after flowering and *A. dorsata* visitation was higher on 11th, 15th and 17th days after flowering and *A. cerana* on 11th and 17th days. *A. florea* visited in higher number on 11th days after flowering. When total *Apis* visitation was considered the mean visitation was more only on 11th days after flowering. The mean total *Apis* visitation differed significantly when the interaction between days after flowering and genotypes was considered.

The variation of bee visitation on different days of flowering both in sesame and niger could be due to the differences in the number of fresh flowers available on any particular day. Patnaik *et al.* (2004) has also reported more *A. cerana* bee visitation on sesame flowers 41 days after sowing.

5.2 Influence of bee attractants on bee visitation in sesame and niger

One day before the first and second spray of attractants the bee visitation was uniform in both sesame and niger.

In sesame Citral E, Citral Z, *F. budrunga*, *S. densifolia*, and Fruit Boost (2.12 to 2.45 bees /5 flowers /minute) were the superior treatments and were on par with each other



Plate 7: *Apis cerana* on niger flower



Plate 8: *Apis florum* on niger flower

followed by the sugar solution and the control after first spraying when overall means of five days were considered.

After second set of spraying Citral E, Citral Z and Fruit Boost attracted higher number of bees (3.94, 4.23 and 3.92 bees /5 flowers /minute) followed by *F. budrunga* (3.40 bees /5 flowers /minute).

In niger when overall mean bee visitation of three days was considered after first spraying Citral E, Citral Z and *F. budrunga* were the superior treatments in attracting maximum number of bees (12.70 to 15.35 bees/5 flowers/minute) and were at par with each other in enticing bees. *S. densifolia*, Fruit Boost and sugar solution were the next superior treatments (10.18 to 12.10 bees/5 flowers/minute).

Mean bee visitation of all five days after second spraying showed that the all the attractants viz, Citral E, Citral Z and *F. budrunga*, *S. densifolia* and Fruit Boost were superior in attracting more number of bees (8.54 to 9.85 bees /5 flowers /minute) followed by Sugar solution treated crop (7.77 bees /5 flowers /minute).

Results of the present investigations clearly indicated the efficiency of Citral E, Citral Z, *F. budrunga*, *S. densifolia* at par with the commercial bee attractant Fruit boost in enticing more pollinators in sesame.

F. budrunga and *S. densifolia* were found to be superior in attracting bees during the first spray but the same uniform results were not obtained after the second spraying in sesame. But Citral E, Citral Z and Fruit Boost showed consistent effect in attracting the bees after first and second spraying in sesame.

Similarly in niger Citral E, Citral Z, *F. budrunga*, *S. densifolia* were as good as Fruit Boost in attracting more bees. Citral E and Citral Z showed consistent effect in attracting bees to niger flowers after first and second spraying.

Some of the plant products were also reported to be attracting the bees. Gallert *et al.* (1985) reported that honey bees were attracted to the lucerne plots sprayed with a crude extract of dried fruit of *Evodia hupehensis*. Doull (1974) reported that Benzene extract of the pollen attracted bees. Similarly Henning *et al.* (1992) found that alfalfa volatile linalool attracted honey bees.

Attractancy of the Fruit boost could be attributed due to the presence of queen mandibular gland pheromone (QMP) that stimulates the foraging activity of workers (Winston and Slessor, 1993). Honey bees stayed significantly longer time and visited more flowers in queen mandibular pheromone sprayed blueberry and cranberry plots as reported by Higo *et al.* (1995).

Viraktamath and Patil (1999), reported increase in number of honey bee visits to attractant treated plots on sesame. Guruprasad (2001) found that spraying of Fruit boost @ 0.5 ml/l had significant influence in attracting more number of pollinators in niger.

Present findings also confirm the results of Manjunatha (2003), and Srikanta Nath, (2008) who reported the significant effect of Fruit boost on bee visitation in sunflower hybrids.

