STUDIES ON MAJOR INSECT PESTS OF SAPOTA WITH SPECIAL REFERENCE TO SAPOTA FRUIT BORER, *Phycita erythrolophia* Hampson AND ITS MANAGEMENT

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INTRODUCITON

Sapota (*Manilkara achras* (Mill.) Farsberg, syn. *Achras zapota* Linn.) belongs to family Sapotaceae is a native of Mexico. It is called by several names such as Chiku, Sapodilla, Zapata or Sapodilla plum in different regions. It is one of the most adoptable tropical fruit crops and it has been found to thrive under varied soil and climatic conditions. It is popular in Sri Lanka, India, Jamaica, Philippines, Central America and Southern Florida. The fruit was introduced during 1888 in a village Gholwad of Thane district of Maharashtra in India, thereafter, it spread to Gujarat, West Bengal, Uttar Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, Punjab and Haryana (Cheema *et al.,* 1954). The first commercial sapota cultivation from Maharashtra was taken up in Gholvad area in 1898 (Sulladmath and Reddy 1990).

In the recent past, it has shown a phenomenal growth and attained the status of a major fruit crop after mango, banana and citrus. India is considered to be the largest producer of sapota in the world and it is being cultivated in an area of about 163.9 thousand ha with a production of 1495.0 metric tonnes (Anon., 2014).

Major sapota producing states are Karnataka (Belgaum, Dharwad, Chickmagalore, Shimoga, and Hassan), Maharashtra (Pune, Thane and Ahmednagar) and Gujarat (Valsad, Surat, Kheda, and Bhavnagar districts). It is also cultivated to some extent in Andhra Pradesh (East and West Godavari, Krishna, Guntur, Kurnool, and Medak districts), West Bengal (South 24 - Paraganas, Midnapur districts), Orissa and Tamil Nadu. Out of the total fruit production in India, Karnataka ranks first contributing 25 per cent of total production of sapota (Anon., 2014). The total area of sapota grown in Karnataka is about 31.7 thousand ha. with an annual production of 373.7 lakh metric tonnes with a productivity of 11.8 metric tonnes per ha (Anon., 2014). The productivity is more or less the same in all the states, except that it is very high in Tamil Nadu and very low in Orissa.

Sapota contains poly-phenols and tannin along with sugars in varying concentrations depending mainly on the stage of ripening (Debrito and Narain 2002). It is an interesting fruit crop especially for its peculiar flowering and fruiting behaviour. In general flowering is erratic and this has been facilitated the harvest of fruit throughout the year. It is therefore rightly called “All the year cropper” (Katyal, 1961).

The fruit greatly vary in size and shape. There are varieties which produce characteristically round fruits such as Calcutta round, Cricket Ball and Barmasi whereas the varieties such as Badam, Oval, Guthi and Vavivalasa produce oval shaped fruits. The varieties Kalipatti and Chattri produce both round and oval shaped fruits on the same tree (Gandhi, 1956). Among the several cultivated varieties, Kalipatti is the leading variety known for its high yielding potentiality and quality. This variety is preferred by the gardeners of transitional tract of Karnataka on account of remarkable resistance to drought condition and diseases.

Sapota is a beautiful and evergreen tree which has a unique behaviour of continuous flowering and fruiting throughout the year in warm and humid climate. Though sapota crop is cultivated since long time, majority of farmers are not well aware of the pest menace to this crop. The main reason behind this is the inability of farmers to realize the losses inflicted by the insect pests because of the continuous flowering habit and long duration between bud initiation and harvesting. Thus, there is a belief among the farmers that no plant protection measures are required in sapota. Proliferation of insect pests in wider area has occurred because of the intensive cultivation of sapota coupled with monoculture of Kalipatti variety supported by changing environmental condition as well as unchecked pest population.

Earlier, insects and diseases were not a serious problem on sapota. The rapid expansion of this crop across the country mainly in the states *viz.,* Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Kerala has seen a corresponding increase in the pest complex too (Somdutt, 2001). Sandhu *et al*., (1974) listed ten insect pests attacking sapota in India. Like any other fruit crop Sapota is found to be infested by more than 23 insect pests (Butani, 1975).

Among the various factors affecting the yield and quality of fruit crops, the damage caused by insect pests is considered as a major constraint. Among the different pests, bud borer, *Anarsia achrasella* Bradley, mid rib folder, *Banisia myrsusalis elearalis* Walker, chiku moth *Nephopteryx eugraphella* Ragonot, Leaf miner *Achrocercops gemoniella* Stainton and fruit flies, *Bactrocera dorsalis* (Hendle) *and Bactrocera zonata* (Saunders) are considered as major pests of sapota. Bud borer, leaf miner as well as mid rib folder remain active throughout the year with varying degrees of infestation

(Patel, 2002). In addition the sapota fruit borer *Phycita erythrolophia* Hampson was reported as a predominant species causing considerable damage to flower buds and fruits of sapota (Vishwanath *et al*., 1978). The early instars larvae of sapota fruit borer, *P. erythrolophia* feeds on flower buds whereas, the later instars cause damage to fruits by boring into pulp and due to its continuous feeding the excretary pellets got entrapped in silken web, thus resulting in premature fruit fall and pest was found active throughout the year (Patil,1986). The detailed study on the major pests of sapota with special reference to sapota fruit borer, *P. erythrolophia* is lacking and hence the present study has been taken up with the following objectives.

1. Survey of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson.
2. To study the seasonal incidence of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia*.
3. Management of sapota fruit borer, *Phycita erythrolophia*.

REVIEW OF LITERATURE

The relevant literature on major insect pests of sapota on survey and seasonal incidence of major pests of sapota in relation to weather parameters and management of sapota fruit borer, *Phycita erythrolophia* Hampson was reviewed and described in this chapter.

2.1 Insect pest status of sapota

Sandhu *et al*., (1974) listed ten insect pests attacking sapota in India. This was the first record of genus *phycita* occurring on sapota (Vishwanath *et al*., 1978). The caterpillars of unidentified species of *phycita* boring flower buds of sapota in silver jubilee orchard, UAS, Dharwad was observed. Butani (1979) listed 25 insect pests and mites attacting sapota trees in India. Patel (2001a) reported 16 insect pests ant mites from Gujarat. A pest like seed borer, *Trymalitis margarias* Meyrick was reported from Dahanu area of Maharastra adjoining south Gujarat. Shukla (2011) observed 18 insect pests and mites attacking sapota and also provided information regarding their identification, nature of damage and management practices. A list of insect pests and mites attacking sapota crop at various stages is compiled and presented in table – 1.

2.2 Survey of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson

2.2.1 Major insect pests of sapota

Bud borer, *Anarsia achrasella* Bradley

The infestation of bud borer was maximum in the month of June and minimum in the month of January in valsad district of Gujarat state (Anon., 1985). Highest infestation of bud borer, *A.achrasella* was noticed in the month of September (8.57 %) and lowest in January (0.35 %) at Fruit Research Station, Gandevi, Gujarat (Anon., 1995)

Anarsia achrasella caused as high as 20.42 % incidence in October on leaves and 31.65% infestation on buds of sapota in the month of May in South Gujarat (Anon., 1998)

Chiku moth, *Nephopteryx eugraphella* Ragonot

Roving survey carried out in Valsad district of Gujarat reveled the maximum per cent (2.5) infestation of chiku month, *N. eugraphella* in the month of August and minimum (0.04) in the month of January (Anon., 1985).

Higher per cent infestation of *N. eugraphella* on buds (19.23%) was noticed in Junagad area of Gujarat (Anon., 1986). Survey was carried out in Valsad district of Gujarat state wherein maximum infestation of chiku month, *N. eugraphella* on leaves was recorded in the month of August (2.60%) and minimum in the month of April (Anon., 1989)

The Higher percentage of infestation of *N. eugraphella* on buds as well as on leaves was found during August to November, while it was low in the rest of the months in south Gujarat. The damage was as high as 17.55 and 12.21%, respectively (Anon., 1989 and 1997).

Leaf miner, *Achrocercops gemoniella* Stainton

The infestation of leaf miner, *A. gemoniella* was high in the month of September in valsad district of Gujarat state (Anon., 1985). More or less proportional rate of infestation by *A. gemoniella* throughout the year on sapota in Junagadh has been recorded (Anon., 1986).

High infestation of leaf miner, *A.gemoniella* was noticed in the month of June and August and low in the month of March and April in the chiku orchard of valasad district of Gujarat state (Anon., 1987). The activity of leaf miner was at its peak in the month of May and September, while it was low in the month of October and November (Anon., 1995)

Sapota mid rib folder, *Banisia myrsusalis elearalis* Walker

In chiku orchard of Valsad, the maximum infestation of mid rib folder was in November and December (Anon., 1987).The higher infestation was reported in the months of October and November (Anon., 1995 and 1998)

Sapota fruit borer, *Phycita erythrolophia* Hampson

The literature related to survey of sapota fruit borer incidence is lacking.