Niera and Barriga (1995) reported the increased number of honey bee visits to bee attractant treated plots of flowering raspberry. Similar increased bee visitation on the crops sprayed with attractants was reported in apple and pear (Currie *et al.*, 1992a) berry (Currie *et al.*, 1992b), pear, plum and apple (Mayer *et al.*, 1989) cardamom (Bhat and Sudharshan, 1999) sunflower (Sanjivan Kumar *et al.*, 2000) and cucumber (Viraktamath and Anagoudar, 2002)

5.3 Influence of bee attractants on yield parameters of sesame and niger

5.3.1 Influence of bee attractants on bee visitation on quantitative parameters

In sesame higher number of capsules/ plant was produced in the crop that received Citral Z, Citral E, Fruit Boost and Sugar solution. Thus the spray of attractants enhanced the number of capsules per plant from 22.66 to 24.84 per cent over the control. (43.07, 42.50, 42.32, 47.12 capsules per plant). Similar effect was also recorded though production of

capsules is largely genotypic character the increase in the number of capsules in the present investigation perhaps could be attributed to development of more pollinated flowers into capsules due to higher number of bee visits.

However in niger number of capitulum per plant did not differ significantly from the unsprayed crop. These findings are in line with the report of Guruprasad (2001) who reported no significant differences in the number of capitulums per plant in niger between attractant sprayed and unsprayed crop. Application of attractants had no beneficial effect in increasing seeds per pod both in sesame and niger.

Contrarily Viraktamath and Patil (1999) reported application of Bee-Q and Bee-here increased the seeds per pod in sesame. Similarly Guruprasad (2001) and Srikanta Nath (2008) found that spraying of Fruit boost had significant effect on increasing number of seeds per capitulum in niger and *Swertia densifolia*, *Fagara budrunga* and Citral Z treated crop produced higher number of seeds per capitulum in sunflower respectively.

In sesame heavier seeds were produced in the crop treated with Citral Z (3.02 g) and Fruit Boost (2.85 g). Similar results were obtained by Viraktamath and Patil (1999) who reported that in sesame two applications of Bee-Q and Bee here resulted in heavier seeds.

Similarly Citral E (4.64 g), Fruit Boost (4.53 g), Citral Z (4.29 g), *F. budrunga* (4.13g), and *S. densifolia* (4.08 g) treated crops produced significantly heavier seeds over the sugar solution sprayed crop and also untreated control in niger. Thus percentage of heavier seeds increased from 15.58 to 31.44 over the control.

These results confirm the findings of Guruprasad (2001) who found heavier seeds in Fruit Boost treated crop of niger. Seed weight was also enhanced due to application of bee attractants in other oil seeds like sunflower (Manjunatha, 2003, Srikanta Nath, 2008, and mustard Murasing and Viraktamath, 2002)

Highest seed yield was obtained from the crop applied with Citral Z (1.50 q/ha) and Citral E (1.41 q/ha) which was as good as Fruit Boost (1.51 q/ha) treated crop in sesame. Thus the per cent yield was enhanced from 48.42 to 58.94 per cent over the control.

In niger significantly highest seed yield of (1.01 q /ha) was produced in Citral E received plots which was on par with Citral Z (0.91 q /ha) and Fruit Boost (0.89 q /ha) treated plot. Thus the yield was enhanced by 43.55 to 62.90 per cent over control. The increase in the yield was attributed to the heavier seeds produced in the sprayed crop.

Viraktamath and Patil (1999) also found that two applications of Bee-Q and Bee here increased the yield in sesame.

The results of the present investigation strengthen the findings of Guruprasad who reported that niger sprayed with Fruit Boost recorded the highest yield. Similarly sunflower sprayed with *S. densifolia* produced highest yield (Srikanta Nath, 2008) and Bee-Q sprayed niger crop recorded higher yield (Sattigi *et al.*, 2004).

Increased yield due to spray of attractants is also reported in sunflower (Bhosle *et al.* 1992, Sanjivan Kumar *et al.* 2000), mustard (Murasing and Viraktamath, 2002). Similar increase in yield is reported in cranberry and blue berry (Currie *et al.*, 1992b), watermelon (Elmstrom and Maynard, 1990; Maynard *et al.*, 1992, Schultheis *et al.*, 1994) apple (Rajotte and Fell, 1982) Pear, Plum and apple (Mayer *et al.*, 1989) cardamom (Bhat and Sudharshan, 1999), cucumber (Viraktamath and Anagoudar, 2002) and onion (Kalmath and Sattigi, 2002).

5.3.2 Influence of bee attractants on qualitative parameters of sesame and niger

Germination percentage of the seeds produced from the various bee attractant treated crop did not differ significantly from the seeds of unsprayed crop both in sesame and niger. These results in line with the findings of Srikanta Nath (2008) who also did not notice any positive effect due to spray of the attractants.