Table-1: Insect pests and mites infesting sapota

Sl. No	Plant parts damaged	Common Name	Scientific Name	Family/ Order	Place	Reference
1	Flower/ bud	Chiku moth	*Nephopteryx eugraphella* Ragonot	Pyralidae: Lepidoptera	Bihar Gujarat	(Misra, 1920) (Jhala *et al*., 1986)
2		Bud borer	*Anarsia achrasella* Bradley	Gelechidae: Lepidoptera	Gujarat	(Patel *et al*., 1964)
3		Bud borer	*Phycita* sp.	Phycitidae: Lepidoptera	Dharwad	(Vishwanath *et al*., 1978)
4	Fruit	Fruit fly	*Dacuscorrectus* Bezzi	Tephritidae: Diptera	Gujarat	(Butani, 1975) (Shah and Vora,1974)
5			*Bactrocera dorsalis* (Hendle), *Bactrocera. zonata* (Saunders) and *Bactrocera. correcta* (Bezzi)	Tephritidae: Diptera	Gujarat	(Patel and Patel, 1998)
6		Mealy bug	*Rastrococcus iceryoides* (Green)	Pseudococcidae:Hemiptera		(Nayar *et al*., 1976)
7			*Ferrsia virgata* (Cockrell)	Pseudococcidae: Hemiptera	Gujarat	(Jhala *et al*., 1988)
8	Seed	Seed borer	*Trymalitis margarias* Meyrick	Totricidae: Lepidoptera	Gujarat	(Patel, 2001b)
9	Leaves	Leaf miner	*Achrocercops gemoniella* Stainton	Gracillaridae: Lepidoptera	Bihar Gujarat	(Fletcher, 1920) (Patel, 1981)
10		Mid rib folder	*Banisia myrsusalis elearalis* Walker	Thyrididae: Lepidoptera	Punjab Gujarat	(Sandhu and Sran, 1980) (Jhala *et al*., 1988)
11		Leaf eating caterpillar	*Anarsia anthrivara* Clarke	Gelechidae: Lepidoptera	Gujarat	(Jhala *et al*., 1988)
12		Leaf eating caterpillar	*Metanastria hyrtaca* (Craner)	Lasiocampidae:Lepidoptera	South India	(Beeson, 1941)
13		Semilooper	*Achaea meracataria* Fabricius	Noctuidae: Lepidoptera	Gujarat	(Patel and Patel, 1999)
14		Jassid	*Flata* sp.	Flatidae: Hemiptera	Gujarat	(Jhala *et al*., 1988)
15		Eriophyid mite/ gall mite	*Aceria* sp.	Eriophyidae: Acarina	Gujarat	(Jhala *et al*., 1988)
16	Others	Chaffer beetle	*Holotrichia (phyllophaga) consanguinea* (Blanchard)	Scarabaeidae: coleoptera	South India	(Hussain, 1974)
17		Bark eating caterpillar	*Inderbella tetraonis* (Moore)	Metarbelidae: Lepidoptera	Maharashtra	(Bhat and Patil, 1933)
18		Grey weevil	*Myllocerus undecimpustulatus*	Curculionidae: Coleoptera	Bihar	(Fletcher, 1917)

2.3 Study the seasonal incidence of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia*.

2.3.1 Major insect pests of sapota

Bud borer, *Anarsia achrasella* Bradley

Bradley (1981) reported *A.achrasella* larvae infesting the flower buds and young leaves of sapota was severe from November to February and May to June and least in July and August. Patel (1981) observed that, the maximum per cent infestation on buds (18.03) was found in June and minimum (2.92) in August at Gandevi in Valsad district. The population of *A.achrasella* was maximum during September to December and again from April to June and minimum population was observed from July to August Patil *et al.,* (1986). Jhala *et al.,* (1986) observed that, the infestation was maximum in June and minimum in September at Amalsad and Navsari in Valsad district. Infestation of chiku bud borer remained more or less throughout the year with its peak period of infestation during the early part of monsoon (Patel *et al.,* 1986).The infestation of bud borer ranged from 10.91 to 15.46 per cent at college farm, Navasari by (Shah *et al.,* 1986).

Patel (1990) observed infestation of bud borer was maximum in the month of May and minimum in October, while on leaves it was high in the month of January (7.11%) and minimum in August (0.43%) at G. A. U farm, Navasari. Similarly, maximum incidence of borer was recorded 5.25% during January (Jothi *et al.,* 1994)

The higher activity of bud borer *A. achrasella* was reported on leaves in August at Navsari, Gujarat. Deshmukh (2001). The highest per cent bud infestation due to *A.achrasella* was found during the month of February and May (Anon., 2001). The bud borer incidence was maximum from March to June (Arun and Azeez, 2004). Bud borer (*A. achrasella*) is one of the important pests and was active throughout the year. The maximum incidence was recorded from February to April (Anon., 2009).

Dongre (2011) reported maximum damage of *A. achrasella* to the buds (19.84 %) during second fortnight of March while it was 15.45 % to the leaves during second fortnight of August. Bud borer was active throughout the year with a varying degree of infestation ranging from a minimum of 2.14 per cent (first fortnight of October) to maximum of 11.29 per cent (second fortnight of March) (Sathish *et al.,* 2014).

Effect of weather parameters

Patel (1990) reported from south Gujarat that the bud borer incidence on buds was not influenced by the weather parameters but, on the leaves, it had significant correlation with maximum temperature and sunshine hours while negative significant correlation with minimum temperature, relative humidity, rain fall and rainy days. Parvathi and Belavadi (1994) reported that, there was no influence of abiotic factors on the population of bud borer, *A. achrasella* in Karnataka. In south Gujarat, the bud borer incidence on buds had significantly negative correlation with minimum temperature, relative humidity and rain fall but incidence on leaves was not influenced by any of the weather parameters (Anon., 1998).

Sushil Kumar and Bhatt (2002) observed that, bud borer infestation had significant positive correlation with maximum temperature. Jayanthi *et al.,* (2008) studied on the role and reliability of weather factors on the incidence of sapota bud borer, *Anarsia achrasella*. This study clearly showed that preceding week's weather variables *viz*., minimum temperature, evaporation and wind speed were found to be important predictors of bud borer incidence. The model developed using wind speed and evaporation ($Y=-16.4+3.26X_6$ (wind speed) + 2.29X7 (Evaporation)) predicted borer incidence reasonably well based on R^2 value and minimum average prediction errors.

Dongre (2011) reported that pest damage had significant positive correlation with maximum temperature. Similarly, there was a significant and positive correlation between bud borer damage and maximum temperature. Thus the pest infestation increases with increase in temperature and vice versa. Rest of the weather factors *viz*., minimum temperature, relative humidity and rain fall had no influence on pest population during the period of study (Sathish *et al.,* 2014)

Sapota leaf webber, *Nephopteryx eugraphella* Ragonot

Gupta and Gangrade (1955) reported that the damage caused by *N. eugraphella* to shoots was greater in June and September. Chiku moth was found infesting with peak period during the later

months of the monsoon, i.e. September-November (Patel *et al*, 1986). Patel *et al*., (1988) observed that the larvae excavated the flower buds and such fruits totally failed to develop in to fruit. It was observed in the laboratory that on an average 11.34 buds were damaged during the larval period of chiku moth (*N. eugraphella*).

Patel (1990) recorded higher per cent infestation on buds as well on leaves was found during August to November at GAU, College farm, Navsari. Patel and Jhala (1991) carried out experiment at Fruit Research Station; N.A.U Gandevi and found the maximum percent infestation (10.99 %) in the month of November and minimum in May and June.

Infestation of *N. eugraphella* on buds remained from 0.02 to 41% the maximum infestation of 40.92% was recorded in the month of July and minimum 0.40% in February. Patel (1996) reported that in south Gujarat the infestation of *N.eugraphella* on sapota trees remained higher in September to January. There were two peak of infestation on buds, which is second fortnight of September and recorded in first fortnight of November. Jhala *et al*., (1996) reported that infestation of *N. eugraphella* on sapota buds was high (9.36%) in June and October.

Patange *et al*. (1997) reported the peak infestation of chiku moth (*N. eugraphella*) from June to November in Maharashtra. Whereas, Dongre (2011) reported *N. eugraphella* damage on bud and it was recorded maximum (9.57 %) in second fortnight of June and on leaves, it was recorded 10.15 per cent in the month of October first fortnight.

Shukla (2011) and Patel (2001a) reported that extent of leaf area infested by *N. eugraphella* varied from 4.55 to 16.15 per cent. Damage to flowers/buds varied from 1.0 to 6.6 per cent. The pest was active throughout the year with the peak in May-June on flower/bud and in the month of February on leaves.

Effect of weather parameter

Patel (1990) and Patel *et al.,*(1992) reported that incidence of *N. eugraphella* on bud had significant positive correlation with minimum and average temperature, evening relative humidity and rainy days while per cent infestation was significant but negatively correlated with minimum, average temperature as well as evening and per cent RH under south Gujarat condition. However, Infestation of *N. eugraphella* on buds in middle Gujarat had significant positive correlation with rain fall, minimum temperature, morning and afternoon RH as well as morning and mean vapor pressure deficit. Infestation on leaves also had significant positive correlation with bright sunshine hour's, maximum temperature and mean relative humidity, morning afternoon vapor pressure and afternoon vapor pressure deficit (Patel 1996).Chiku moth infestation on bud was not influenced by any parameter under south Gujarat condition, while on leaves it had significant negative correlation with maximum temperature and positive with minimum temperature and rain fall (Anon., 1998).