However Patil (1999) reported that germination percentage of sesame seeds improved in the Bee-Q and Bee-here sprayed crops. Similarly Guruprasad (2001) obtained higher germination of niger seeds in Fruit Boost and floral scented water treatments. Similarly Murasing and Viraktamath (2002) and Manjunatha (2003) also reported that seeds from Bee-

Q sprayed crop in mustard and seeds from Fruit Boost sprayed sunflower showed higher germination.

In sesame attractants had no effect on shoot length which is in contradiction to the results of Patil (1999), Manjunatha (2003), Murasing and Viraktamath (2002) who obtained positive influence on shoot length in sesame, sunflower and mustard respectively.

Niger crop applied with Citral E, Citral Z, *F. budrunga*, and *S. densifolia* were the next best treatments to Fruit Boost and produced the longest shoot length which is in contrast to the results of Srikanta Nath (2008) who reported no effect of attractants on shoot length of sunflower.

Seeds from the sesame crop applied with Fruit Boost produced significantly longer roots (8.55cm) followed by the seeds from the other treatments viz; Citral E, Citral Z, *F. budrunga*. These results are in agreement with the results of Patil (1999) who reported beneficial effect of attractant in enhancing root length of sesame.

In niger *S. densifolia* (9.7cm), Citral Z (8.6cm) and Fruit Boost (8.78cm) treatments produced longer roots followed by Citral E. Similar results were also obtained by Guruprasad (2001) and Manjunatha (2003) in niger and sunflower respectively but Srikanta Nath (2008) reported that there was no effect of attractants in increasing the root length of sunflower.

Vigour index of the seedling was found higher in Fruit Boost (1251.70), *S. densifolia* (1198.00) and Citral E (1177.90) treated plots in sesame and resulted in percent increase of 58.94 to 48.42 over control. In niger vigour index was found maximum in Fruit Boost received plots (1415.78). Similar observations were recorded by (Manjunatha, 2003) in sunflower but not in tune with the results of Srikanta Nath (2008).

6. SUMMARY AND CONCLUSIONS

Results of the investigations carried out at Main Agricultural Research station, University of Agricultural Sciences, Dharwad, on foraging behaviour of honey bees in three different genotypes of sesame and niger, the influence of bee attractants on bee visitation and influence of these attractants on yield parameters of sesame and niger are summarized below.

In sesame and niger the total *Apis* pollinators visitation on different genotypes did not differ. But the bee visits after days of flowering was different in both sesame and niger. Total *Apis* visitation differed significantly when the interaction between genotypes and days after flowering was considered.

Spraying of bee attractants had significant effect in attracting bees to sesame and niger.

In sesame Citral E, Citral Z, *F. budrunga*, *S. densifolia*, was as good as the commercial bee attractant Fruit Boost and found to be superior in attracting more number of bees compared to the control.

In niger, Citral E, Citral Z, *F. budrunga*, *S. densifolia* and Fruit Boost were the best treatments in attracting more number of bees in comparison to the control.

Application of bee attractants enhanced both the quantitative and qualitative yield parameters of sesame and niger.

In sesame higher number of capsules/ plant was produced in the crop that received Citral Z, Citral E, Fruit Boost and Sugar solution. (42.32 to 47.12 capsules/ plant). However in niger application of bee attractants did not improve the number of capitulum per plant.

Citral Z and Fruit Boost treated sesame crop produced the heavier seeds (2.85 g to 3.02 g). Citral E, Fruit Boost, Citral Z, *F. budrunga* and *S. densifolia* (4.64 g to 4.08 g) were the best treatments in producing heavier seeds in niger crop.

Highest yield was obtained from Citral Z and Citral E which was as good as Fruit Boost (1.41 to 1.51 q/ha) in sesame and accounted for an increase of 48.42 to 58.94 per cent. In niger also Citral Z, Citral E and Fruit Boost treated crop produced the highest yield of 0.89 to 1.01 q/ha and it accounts for an yield increase of 43.55 to 62.90 percent.

Application of bee attractants had no effect on the germination percentage of seeds both in sesame and niger.

Attractants had no effect in improving the shoot length of sesame, but in niger Citral E, Citral Z, *F. budrunga*, and *S. densifolia* were the next best treatments to Fruit Boost and produced the longer shoot length (8.57 to 10.04 cm).