Leaf miner, *Achrocercops gemoniella* Stainton

Patel (1981) reported that the infestation of leaf miner *A. gemoniella* on leaves was highest in August and minimum in February and March at GAU, Navsari. Jhala *et al*. (1986) reported that, per cent infestation of leaf miner, *Achrocercops gemoniella* was maximum in September while minimum in March, April and June at GAU, Navsari.

The occurance of leaf miner, *A.gemoniella* pest was present throughout the year in south Gujarat with the peak activity in the month of July and May (Patel, 1990) as well as June- July and September-October have been reported (Patel and Jhala 1991). Deshmukh (2001) reported that, peak activity of leaf miner, *A.gemoniella* and margin folder in August, May and September at Navsari. Shukla (2011) observed 15 -18 per cent leaf miner damage during the month of June and September.

Effect of weather parameters

Patel (1990) reported that from South Gujarat that incidence of leaf miner *A.gemoniella* had positive significant correlation with minimum and average temperature, relative humidity, rainfall and rainy days. While significant negative correlation with maximum temperature and sunshine hours. Infestation of leaf miner, *A. gemoniella* was significantly positive correlation with minimum and average temperature as well as evening and relative humidity under South Gujarat condition.

There was no influence of any of the weather parameters on infestation of leaf miner, *A.gemoniella* in south Gujarat condition (Anon., 1997). Significant negative correlation with maximum temperature and positive correlation with minimum temperature as well as rainfall have been further reported from south Gujarat (Anon., 1998). Significant positive correlation with minimum temperature

have been further reported from same place (Anon., 1998).Dongre (2011) reported that, leaf miner had significant positive correlation with minimum temperature, relative humidity and rainfall.

Fruit borer, *Phycita erythrolophia* Hampson

Vishwanath *et al.,* (1978) reported the occurrence of *Phycita* sp. as a new pest boring into unopened flower buds and feed on the corolla and gynoecium. The damaged flower did not set fruits.

Sandhu *et al.* (1981) observed an unidentified larva which was damaging the fruits of sapota by boring the fruits and feeding on the pulp of fruit.

The population of *P. erythrolophia* was maximum during September to December and was minimum during February to March and again during second fortnight of June to first fortnight of August on sapota tree (Patil, 1986).

Effect of weather parameters

Availabe literature revealed no information on relationship between sapota fruit borer damage and various weather parameters *viz.,* temperature (maximum and minimum), relative humidity (morning and evening) and rainfall.

Sapota mid rib folder, *Banisia myrsusalis elearalis* Walker

Patel (1981) observed maximum infestation of mid rib folder in December and minimum in June and October in Gandevi of Valsad district (Gujarat) as compared to other months in a year. Jhala *et al.,* (1986) reported that, the infestation of *B. m. elearalis* was high in June and minimum in April.

Deshmukh (2001) reported that, mid rib folder on sapota was active during dry and cold days, with a highest damage in October at Navsari (Gujarat). Sushil Kumar and Bhatt (2002) noticed higher leaf folder activity in sapota orchard during October to December and reached its peak (7.01 %) during December. Shukla (2011) revealed that, infestation of mid rib folder on sapota coincides with new flush of leaves and recorded maximum 10 to 15 per cent damage was during November to January

Mealy bugs, *Planococcus citri* Risso, *Planococcusl ilacinus* Cockerell

Mehta and Varma, (1968*)* observed *P.lilacinus* being active during summer months. Sandhu *et al.,* (1974) reported that *P.lilacinus* cause damage to sapota tree in summer months. Butani (1975) observed *P.lilacinus* infesting the leaves, tender shoots and fruits near flower stalks of sapota plants during summer months.

Mani and Krishnamoorthy (2008) reported pink hibiscus mealy bug, *Maconellicoccus hirsutus* (Green) on sapota at IIHR farm, Bangalore. The population declined from April to June and there was no significant influence of weather factors on mealy bugs population.

Sharma and Arora (2009) reported six mealy bug species on fruit crops *viz., Planococcus citri* (Risso), *P. lilacinus*, *Ferrisia virgata* (Cockerell), *Nipaecoccus viridis* (Newstead), *M. hirsutus* and *Drosicha mangiferae* (Green). Among these *P. lilacinus* had 5-15 per cent infestation on sapota.

Scale insects, *Coccus viridis* Green, *Icerya* sp.

Butani (1975) reported, scale insects like *Chloropulvinaria psidii* (Maskell) and *Rastrococcus iceryoides*(Green) invading the sapota leaves. *C psidii* and *R. iceryoides* (Nayar *et al.,* 1976) which cause damage to sapota tree.

Mani *et al.* (2008) studied the population dynamics of soft green scale, *Coccus viridis* (Green) for two years at IIHR farm, Bangalore. The results revealed that population declined from May, 2004(3.72/leaf) to March, 2006(1.62/leaf) and a significant positive correlation of scale population with minimum temperature was recorded.

Shukla (2011) provided information about scale insects damaging the sapota plants but did not mention the species.

Natural enemies

Gupta and Gangrade (1955) reported that the sapota leaf webber larvae are occasionally parasitized up to 15 per cent by two braconids. Three different parasitoid, *viz.,* an Ichneumonid, a yellow Braconid and a black Braconid to attacking, Sapota leaf webber, *N. eugraphella.* The

percentage of larval parasitism in nature during the 1946-47 and 1947-48 varied from 9.50 to 14.50 per cent. Sukheja (1973) reported that there is also an Ichneumonid pupal parasitoid. But all these natural enemies are not capable of bringing down the population of the pest during maximum infestation.

Mani *et al.,* (2008) reported that two coccinellid predators *Chilocorus nigrita* (Fab.) *Cryptolaemus montrouzieri* (Muls.) and one aphelinid parasitoid *Coccophagus* sp. were recorded on *C. viridis*. Both the predators played a minor role in the population fluctuation of *C. viridis*. The parasitoid *Coccophagus sp.* was the dominant natural enemy observed throughout the study recording a mean of 10.24 to 94.67% parasitism.

2.4 Management of sapota fruit borer, *Phycita erythrolophia* Hampson.

The literature on the evaluation of insecticides for the management of sapota fruit borer, *P. erythrolophia*is very scanty. Hence the literature in the bio efficacy of insecticides and evaluation of different molecules in the management of bud borer *A. achrasella* and leaf webber, *N. eugraphella* presented here under.

Patil (1986) reported that monocrotophos 0.05 per cent and qunialphos 0.05 per cent were found to be very effective in controlling the *p. erythrolophia* and *A. achrasella,* respectively. Radadia and Bhalani (1986) reported that monocrotophos (0.05%), quinalphos (0.03%), chlorpyrifos (0.04%) and carbaryl (0.2%) were effective in controlling the bud borer, *A. achrasella* accounting for over 97.0% larval mortality after 5 days of insecticidal application. Patel *et al.,* (1991) reported a significant reduction in the bud damage by *A. achrasella* in the chiku orchard with black tulsi leaves extract baited trap as compared to orchard without traps. Patel and Patel (1995) recommended an installation of black tulsi extract baited traps along with 3 sprays of endosulfan (0.07) for effective control of bud borer.

Deshmukh (2001) observed that Polytrin-C at0.044 per cent was most effective controlling bud borer. Patel (2001a) reported that two spray of neemark at 1 per cent effectively controlled the bud boring (*A. achrasella* and *N. eugraphella*) infesting pests. A module consisting of black tulsi extract baited trap (one trap/two trees) + spray application of synthetic insecticides dichlorvos at 0.03 %, profenophos (40 %) + cypermethrin (4%) at 0.044 per cent and botanical insecticides (Nimbecidine at 0.3%) alternatively at fifteen days interval was recommended for the control of *A.achrasella* on sapota (Anon., 2007).

Application of profenophos (40%) + cypermethrin (4 %) at the rate of 0.044 per cent proved effective against *A. achrasella* on sapota trees (Anon., 2008). Suryavanshi and Patel (2009) reported that Polytrin-C (profenophos and cypermethrin) at 0.044 per cent (0.69%) and Nurelle-D (chlorpyriphos and cypermethrin) at 0.055 per cent (1.40%) were significantly effective in controlling bud borer, *A. achrasella.*

Thumar (2012) reported that module 3 (Installation of black tulsi extract baited trap at the rate of 1 trap/2 trees at initiation of bud, spray of azadirachtin 0.15 EC at the rate of 40 ml/10 liters of water on initiation of bud damage and three sprays of profenophos (40 %) + cypermethrin (4 %) at the rate of 0.044 per cent at 15 days interval after azadirachtin spray) and module 2 (Installation of black tulsi extract baited traps at initiation of bud followed by alternate spray of endosulfan 35 EC at the rate of 0.07 per cent and carbaryl 50 WP at the rate of 0.2 per cent at 15 days interval) were equally effective for the management of bud borer in sapota.

MATERIAL AND METHODS

Studies were conducted on survey and seasonal incidence of major insect pests of sapota with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson and their natural enemies and management of sapota fruit borer. The field experiment was conducted in new orchard, Agriculture College, Dharwad and Saidapur farm, KVK, Dharwad is situated at 15°12' N latitude and 76°34' E longitude with an altitude of 678 meters above the mean sea level (MSL).The materials used and the method adopted is presented in the following pages.

3.1 Survey of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson

The roving survey was carried out in selected talks of Dharwad (Dharwad, Hubli and Kalghatagi), Bagalkot (Bagalkot) and Belgaum (Khanapur) districts. In each taluk ten villages were selected and in each village two sapota fields were selected (Table-2).The fields were visited at 15 days intervals at maximum flowering stage of sapota trees of ´ Kalipatti´ variety (August to October and February to March).

Bud borer

Observations were taken on the incidence of sapota Bud borer, *Anarsia achrasella* Bradley from five randomly selected twigs of ten sapota trees from each field from each taluk and number of damaged flower buds/ twig and total number of flower buds observed/ twig. Later, the per cent infestation was worked out using formula:

$$\text{Per cent flower buds damaged} = \frac{\text{Number of damaged flower buds}}{\text{Total number of flower buds observed}} \times 100$$

Fruit borer

Observation were taken on the incidence of sapota fruit borer *P. erythrolophia* were recorded from five randomly selected twigs of ten trees from each sapota field. The observations were also taken on the incidence of fruit borer from 30 fallen flower buds from each tree and harvested fruits of sapota by selecting 50 fruits randomly during the period of survey.

Per cent infestation of sapota fruit borer, *P. erythrolophia* was worked out by using formula:

$$\text{Per cent flower buds damaged} = \frac{\text{Number of damaged flower buds}}{\text{Total number of flower buds observed}} \times 100$$

$$\text{Per cent fruits damaged} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits observed}} \times 100$$

Leaf webber

Observations on leaf webber, *Nephopteryx eugraphella* Ragonot were taken from five randomly selected twigs of ten trees from each sapota field. Number of damaged leaves / twig and total number of leaves / twig were recorded and later per cent infestation was worked out by using formula:

$$\text{Per cent leaves damaged} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves observed}} \times 100$$

Leaf miner

Incidence of leaf miner, *Achrocercops gemoniella* Stain were taken from five randomly selected twigs of ten trees from each sapota field. Number of damaged leaves/ twig and total number of leaves/ twig were recorded and later per cent infestation was worked out using formula

$$\text{Per cent leaves damaged} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves observed}} \times 100$$

Table-2: Places surveyed during the study period

Sl. No.	Districts	Taluks	Villages surved	
1	Dharwad	Dharwad	Mansur	Mummigatti
			Kotur	Kurabagatti
			Dasanakoppa	Narendra
			Garag	Katagi
			Guledakoppa	Lokur
2	Dharwad	Hubli	Katnur	Palikoppa
			Nagashettykoppa	Halyal
			Katnur	Nagarhalli
			Agadi	Nulvi
			Kirasur	Tarihal
3	Dharwad	Kalaghatagi	Dummanwad	Solargoppa
			Hirehonnihalli	Mukkall
			Hugnikere	Jammihall
			Devikoppa	Dastikoppa
			Dyamapur	Ramanall
4	Belgaum	Khanapur	Kasbanandgad	Mangenakoppa
			Morab	Deminkopa.
			Asoga	Kelil
			Gundyanati	Bidi
			Nanadagada	Budase
5	Bagalkot	Bagalkot	Kadampur	Chebbi
			Sirur	Chikkguladal
			Bevoor	Bannidinni
			Hirisansi	Hallur
			Alur	Illal

Other insect pests

During the period of survey other insect pests *viz.,* Mid rib folder, *Banisia myrsusalis elearalis* Walker, Mealy bugs (unidentified)and scales, *Coccus viridis* Green were observed attacking the leaves, twigs, and fruits.

Natural enemies

During the period of survey each of the selected sapota tree was observed thoroughly from each field in selected talukas to record the natural enemies associated with the pests of sapota. Two hundred fallen buds below tree were collected from five randomly selected trees at the rate of 40 flower buds/tree and kept in cage in laboratory for emergence of parasites' if any. Similarly, 100 infested fruits by fruit borer were collected from five randomly selected trees at the rate of 20/ tree.

3.2 Seasonal incidence of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia.*

The studies were carried out during 2013-2014 and observations on the seasonal incidence of bud borer, *A. achrasella*, fruit borer, *P. erythrolophia*, leaf miner, *A. gemoniella* and leaf webber, *N. eugraphella* were recorded from four sapota varieties *viz.,* Kalipatti, DSH-1, DSH-2 and Cricket ball at new orchard College of Agriculture, Dharwad and DSH-2 variety at KVK, Sadapur Farm, Dharwad. No insecticidal application was done during the period of study. The observations were recorded at 15 days intervals from June 2013 till May 2014.

Bud borer, *Anarsia achrasella*

The observations on seasonal incidence of Bud borer, *A. achrasella* was recorded from five medium sized trees from different genotypes as mentioned above. Randomly selected sapota tree was marked with white paint for recording observations. From each of the tree ten twigs were selected and in each twig all the flower buds were observed for the incidence of bud borer. The number of total and damaged flower buds per twig of each variety was counted for computing the percentage of infestation. Five trees from each variety fifty flower buds were selected and larval populations were estimated by counting the total number of larvae per fifty flower buds. The bud borer incidence was also taken from fallen flower buds under the sapota tree.

Per cent infestation of bud borer *A.achrasella* was worked out by using formula:

$$\text{Per cent infestation} = \frac{\text{Total no. of infested flower buds}}{\text{Total no. of flower buds}} \text{ X } 100$$

Sapota Fruit borer, *Phycita erythrolophia*

To study the seasonal incidence of fruit borer, *P. erythrolophia,* five medium sized trees from different genotypes were selected randomly. From each of the tree, ten twigs having buds / fruits were selected and in each twig all the flower buds and fruits were observed for the incidence of fruit borers. The number of total and damaged flower buds and fruits per twig of each variety was counted for computing the percentage of infestation. Observations on the fruit borer incidence was taken from fifty fallen flower buds under the sapota tree. Five trees from each variety fifty flower buds and fruits were selected and larval populations were estimated by counting the total number of larvae per fifty flower buds and fruits. Also the incidence of sapota fruit borer was taken from harvested sapota fruits at different months from each variety and per cent fruit damage was worked out. Mean percentage of fruits damaged by fruit borer was worked out on different genotypes by using formula:

$$\text{Per cent flower buds damaged} = \frac{\text{Number of damaged flower buds}}{\text{Total number of flower buds observed}} \times 100$$

$$\text{Per cent fruits damaged} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits observed}} \times 100$$

Leaf webber, *Nephopteryx eugraphella*

To study the seasonal incidence of leaf webber, *N. eugraphella* five medium sized trees from different genotypes were selected randomly. From each of the tree ten twigs were selected and in each twig all the leaves were observed for the incidence of leaf webber. Observations were taken on number of damaged leaves / twig and total number of leaves observed/ twig on different genotypes and per cent of infestation was worked out. Mean percentage of leaves damaged by leaf webber was worked out on different genotypes by using formula:

$$\text{Per cent leaves damaged} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves observed}} \times 100$$

Leaf miner, *Achrocercops gemoniella* Stainton

To study the seasonal incidence of leaf miner, *A.gemoniella* five medium sized trees from different genotypes were selected randomly. From each of the tree ten twigs were selected and in each twig leaves were observed for the incidence of leaf miner. Observations were taken on number of damaged leaves / twig and total number of leaves observed/ twig was observed on different genotypes and per cent of infestation was worked out. Mean percentage of leaves damaged by leaf webber was worked out on different genotypes by using formula:

$$\text{Per cent leaves damaged} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves observed}} \times 100$$

Other insect pests

During the period of studies other insect pests *viz.,* mid rib folder, *Banisia myrsusalis elearalis* Walker, Mealy bugs (unidentified)and scales, *Coccus viridis* Green were observed. From each of the tree, ten twigs having buds / fruits/leaves were selected and in each twig all the flower buds, fruits and leaves were observed for the presence of pests. Each of the selected sapota trees was observed thoroughly from each field in selected new orchard, Agriculture College, Dharwad and Saidapur farm, KVK, Dharwad.

Natural enemies

During the period of study each of the selected sapota trees were observed thoroughly from each field in selected new orchard, Agriculture college, Dharwad and Saidapur farm, KVK, Dharwad to record the natural enemies associated with the pests of sapota. Two hundred fallen buds below tree were collected from five randomly selected trees at the rate of 40 flower buds/tree and kept in cage in laboratory for emergence of parasites' if any. Similarly, 100 infested fruits by fruit borer were collected from five randomly selected trees at the rate of 20/ tree.