Root length of sesame and niger was improved as a result of application of attractants. Similarly the vigour index was also increased by the application of attractants in sesame and niger.

- ✓ Total *Apis* pollinator visitation did not differ in both sesame and niger genotypes, however the total mean bee visitation was significantly different on different days after flowering, similarly the interaction between the genotypes and the days after flowering was also different in both the crops.
- ✓ In sesame Citral E, Citral Z, *F. budrunga*, *S. densifolia*, were found to be as good as the commercial bee attractant Fruit Boost in enticing the bees. In niger also Citral E, Citral Z, *F. budrunga*, *S. densifolia* were found to be as superior as Fruit Boost and attracted bees in higher numbers.
- ✓ In sesame higher yield was obtained from Citral Z and Citral E which was as good as Fruit Boost (1.41 to 1.51 q/ha) and resulted in an increase in yield of about 48.42 to 58.94 per cent over the control. Citral Z, Citral E and Fruit Boost received crop produced the higher yield of 0.89 to 1.01 q/ha accounting for an increase of 43.55 to 62.90 per cent over control in niger.

REFERENCES

- Abdul-Baki and Anderson, J. D., 1973, Vigour determination in soybean seed by multiple criteria. *Crop Sci.* **13**: 630-662.
- Ambrose, J. T., Schultheis, J. R., Bambara, S. B. and Mangum, W., 1995, An evaluation of selected commercial bee attractants in the pollination of cucumbers and watermelons. *J. Apic. Res.* **135**: 267-272.
- Anonymous, 1996, International rules for seed testing. *Seed Sci. & Technol.* (Supplement): 1-335.
- Anonymous, 2005, observations made during "national seminar on strategies for enhancing production and export of sesame and niger" and "annual workshop of aicrp on sesame and niger research workers 2005".
- Belletti, A. and Zani, A., 1981, A bee attractant for carrots grown for seed, *Sementi Elette*, **27**: 23-27.
- Bhat, S. S. and Sudharshan M. R., 1999, Studies on the efficacy of Bee-Q in augmenting pollination, Fruit and Seed set in cardamom (*Elettaria cardamomum maton*) - A preliminary report, *Indian Bee J.*, **61**: 49-54.
- Bhosle, B. B., Shetgar, S. S. and Bilapate, G. G., and Londhe, G. M., 1992, Effects of attractant sprays for pollinators on sunflower yield. *J. Maha. Agric. Uni.* **17**: 135.
- Burgett, M. and Fisher, G. C., 1979, An evaluation of Beeline as a pollinator attractant on red clover. *Am. Bee J.* **119**: 356-357.
- Butts, K. M., 1991, Bee attractants: improving straw berry quality? *Citrus and Vegetable Magazine.* **55**: 16-17.
- Currie, R. W., Winston, M. L., Slessor, K. N. and Mayer D. F., 1992a, Effect of synthetic queen mandibular pheromone sprays on pollination of fruit crops by honey bees, (Hymenoptera: Apidae). *J. Econ. Ento.* **85**: 1293-1299.
- Currie, R. W., Winston, M. L., Slessor, K. N. and Mayer D.F., 1992b, Effect of synthetic queen mandibular pheromone sprays on honey bee (Hymenoptera: Apidae), pollination of berry crops. *J. Econ. Ento.* **85**: 1300-1306.
- Doull, K. M., 1974, Effects of attractants and phagostimulants in pollen and pollen supplement on the feeding behaviour of honeybees in the hive. *J. Apic. Res.* **13**: 47-54.
- Ellis, A. and Delaplane, K. S., 2009, An evaluation of Fruit Boost as an aid for honey bee pollination under conditions of competing bloom. *J. Apic. Res.* **48**: 15-18.
- Elmstrom, G.W. and Maynard, D. N., 1990, Attraction of honey bees to watermelon with bee attractant. *Proceedings of the Florida State Horticultural Society*, **103**: 130-133.
- Ganapathi, K., 2005, Impact of bee attractants on bee activity and yield parameters of Bt cotton. *M.Sc. (Agri.) Thesis*, Uni. Agric. Sci. Dharwad (India).
- Gellert, M., Rozsa, Z., Kovacs, Z., Szendrei, K., Hussain, R.A., Reisch, G. and Reisch, J., 1985, Honey bee attractants in the fruits of *Evodia hupehensis* Dode. *Herba Hungarica.* **24**: 53-65.
- Guruprasad, G. S., 2001, Maximization of productivity of niger through enhancement of pollination. *M.Sc. (Agri.) Thesis*, Uni. Agric. Sci. Dharwad (India).
- Henning, J. A., Ying-Shin Peng, Montague, M. A. and Teuber, L. R., 1992, Honey bee (Hymenoptera: Apidae), behavioural response to primary alfalfa floral volatiles. *J. Econ. Ento.* **85**: 233-239.
- Higo, H.A., Winston, M. L. and Slessor, K. N., 1995, Mechanisms by which honey bee (Hymenoptera: Apidae), queen pheromone sprays enhance pollination. *Ann. Entomol. Soc. Am.* **88**: 366-373.
- Kalmath, B. S., 2002, Impact of bee pollination on onion seed production. *M.Sc. (Agri.) Thesis*, Uni. Agric. Sci. Dharwad (India).