Relationship between insect pests of sapota and weather parameters

The meteorological data was collected from observatory of main Agricultural research station (MARS), Dharwad. The data on per cent damage by pests of sapota were correlated to understand the relationship between incidence of pests and various weather parameters *viz.,* temperature (maximum and minimum), relative humidity (morning and evening) and rainfall.

3.3 Management of sapota Fruit borer, *Phycita erythrolophia*

The field experiment was conducted to study the evaluation of selected insecticides for managing sapota fruit borer, *P. erythrolophia* during November 2013-14 on Kalipatti variety at New Orchard, College of Agriculture, Dharwad and DSH-2 variety during January 2013-14 at Sadapur Farm, KVK, Dharwad on thirty six sapota trees chosen for the study.

Randomized Block Design (RBD) was used for the experiment with three replications and twelve treatments. Only one spray was given. Each tree was sprayed with 10 liters of spray fluid with the help of foot sprayer. The observations on larval population as well as damaged fruits were made from five randomly selected twigs on each marked/tagged sapota tree. Incidence of sapota fruit borer was recorded a day before and three, seven and twenty days after spray. The per cent damaged fruits were worked out. The data obtained from each of the objectives were subjected to statistical analysis after suitable transformation. The details of treatments employed in the present investigation are given in table 3.

3.3.1 Cost economics

The cost benefit ratio was calculated by considering the yield, cost of plant protection, total cost of production in each treatment. The gross returns were worked out by taking the selling price of sapota fruits as Rs 40/kg. The net returns in different treatments was worked out by deducting total cost of production from gross returns. Finally, the B: C ratio was worked out by dividing gross returns and total cost of production in each treatment.

Table-3: Details of treatments employed for the management of sapota fruit borer

SL. No.	Treatment (Common name)	Trade name	Dosage
1	Spinosad 45 SC	Tracer	0.3 ml/l
2	Flubendiamide 480 SC	Fame	0.1 ml/l
3	Emamectin benzoate 5 SG	Proclaim	0.2 g/l
4	DDVP 76 EC	Nuvon	0.5 ml/l
5	Profenophos 50 EC	Curacron	2.0 ml/l
6	Navoluron 10 EC	Rimon	1.0 ml/l
7	*Bacillus thuringiensis*	Dipel	2.0 kg/ha
8	Rynaxypyr 20 SC	Coragen	0.2ml/l
9	Indoxacarb 14.5 SC	Avunt	0.5ml/l
10	NSKE	Nimbicidine	5%
11	Malathion 50 EC (standard check)	Malathion	2.0 ml/l
12	Untreated check	-	-

EXPERIMENTAL RESULTS

Investigations on survey of major insect pests of sapota with special reference to sapota fruit borer were carried out in selected taluks of north Karnataka districts. Investigations were carried out on the Seasonal incidence of insect pests of sapota with special reference to sapota fruit borer *Phycita erythrolophia* Hampson and its management were carried out at new orchard, Agriculture College, Dharwad and saidapur farm, KVK, Dharwad, respectively. The results obtained from the experimental study are presented as here under.

4.1 Survey of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson.

The roving survey was carried out during peak flowering period *i.e.* August to October and February to March in selected taluks of each district of Dharwad, Belgaum, Bagalkot. The results indicated that the pest was observed in all the selected taluks surveyed over three districts of North Karnataka.

4.1.1 Extent of damage

Dharwad taluk

The incidence of four major pests recorded in Dharwad taluk on Kalipatti variety is presented in table-4. Among four major pests highest incidence of 8.65per cent was recorded by fruit borer followed by bud borer (6.95 %). The minimum incidence was recorded by leaf miner (3.04 %) followed by leaf webber (3.62 %)

The overall mean percentage of damage by all the four major pests indicated that higher incidence (6.09 to 8.65 %) was recorded during February and March months. Whereas, the incidence was low (3.40 to 4.80 %) during August to October months

The incidence of bud borer (Plate-1) during different months ranged from 2.27 to 14.00 per cent. Higher incidence of bud borer was noticed during February to March which ranged from 8.60 to 14.00 per cent. Whereas, the incidence of the pest during August to October was low which ranged from 2.27 to 5.42 per cent.

The fruit borer incidence (Plate-2) ranged from 3.07 to 19.10 per cent. Higher incidence was noticed during February to March (12.88 to 19.10%). Whereas, during the rainy season *i. e* from August to October it was low which ranged from 3.07 to 5.04 per cent.

Incidence of the leaf webber (Plate-3) in different months ranged from 0.66 to 6.77 per cent. Higher the incidence of leaf webber was recorded during October (6.74 to 6.77 %). The incidence of leaf webber was low during remaining period (August to September and second fortnight of February to March) which ranged from 0.66 to 4.61per cent

The leaf miner incidence (Plate-4) ranged from 0.50 to 5.98 per cent. Higher incidence of the pest was noticed during September and October months which ranged from 4.22 to 5.98 per cent. Whereas, during the remaining period it was low (0.50 to 3.42%).

Hubli taluk

The incidence of four major pests recorded in Hubli taluk on Kalipatti variety presented in table-5. Revealed that highest incidence of 8.53 per cent by fruit borer followed by bud borer (6.69 %). The minimum incidence was recorded by leaf miner (2.76 %) followed by leaf webber (3.22 %)

The overall mean percentage of damage by all the four major pests indicated that higher incidence (6.95 to 9.47 %) was recorded during February and March months, whereas the incidence was low (2.48 to 4.04 %) during August to October months.

The incidence of bud borer during different months ranged from 1.03 to 16.15 per cent. Higher incidence of bud borer was noticed during February to March which ranged from 10.84 to 16.15 per cent. Whereas, the incidence of the pest during August to October was low which ranged from 1.03 to 5.53 per cent

Table-4: Roving survey for major insecst pests of sapota in Dharwad taluk during 2013-14 in Kalipatti variety

Sl. No	Village	Month	Fortnight	Per cent damage				Mean
				Bud borer	Fruit borer	leaf webber	Leaf miner	
1	Mansur	August-2013	I	4.12	5.04	1.42	3.42	3.63
2								
3	Kotur		II	5.42	4.27	4.67	1.62	3.99
4								
5	Dasanakoppa	September	I	4.30	4.14	3.37	4.22	4.00
6								
7	Garag		II	3.13	3.07	2.34	5.14	3.40
8								
9	Guledakoppa	October	I	2.27	4.34	6.74	5.88	4.80
10								
11	Mummigatti		II	2.34	3.63	6.77	5.98	4.68
12								
13	Kurabagatti	February-2014	I	12.46	12.88	4.63	0.50	7.61
14								
15	Narendra		II	8.60	13.85	1.10	0.81	6.09
16								
17	Katagi	March	I	12.91	16.22	1.40	1.15	7.92
18								
19	Lokur		II	14.00	19.10	0.66	0.86	8.65
20								
	Mean			6.95	8.65	3.62	3.04	

*Bud borer, *Anarsia achrasella*, Fruit borer*, Phycita erythrolophia*,
*Leaf webber, *Nephopteryx eugraphella* and Leaf miner, *Achrocercops gemoniella*

Larva boring at the base of the flower bud

Larva feeding inside the unopended flower buds

Larva feeding on fallen flower buds with excreta

Plate 1: Damage due to bud borer, *Anarsia achraxella*

The fruit borer incidence ranged from 2.24 to 19.65 per cent. Higher incidence was noticed during February to March (11.22 to 19.56%). Whereas, during the remaining period (from August to October) it was low which ranged from 2.24 to 4.60 per cent.

Incidence of the leaf webber in different months ranged from 0.70 to 6.50 per cent. Higher incidence of leaf webber during October (6.33 to 6.50 %) was noticed and it was low during the remaining period (August to September and February to march month) which ranged from 0.70 to 4.59 per cent.

The leaf miner incidence ranged from 0.99 to 5.64 per cent. Higher incidence of the pest was noticed during October (5.39 to 5.64 %) whereas, during the remaining period it was low which ranged from 0.99 to 4.64 per cent.

Kalghatagi taluk

The incidence of four major pests were recorded in Kalghatagi taluk on Kalipatti variety (Table-6). Among the four pests highest incidence of 8.90 per cent was recorded by fruit borer followed by bud borer (7.12 %),whereas it was minimum by leaf miner (2.58 %) followed by leaf webber (2.96 %)

The overall mean percentage of damage by all the four major pests indicated that higher incidence (6.27 to 9.93 %) was recorded during February and March months. Whereas, the incidence was low (3.28 to 4.73 %) during August to October months.

The incidence of bud borer during different months ranged from 1.70 to 15.97 per cent. Higher incidence of bud borer was noticed during February to March which ranged from 7.47 to 15.97 per cent. Whereas, the incidence of the pest during September to October was low which ranged from 1.70 to 4.90 per cent

The fruit borer incidence ranged from 2.08 to 20.61 per cent. Higher incidence was noticed during February to March (14.02 to 20.61%). Whereas, during the remaining period *i. e* from August to October it was low which ranged from 2.08 to 6.19 per cent.

Incidence of the leaf webber during the survey period ranged from 1.22 to 7.61 per cent. Higher incidence of leaf webber was recorded during October (5.78 to 7.61 %), and it was low during the remaining period (August to September and February to March) which ranged from 1.22 to 3.16 per cent.

The leaf miner incidence ranged from 0.83 to 6.84 per cent. Higher incidence of the pest was noticed during first fortnight of October (6.84 %) whereas, during the remaining period it was low which ranged from 0.83 to 3.60 per cent.

Khanapur taluk

The incidences of four major pests in Khanapur taluk on Kalipatti variety indicated that highest incidence of 10.54 per cent was recorded by fruit borer followed by bud borer (7.43 %). The minimum incidence was recorded by leaf miner (2.43 %) followed by leaf webber (2.66 %) (Table-7)

The overall mean percentage of damage by all the four major pests indicated that higher incidence (8.96 to 10.43 %) was recorded during February and March months. Whereas, the incidence was low (2.26 to 3.82 %) during August to October months.

The incidence of bud borer during different months ranged from 1.05 to 14.30 per cent. Higher incidence of bud borer was noticed during February to March which ranged from 13.13 to 14.30 per cent, whereas the incidence of the pest was low during September and October months (1.15 to 3.88%)

The fruit borer incidence ranged from 1.51 to 22.43 per cent. Higher incidence was noticed during February to March (19.17 to 22.43%). Whereas, during the remaining period it was low during second fortnight of September to October (1.51 to 2.59%)

The incidence of leaf webber in different months ranged from 0.89 to 7.40 per cent. Higher incidence of leaf webber was noticed during October (4.88 to 7.40 %). Incidence of leaf webber was low during the remaining period (August to September and February to march month) which ranged from 0.98 to 3.05 per cent.

Table-5: Roving survey for major insecst pests of sapota in Hubli taluk during 2013-14 in kalipatti variety

Sl. No	Village	Month	Fortnight	Per cent damage				Mean
				Bud borer	Fruit borer	leaf webber	Leaf miner	
1	Katnur	August-2013	I	4.55	5.10	1.46	2.19	3.32
2								
3	Nagashettykoppa		II	5.53	4.60	3.92	1.22	3.82
4								
5	Katnur	September	I	3.25	4.07	3.97	3.72	3.75
6								
7	Agadi		II	1.03	2.28	2.00	4.64	2.48
8								
9	Kirasur	October	I	1.81	2.24	6.50	5.64	4.04
10								
11	Palikoppa		II	1.19	2.97	6.33	5.39	3.97
12								
13	Halyal	February-2014	I	11.10	11.22	4.59	1.56	7.12
14								
15	Nagarhalli		II	11.49	13.97	1.27	1.06	6.95
16								
17	Nulvi	March	I	10.84	19.56	0.70	1.24	8.08
18								
19	Tarihal		II	16.15	19.28	1.45	0.99	9.47
20								
Mean				6.69	8.53	3.22	2.76	

*Bud borer, *Anarsia achrasella*, Fruit borer*, Phycita erythrolophia*,
*Leaf webber, *Nephopteryx eugraphella* and Leaf miner, *Achrocercops gemoniella*

a) Fruit borer damage on flower buds with excreta

b) Fruit borer larva in fallen fruits

Plate 2: Damage due to sapota fruit borer, *Phycita erythrolophia*

C) Damage by fruit borer on adjuscent fruits

d) Exit hole on the sapota fruit

e) Larva feeding on pulp of fruit

Plate 2. (Contd…) Damage due to sapota fruit borer, *Phycita erythrolophia*

Webbing of young leaves

Larva feeding on leaf

Webbing of leaf and flower bud by learva

Scraped leaves by leaf webber lerva

Plate 3: Damage due to leaf webber, *Nephopteryx eugraphella*

Mined epidermal layer of leaf

Caterpiller inside the mined leaf

Plate 4: Damage due to leaf miner, *Achrocercops gemoniella*

The leaf miner incidence ranged from 0.91 to 6.15 per cent. Higher incidence of the pest was noticed during October (4.26 to 6.15 %). Whereas, during the remaining period it was low which ranged from 0.91 to 3.26 per cent.

Bagalkot taluk

Among four major pests, highest incidence of 9.23 per cent was recorded by fruit borer followed by bud borer (6.61 %). The minimum incidence was recorded by leaf miner (2.47 %) followed by leaf webber (3.27 %) (Table-8)

The overall mean percentage of damage by all the four major pests indicated that higher incidence (6.75 to 8.51 %) was recorded during February and March months. Whereas, the incidence was low (2.47 to 4.40 %) during August to October months.

The incidence of bud borer during different months ranged from 1.05 to 14.54 per cent. Higher incidence of bud borer was noticed during February to March which ranged from 8.65 to 14.54 per cent whereas the incidence of the pest from second fortnight of September to October (1.05 to 2.90). However the moderate level of incidence (4.97 to 5.43%) was recorded from August to first fortnight of September.

The fruit borer incidence ranges from 2.41 to 19.86 per cent fruit damage. Higher incidence was noticed during February to March (14.01 to 19.86%). Whereas, during the remaining period (August to October) it was low which ranged from 2.41 to 5.70 per cent.

Incidence of the leaf webber in different months ranged from 1.16 to 7.51 per cent. Higher incidence of leaf webber was recorded during October and first fortnight of February (6.51 to 7.51 %). Incidence of leaf webber was low during remaining period (August to September and second fortnight of February to March) which ranged from 1.16 to 3.28 per cent.

The leaf miner incidence ranged from 0.60 to 6.87 per cent. Higher incidence of the pest was noticed during October (4.62 to 6.87 %). Whereas, during the remaining period it was low which ranged from 0.60 to 2.99 per cent.

The perusal of comperative data on the incidence of four major pests of sapota in five selected talukas (Fig-1) clearly indicate that the incidence of by both bud borer and fruit borer was higher compared to other two pests namely leaf webber and leaf miner (Table-9).

The perusal of comparative data on the incidence of four major pests of sapota during different months in five selected talukas (Fig-2) clearly indicate that the incidence by four major pests was higher in summer months (February and March) compared to remaining months (Table-10).

4.1.2 Extent of sapota fruit borer damage on fallen flower buds

The incidence of *P.erythrolophia* on fallen flower buds in five surveyed talukas indicated lower incidence which ranged from 0.58 to 1.86 per cent (Table-11).

4.1.3 Extent of sapota fruit borer damage on harveated sapota fruits

The incidence of sapota fruit borer on harvested sapota fruits during period of survey varied from 4.76 to 6.52 per cent in different talukas. However, the fruit borer incidence across the talukas was more in fruits harvested during February and March, whereas, the incidence was low on the harvested fruits during August to October months (Table-12).

4.1.4 Other insect pests

During the period of survey other insect pests of sapota were also recorded which includes mid rib folder, *Banisia myrsusalis elearalis* Walker infesting on young leaves (Plate-5), mealy bugs(Unidentified) (Plate-6) was observed on sucking the sap from the leaves, twigs and fruits and scales, *Coccus viridis* Green (Plate-7) on underside of leaves of midrib (Table-13).

4.1.5 Natural enemies

Natural enemies were also recorded during period of survey. The adults of coccinellid beetle (Plate-8), *Chelomenes sexmaculata* (Fabricius), eggs and adults of green lace wing *Chrysoperla* sp., (Plate-8), Reduvid bugs and spiders (Unidentified) (Plate-9) were noticed in sapota orchard during 2013-14 (Table-13)

Table-6: Roving survey for major insecst pests of sapota in Kalghatagi taluk during 2013-14 in kalipatti variety

Sl. No	Village	Month	Fortnight	Per cent damage				Mean
				Bud borer	Fruit borer	leaf webber	Leaf miner	
1	Dastikoppa	August-2013	I					3.72
2				5.93	4.79	1.23	2.95	
3	Dummawad		II					4.40
4				6.72	6.19	2.66	1.13	
5	Hirehonnihalli	September	I					3.28
6				4.38	3.84	3.07	1.82	
7	Hugnikere		II					3.28
8				2.99	4.86	1.67	3.60	
9	Devikoppa	October	I					4.10
10				1.70	2.08	5.78	6.84	
11	Solargoppa		II					4.73
12				4.90	2.84	7.61	3.57	
13	Dyamapur	February-2014	I					7.09
14				9.87	13.54	3.16	1.79	
15	Mukkall		II					6.27
16				7.47	14.02	1.88	1.71	
17	Jammihal	March	I					7.37
18				11.26	16.20	1.22	0.83	
19	Ramanall		II					
20				15.97	20.61	1.60	1.57	9.93
	Mean			7.12	8.90	2.96	2.58	

*Bud borer, *Anarsia achrasella*, Fruit borer*, Phycita erythrolophia*,
*Leaf webber, *Nephopteryx eugraphella* and Leaf miner, *Achrocercops gemoniella*

Table-7: Roving survey for major insecst pests of sapota in Khanapur taluk during 2013-14 in kalipatti variety