- Kalmath, B. S. and Sattigi, H. N., 2002, Effect of different attractants on attracting the bees to onion (*Allium cepa*) crop. *Indian Bee J.*, **64**: 68-71.
- Kalmath, B. S. and Sattigi, H. N., 2004, Effect of bee pollination by using attractants on the qualitative parameters of onion seed. *Pest Management and Econ. Zool.* **12**: 97-99.
- Kalmath, B. S. and Sattigi, H. N., 2005, Use of attractants in maximizing the quantitative parameters of onion seed. *Changing trends in pollen spore-research*, 41-46
- Ken-Naumann, K., Winston, M. L., Slessor, K. N. and Smirle, M. J., 1994, Synthetic honey bee (Hymenoptera: Apidae) queen mandibular Gland pheromone applications affect pear and sweet cherry pollination. *J. Econ. Ent.* **87**: 1595-1599.
- Kulkarni S. N., 2007, Foraging behaviour and pollination efficiency of Indian honey bee *Apis cerana indica* on sesame (*Sesamum indicum* L. ISOR National seminar, 29-31.
- Mackenzie, K. E. and Averill, A. L., 1992, a new honey bee attractant, the queen mandibular pheromone. *Cranberries* **56**: 13-14.
- Malerbo - Souza, D.T. and Nogueira - Couto, R.H., 1998, Effect of attractants and repellents on the behaviour of honey bees (*Apis mellifera* L.) *Scientia - Agricola.* **55**: 388-394.
- Malerbo Souza, D. T., Nogueira - Couto, and R. H. Couto, L. A., 2004, Honey bee attractants and pollination in sweet orange, *citrus sinensis* Osbeck, var. Pera-rio. *J. Venom. Anim. Toxins incl. Trop. Dis.*, **10**:362-368.
- Manjunatha, K., 2003, Field scale evaluation of bee attractants for their efficacy in sunflower. *M.Sc. (Agri.) Thesis*, Uni. Agric. Sci. Dharwad (India).
- Margalith, R., Lensky, Y. and Rabinowitch, H.D., 1984, An evaluation of Beeline as a honeybee attractant to cucumbers and its effect on hybrid seed production, *J. Apic. Res.*, **23** (1): 50-54.
- Mayer, D. F., Britt, R. L. and Lunden, J. D., 1989, An evaluation of Bee scent as a honeybee attractant. *Good Fruit Grower* **40**: 40.
- Mayer, D.F. and Johansen C. A., 1982, Field evaluation of chemical pollinator attractants on tree fruits. *Am. Bee J.* **122**: 287-289.
- Maynard, D. N., Elmstrom, G. W. and Mc Cuiston, F. T., 1992, Periodicity of watermelon fruit set and effect of bee attractant on yield. *Proc. Iter. Am. Soc. Tropic. Hort.* **36**: 81-87.
- McGourty, M. A., 1992, field evaluation of "bee-here a pheromone-based forage attractant for honey bees, *Apis mellifera* L., applied to red clover, *Trifolium pratense* L. Corvallis: Oregon State University, [Master of Agriculture Thesis].
- Mohana Rao, G. and Suryanarayana, M.C., 1990, Studies on the foraging behaviour of honeybees and its effect on seed yield of niger. *Indian Bee J.* **52**: 31-33.
- Mohana Rao, G. M., Lazar, M., and Suryanarayana, M. C., 1981, Foraging behaviour of honeybees in sesame (*Sesamum indicum* L.) *Indian Bee J.* **43**: 97-100.
- Murasing, S. and Viraktamath, S., 2002. Role of bee attractants in pollination and productivity of mustard (*Brassica juncea* L.). Proceedings of 6th Asian Apiculture Association (AAA) International conference and world APIEXPO, Feb-24 to March 1, Bangalore, p.78.
- Nagaraj C.J. and Bhat N.S., 2006, Extent of Dependability of Niger on Honey bees for cross pollination, *Indian Bee J.* **68**: 80-89.
- Nagiri, S. and Patnaik, H.P., 2006, Foraging activity of *Apis cerana indica* in response to bee attractant/stimulant feedings, *J. Pl. Prot. and Environ.* **3**: 21-23.
- Naik, D. G., Banhatti, P., Chanwda, S. S. and Thomas, D., 2003, *Fagara budrunga* fruit extract as an attractant for *Apis cerana*. *J. Apic. Res.* **42**: 48-49.