Sl. No	Village	Month	Fortnight	Per cent damage				Mean
				Bud borer	Fruit borer	leaf webber	Leaf miner	
1	Budase	August-2013	I	5.52	6.56	0.89	1.88	3.71
2								
3	Kasbanandgad		II	5.65	4.19	2.44	1.20	3.54
4								
5	Morab	September	I	3.88	4.88	2.39	1.56	3.18
6								
7	Asoga		II	2.20	1.51	2.09	3.26	2.26
8								
9	Gundyanati .	October	I	1.15	1.84	4.88	6.15	3.51
10								
11	Nanadagada .		II	1.05	2.59	7.4	4.255	3.82
12								
13	Mangenakoppa	February-2014	I	14.30	22.43	3.05	1.94	10.43
14								
15	Deminkopa		II	13.13	19.17	1.3	2.245	8.96
16								
17	Kelil	March	I	14.23	21.36	0.96	0.935	9.37
18								
19	Bidi		II	13.20	20.88	1.07	0.91	9.02
20								
	Mean			7.43	10.54	2.66	2.43	

*Bud borer, *Anarsia achrasella*, Fruit borer*, Phycita erythrolophia*,
*Leaf webber, *Nephopteryx eugraphella* and Leaf miner, *Achrocercops gemoniella*

Table 8: Roving survey for major insecst pests of sapota in Bagalkot taluk during 2013-14 in kalipatti variety

Sl. No	Village	Month	Fortnight	Per cent damage				Mean
				Bud borer	Fruit borer	leaf webber	Leaf miner	
1	Kadampur	August-2013	I	5.43	5.70	1.96	2.99	4.02
2								
3	Sirur		II	4.97	5.16	3.28	1.94	3.84
4								
5	Bevoor	September	I	5.30	5.03	2.69	1.34	3.59
6								
7	Hirisansi		II	1.71	4.09	1.24	2.85	2.47
8								
9	Alur	October	I	1.05	3.17	6.51	6.87	4.40
10								
11	Chebbi		II	2.90	2.41	7.51	4.62	4.36
12								
13	Bannidinni	February-2014	I	8.65	14.01	6.02	1.37	7.51
14								
15	Chikkguladal		II	9.56	15.17	1.17	1.09	6.75
16								
17	Hallur	March	I	12.02	19.86	1.17	0.99	8.51
18								
19	Ilal		II	14.54	17.71	1.16	0.60	8.50
20								
	Mean			6.61	9.23	3.27	2.47	

*Bud borer, *Anarsia achrasella*, Fruit borer*, Phycita erythrolophia*,
*Leaf webber, *Nephopteryx eugraphella* and Leaf miner, *Achrocercops gemoniella*

Table-9: Comparative data on the incidence of four major pests in five selected taluks

Sl.No	District	Taluks	Mean Per cent damage due to				Mean
			Bud borer	Fruit borer	Leaf webber	Leaf miner	
1	Dharwad	Dharwad	6.95	8.65	3.62	3.04	5.57
2		Hubli	6.69	8.53	3.22	2.76	5.35
3		Kalghatagi	7.12	8.90	2.96	2.58	5.39
4	Belgaum	Khanapur	7.43	10.54	2.66	2.43	5.77
5	Bagalkot	Bagalkot	6.61	9.23	3.27	2.47	5.30
Mean			6.96	9.17	3.15	2.66	

Table: 10 Comparative data on the incidence of major pests of sapota during different moths in five selected taluks during 2013-14

Sl.No	Months	Talukas						Overall mean
		Fortnight	Dharwad	Hubli	Kalghatagi	Khanapur	Bagalkot	
1	August	I	3.63	3.32	3.72	3.71	4.02	3.68
		II	3.99	3.82	4.40	3.54	3.84	3.92
2	September	I	4.00	3.75	3.28	3.18	3.59	3.56
		II	3.40	2.48	3.28	2.26	2.47	2.18
3	October	I	4.80	4.04	4.10	3.51	4.40	4.17
		II	4.68	3.97	4.73	3.82	4.36	4.31
4	February	I	7.61	7.12	7.07	10.43	7.51	7.95
		II	6.09	6.95	6.27	8.96	6.75	7.00
5	March	I	7.92	8.08	7.37	9.37	8.51	8.25
		II	8.65	9.47	9.93	9.02	8.50	9.11

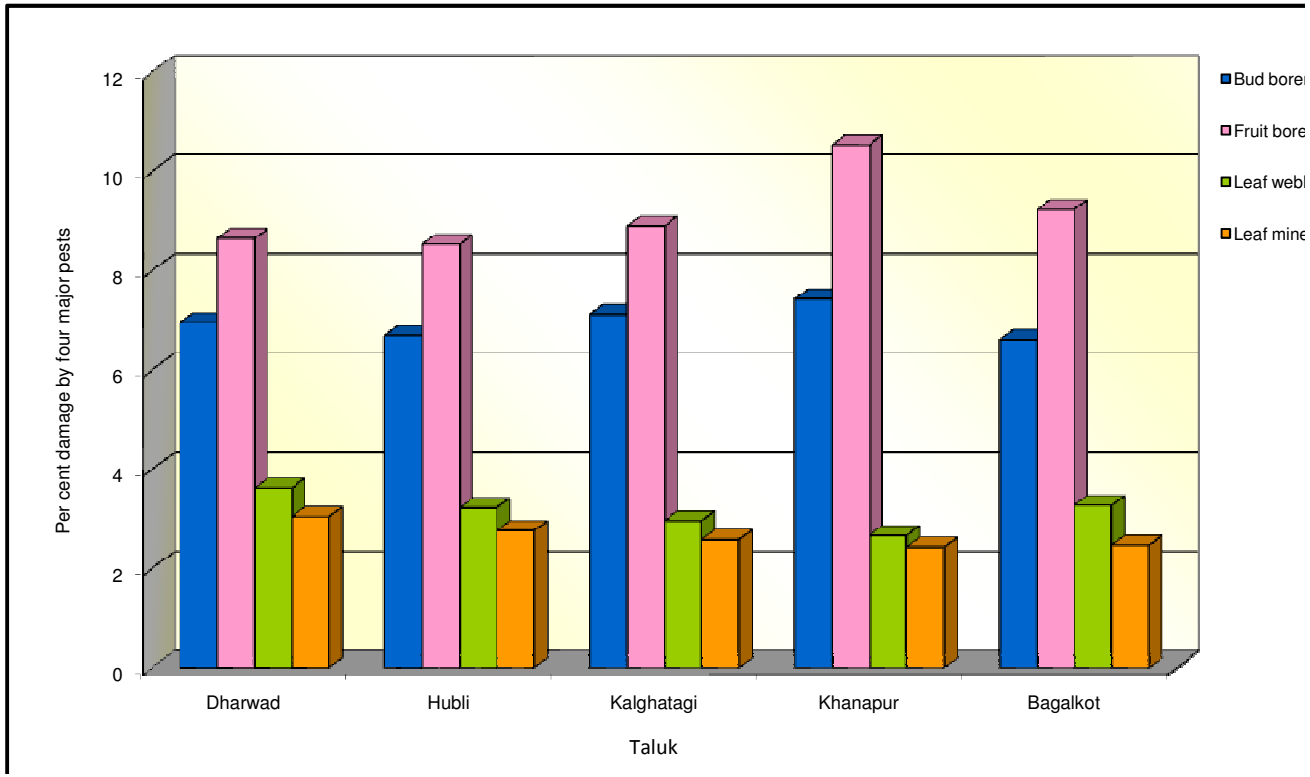

Fig. 1. Comparitive data on the incidence of four major pests in five selected taluks