- Naik, D. G., Dandge, C. and Puntambekar, H., 2007, *Swertia densifolia* leaf extract as a dose-dependant attractant or repellent for *Apis florea* *J. Apic. Res.* **46**: 15-18.
- Naik, D. G., Dandge, C., Puntambekar, H. and Patil, T., 2005, Attractant and repellent properties of *Swertia densifolia* leaf extract towards *Apis cerana indica*. *J. Apic. Res.* **44**: 116–118.
- Narayanan, T.S. and Gavi-gowda, 2005, Influence of insecticidal and sugar syrup spray on foraging activity of honeybees in gherkin (*Cucumis anguria*). *Indian Bee J.* **67**: 67-71.
- Niera and Barriga 1995, Honey bee (*Apis mellifera* L., Hymenoptera: Apidae) pollinating behaviour on raspberry (*Rubus idaeus* L., cv. Heritage) under the effect of two attractant and one repellent treatments. *Agro Sur.* **23**: 52-59.
- Ortiz-Sanchez, F.J., 1993, Evaluation of the efficiency of Beehere as a honey bee (*Apis mellifera* L) attractant to arrow crop (*Cucurbita pepo* L) cultivated in greenhouse conditions in Southern Spain. (Hymenoptera: Apidae). *Entomofauna*, **14**: 465-469.
- Panda, P., Nanda, U.K., Mohapatra, H. and Padhi, 1989, Insect pollination in some oilseed crops in Orissa, India. *Indian Bee J.* **51**: 97-98.
- Panda, P., Rath, L. K., Padhi, J. and Panigrahi, D., 1995, Relative abundance and foraging behaviour of common bee species on niger in Phulbani District, Orissa, India. *Indian Bee J.* **57**: 10-14.
- Panda, P., Sontakke, B. K. Sarangi, P. K., 1988, Preliminary studies on the effect of bee (*Apis cerana indica* F.) Pollination on yield of Sesamum and Niger, *Indian Bee J.* **50**: 63-64.
- Panda, P., Sontakke, B. K. and Panda, B., 1993a, Effect of different modes of pollination on yield of sunflower and niger. *J. Ins. Sci.* **6**: 75-77.
- Panda, P., Sontakke, B. K. and Panda, B., 1993b, Foraging behaviour of honey bee species on different varieties of niger, *Guizotia abyssinica* Cass. in Orissa, *J. Ins. Sci.*, **6**: 104-106.
- Pateel, M. C. and. Sattagi H. N., 2007, Effect of Different Attractants on Attracting the Bees to Cucumber (*Cucumis sativa* L.) Crop. *Karnataka J. Agric. Sci.* **20**: 761-763.
- Patil, B.S., 1999, Role of bee attractants in enhancing productivity and quality of sesamum, *M.Sc Thesis*, Uni. Agric. Sci., Dharwad.
- Patil, B.S., Viraktamath, S., Lingappa, S., Giraddi, R.S., Parameshwarappa, K. and Bhat, A.R.S., 2000, Effect of Bee-Q and Bee-here on pollinators and yield of sesamum, *Insect Environment.* **5**: 151-152.
- Patnaik, H. P., Mohapatra, L. N. and Das, B., 2004, Effect of bee pollination on the yield of sesame under protected conditions, *Indian Bee J.* **66**: 84-91.
- Pinzauti, M., 1985, An evaluation of different substances that attract pronubial insects, *Proceedings of the XXIXth International Congress of Apiculture, Budapest*, 327-332.
- Pinzauti, M., 1990, Kiwi pollination: several ways of increasing the activity of honeybees, *Acta Horticulturae.* **282**: 149-150.
- Pinzauti, M. and Corsi, M., 1981, The use of "Bee line" as an attractant for pollinating insects on flowers of fababean (*Vicia faba* m.): *Informatore Agrario*, **37**: 14913-14914.
- Rajotte, E. G. and Fell, R. D., 1982, A commercial bee attractant ineffective in enhancing apple pollination. *Hort. Sci.* **17**: 230-231.
- Rakesh kumar and Lenin, J. K., 2000, Insect pollinators and effects of cross pollination on yield attributes of Sesame (*Sesamum indicum* L.), *Indian Bee J.* **62**:
- Rapp, R., 1981, The effect of pollination by honey bees (*Apis mellifera* L.) on cucumber cv. 'Delila' seed production. *Fac. Agric.* p.71.

- Sachdeva, Y., Bhatnagar, P. and Gulati, R., 2003, Relative abundance and foraging behaviour of *Apis* spp. on sesamum (*Sesamum indicum*) flowers, *Ann. Pl. Protec. Sci.*, **11**: 281-283.
- Sanjivan Kumar, HariChand, and Singh, R., 2000, increasing the attractiveness of sunflower to honeybees for pollination. *Shashpa*, **7**:151-154.
- Sattigi, H. N., Gundannavar, K. P., Kambrekar, D. N. and Kulkarni, K. A., 2004, Effect of bee pollination on the yield parameters of Niger quality *Karnataka J. Agric. Sci.* **17**: 831-832.
- Schultheis, J. R., Ambrose, J. T., Bambara, S. B. and Mangum, W. A., 1994, Selective bee attractants did not improve cucumber and watermelon yield, *Hort Science*, **29**: 155-158.
- Sengupta and P.K. Das., 2003, Cultivated Annual Oilseed Crops of India/K. Kolkata, Naya Udyog, xii, 296 p., tables, figs., ISBN 81-85971-34-X.
- Singh, P. B. and Sinha, S. N., 1996, Effect of Bee-Q on honeybee visit and seed yield of hybrid sunflower *Seed-Res.* **24**: 151-153.
- Sotomayor, S. C., 1997, Evaluation of different pollination modes in almonds, *Ciencia e Investigacion Agraria.* **24**: 7-11.
- Srikanta Nath, 2008, Evaluation of indigenous bee attractants in sunflower *M.Sc (Agri.) Thesis*, Uni. Agric. Sci. Dharwad (India).
- Srimathi, P., Vijaya, J., Ananthakalaiselvi, A. and Krishnasamy, V., 1999, Bee-Q effect on honey bee visit and seed yield of hybrid sunflower KBSH-1, *Madras Agric. J.* **86**: 338-339.
- Tew, E. J. and Ferree, D. C., 1999. The influence of a synthetic foraging attractant, Bee Scent, on the number of honey Bees visiting apple blossoms and on subsequent fruit production. *Research Circular - Ohio Agricultural Research and Development Center*, The Ohio State University, Wooster, OH 44691.
- Tsirakoglou, V., Thrasivoulou, A. and Hatjina, F., 1997, Techniques to increase the attractiveness of kiwi flowers to honey bees *Acta Hort.* **444**: 439-443.
- Viraktamath, S. and Anagoudar, J. A., 2002, influence of bee attractants in enhancing pollination and yield parameters in *Cucumis sativa* L. *Indian Bee J.* **64**: 23-27.
- Viraktamath, S. and Patil R. K., 1999, Preliminary studies on the influence of bee attractants on bee visitation and yield parameters of sesamum, *Sesamum indicum* L., *Indian Bee J.* **61**: 55-58.
- Viraktamath, S., Patil, B S., Murasing, S. and Guruprasad, G.S., 2001, Relative abundance and pollinator fauna of cross pollinated oil seed crops at Dharwad, Karnataka, India. *Indian Bee J.* **63**: 64-67.
- Viraktamath, S., Patil, R. K., 2002, Effect of bee pollination in maximization of productivity in sunflower. Proceeding of 6th Asian Apiculture Association (AAA) International conference and world APIXO, Feb-24 to Mar-1, Bangalore, p.62.
- Waller C. D., 1970, Attracting honey bees to alfalfa with Citral, Geraniol and Anise. *J. Apic. Res.* **9**: 9-12.
- Winston, M.L. and Slessor, K.N., 1993, Application of queen honey bee mandibular pheromone for bee keeping and crop pollination. *Bee World*, **74**: 111-128.
- Woodrow, A.W., Green, N., Tucjer, H., Schonhorst, M. H. and Hamilton, K. G., 1965, Evaluation of chemicals as honey bee attractants and repellents. *J. Econ. Ent.* **58**: 1094-1102.
- Woyke.W, 1981, some aspects of the role of the honeybee in onion seed production in Poland. *Acta Horticulture*, **111**: 91-98.
- Zvedenok, A. P., 1996, The onion seed crop can be improved. *Kartofel i Ovoshchi*, **4**:

APPENDIX

Monthly meteorological data during crop growth period (2008-09) and the average of 58 years (1950-2008) at Main Agricultural Research Station,
UAS, Dharwad

Months	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
	2008-09	1950-2008	Mean maximum		Mean minimum		2008-09	1950-2008
			2008-09	1950-2008	2008-09	1950-2008		
April	28.8	49.3	34.7	37.3	20.4	19.8	80.4	75.6
May	55.8	80.2	35.1	33.7	20.6	21.3	85.1	66.2
June	101.6	114.2	28.7	28.8	21.0	22.4	91.8	81.1
July	121.0	152.4	28.2	29.1	20.7	21.0	91.3	87.1
August	213.2	98.5	26.9	26.9	20.1	20.0	91.5	86.0
September	162.4	104.9	27.8	28.5	20.0	19.9	91.4	82.1
October	60.4	126.9	30.3	30.0	18.9	18.4	83.5	75.8
November	72.2	33.0	29.3	30.1	15.9	15.9	79.4	68.0
December	0.0	5.2	28.6	29.3	13.8	12.5	75.4	63.2
January	0.0	0.1	29.8	29.6	13.3	14.6	66.6	63.1
February	0.0	1.1	33.2	31.2	16.8	16.3	57.5	51.5
March	29.0	2.3	35.0	32.4	19.9	19.5	73.0	56.0
Total	844.4	768.4						

EVALUATION OF INDIGENOUS BEE ATTRACTANTS IN ENHANCING THE YIELD PARAMETERS OF SESAME AND NIGER

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ABSTRACT

Investigations on the foraging behaviour of honey bees on different genotypes and influence of bee attractants on bee visitation and yield parameters of sesame and niger were carried out at the Main Agricultural Research Station of the University of Agricultural Sciences, Dharwad during *kharif* 2008.

Visitation of honey bees (*Apis dorsata*, *A. cerana* and *A. florea*) was similar on different genotypes of sesame and niger. However, bee visits on different days after flowering and the interaction between genotypes and days after flowering varied significantly.

Citral E, Citral Z, *Fagara budrunga*, *Swertia densifolia* were found to be as good as the commercial bee attractant Fruit Boost in attracting honey bees to sesame and niger flowers (2.12 to 4.23 and 10.18 to 15.35 bees/5 flowers/minute, on respective crops).

Higher number of capsules/ plant was produced in the crop that received Citral Z, Citral E, Fruit Boost and Sugar solution (42.32 to 47.12 capsules/plant) in sesame. However similar influence was not observed in niger. Thousand seed weight was higher in sesame treated with Citral Z and Fruit Boost (2.85 g to 3.02 g). In niger Citral E, Fruit Boost, Citral Z, *F. budrunga* and *S. densifolia* (4.64 g to 4.08 g) had greater effect in producing higher seed weight. Citral Z and Citral E were as good as Fruit Boost producing higher yield in sesame and niger (1.41 to 1.51 in sesame and 0.89 to 1.01 in niger vs 0.95 and 0.62 q/ha in control in respective crops). *F. budrunga* and *S. densifolia* treated crop produced next higher yield in both the crops.

Attractants improved the seed vigour index in sesame (1177.90 to 1251.70 vs 1012.35 in control) while in niger they were next best to Fruit boost (1103.20 to 1220.70 vs 945.00 in control).