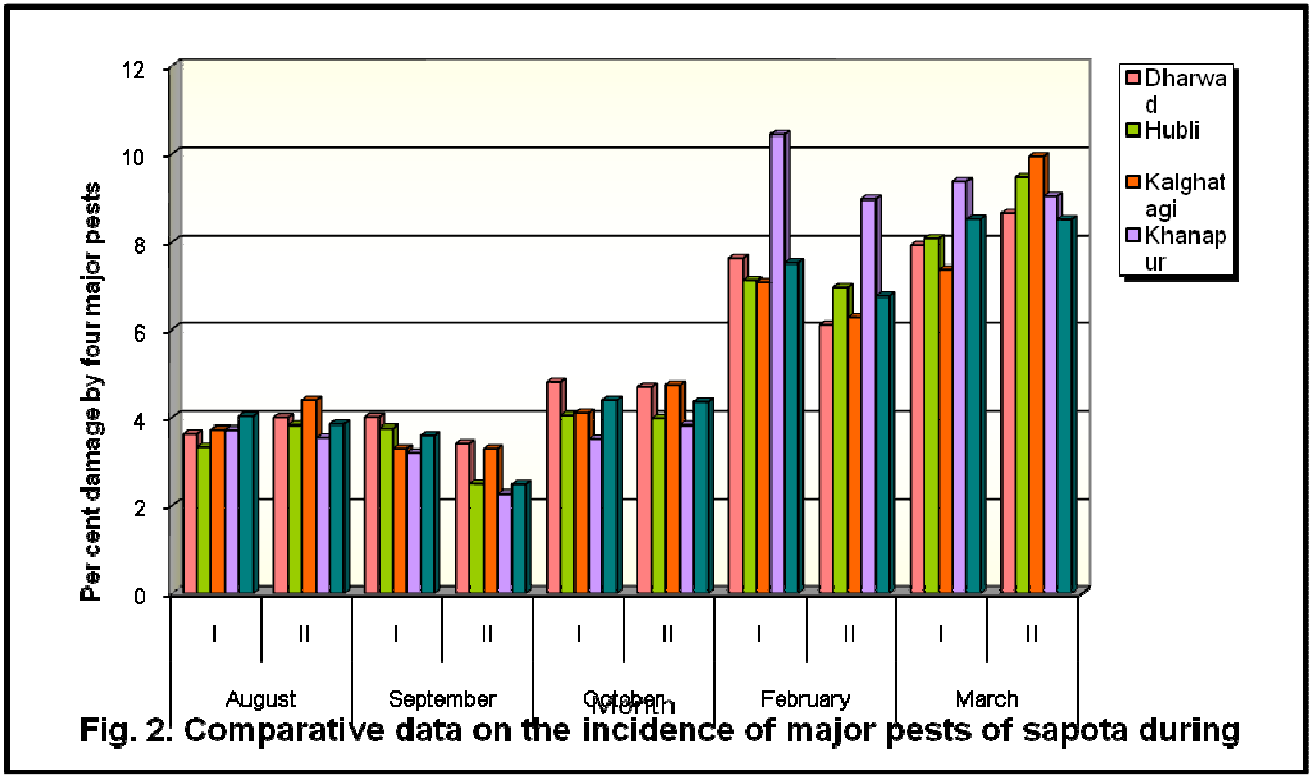

Fig. 2. Comparative data on the incidence of major pests of sapota during

Fig. 2. Comparative data on the incidence of major pests of sapota during different months in five selected taluks during 2013-14

Plate 5: Damage due to midrib folder, *Banisia myrsusalis elearalis*

Table-11: Roving Survey for sapota fruit borer, *Phycita erythrolophia* damage on fallen flower buds during 2013-14 in kalipatti variety

Sl.No	District	Taluk	Per cent flower bud damage
1	Dharwad	Dharwad	0.58
2	Dharwad	Hubli	1.04
3	Dharwad	Kalaghatagi	1.86
4	Belgaum	Khanapur	1.73
5	Bagalkot	Bagalkot	1.28

Infestation on lower surface of leaf

Infestation on twig

Infestation on fruit

Plate 6: Mealybug damage to leaf, twig and fruit

Table-12: Roving Survey for sapota fruit borer, *Phycita erythrolophia* damage on harvested sapota fruits during 2013-14 in kalipatti variety

Sl. No.	District	Talukas	Month	% fruit damage	Taluka Mean(%)
1	Bagalkot	Bagalkot	September -2013	3.52	6.52
2			February-2014	6.78	
3			March	8.36	
4	Belgaum	Khanapur	September-2013	2.81	5.94
5			October	4.59	
6			February-2014	7.36	
7			March	9.02	
8	Dharwad	Dharwad	August-2013	2.81	6.05
9			October	3.51	
10			February-2014	9.47	
11	Dharwad	Hubli	March	8.42	
12			August-2013	2.96	4.76
13			September	1.71	
14			October	3.28	
15			February-2014	8.05	
16			March	7.82	
17	Dharwad	Kalaghatagi	September-2013	3.02	5.99
18			October	5.88	
19			February-2014	7.26	
20			March	7.83	

Infestation by scales along the midrib of leaves

Close up view of scale infestation

Plate 7: Damage due to scales, *Coccus viridis*

Table-13: Other insect pests of sapota and their natural enemies observed during the period of survey

Sl. No.	Insect pests	Scientific Name	Family	Order
1	Mid rib folder	*Banisia myrsusalis elearalis* Walker	Thyrididae	Lepidoptera
2	Scales	*Coccus viridis* Green	Coccidae Margorodidae	Homoptera
3	Mealy bugs	Unidentified	Pseudococcidae	Homoptera
	Natural enemies			
1	Coccinellid	*Chelomenes sexmaculata* (Fabricius)	Coccinellidae	Coleoptera
2	Chrysopid	*Chrysoperla* sp.,	Chrysopidae	Neuroptera
3	Reduviid bug	Unidentified	Reduviidae	Hemiptera

Chelomenes sexmaculata

Chrysoperla sp.

Plate 8: Natural enemies in sapota ecosystem

Reduviid bug (Unidentified)

Spider (Unidentified)

Plate 9: Natural enemies in sapota ecosystem

4.2 Seasonal incidence of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson.

Bud borer, *Anarsia achrasella* Bradley

The larva of *A. achrasella* was found damaging flower buds throughout the year. During the course of investigation the larva was found boring at the base of the contents inside. It feeds on unopened flower buds and contents of ovary. Usually one larva was found in each infested flower bud resulting in considerable loss of buds and flower buds of sapota were found to dry up and drop down.

The seasonal incidence of bud borer on four different genotypes of sapota (Fig-3) was observed throughout the year. The result revealed that bud borer incidence was observed on all the four genotypes (Cricket ball, Kalipatti, DSH-1 and DSH-2) (Table-14).

4.2.1 Extent of damage

The incidence of bud borer was more in Cricket ball (8.59 per cent) followed by DSH-1 (7.09 per cent), Kalipatti (6.84 per cent) and DSH-2, 5.70(KVK farm) and 5.53(New orchard) per cent bud damage.

In general across the four genotypes, the mean percentage of bud damage in different months from June 2013 to May 2014 ranged from 2.15 to 11.86. Maximum incidence (11.86%) was recorded during March whereas, lowest incidence (2.15%) was recorded during October. The perusal of the data clearly reveals that the bud borer incidence was more during dry period *i.e.* (January to June) ranged from 7.85 to 11.86%. Whereas the incidence was low during rainy season *i.e.* from July to October.

The seasonal incidence of bud borer in Cricket ball variety ranged from 2.33 to 15.29 per cent bud damage. Maximum incidence of 15.29 per cent was noticed in first fortnight of March followed by 13.89 during second fortnight of March. Minimum of 2.33 per cent bud damage was found in Second fortnight of August followed by 2.41 per cent during first fortnight of September.

The incidence of bud borer in Kalipatti variety recorded from1.09 to13.85 per cent bud damage. Highest incidence of 13.85 per cent was recorded during first fortnight of March followed by 11.72 per cent during second fortnight of March. Lowest incidence of 1.09 per cent was recorded during first fortnight of October followed by 1.97 per cent during second fortnight of August.

The bud borer incidence on DSH-1 variety varied from 2.14 to 11.29 per cent. Maximum of 11.29 per cent bud damage was noticed in second fortnight of March followed by 10.37 per cent during first fortnight of March. Minimum damage of 2.14 per cent was found during first fortnight followed by 2.58 per cent in the same month.

The infestation of bud borer in DSH-2 variety which ranged from 0.75 to 10.89 per cent bud damage. Maximum incidence of 10.89 per cent was noticed during second fortnight of March followed by 9.18 during fist fortnight of April. Minimum incidence of 0.75 per cent was noticed during first fortnight of October followed by 1.04 per cent during second fortnight of August.

At KVK, saidapur farm, Dharwad, the incidence of bud borer in DSH-2 ranged from 1.27 to 11.54 per cent bud. Minimum incidence of 1.27 per cent was noticed during second fortnight of October followed by 1.52 percent during second fortnight of September. Maximum incidence of 11.54 per cent was recorded during second fortnight of March followed by 10.54 during same month.

The correlation studies made between incidence of bud borer (*A. achrasella*) and weather parameters (Table-15) showed there was a significant and positive correlation between bud borer damage and maximum temperature in all four genotypes. Whereas, morning and evening relative humidity had significant negative correlation with bud borer incidence. In Cricket ball, Kallipatti and DSH-2 genotype there was negative correlation between minimum temperature and the bud borer incidence. There was negative correlation between rainfall and the bud borer incidence but it was significant in Cricket ball and DSH-2 genotypes.

Damage on fallen flower buds

The seasonal incidence of sapota bud borer on fallen flower buds in different geneotypes was recoded at new orchard Agriculture College, Dharwad and saidapur farm, KVK, Dharwad (Table-16).

Table-14: Seasonal incidence of sapota bud borer, *Anarsia achrasella* damage during 2013-14 on different genotypes

Sl. No.	Month	Fortnight	Per cent bud damage					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	12.50	9.50	5.16	6.89	7.51	7.85
2		II	10.46	8.46	5.87	5.21	6.58	
3	July	I	9.22	7.22	6.13	5.23	4.23	5.82
4		II	7.26	5.26	5.40	3.41	4.86	
5	August	I	5.58	3.58	7.07	1.26	3.21	3.45
6		II	2.33	1.97	5.42	1.04	3.07	
7	September	I	2.41	3.41	7.84	2.33	2.75	3.56
8		II	3.26	2.24	8.02	1.25	2.04	
9	October	I	2.79	1.09	2.14	0.75	1.52	2.15
10		II	4.04	2.73	2.58	2.58	1.27	
11	November	I	4.85	2.41	4.68	2.79	2.15	4.20
12		II	6.61	4.86	5.78	3.56	4.26	
13	December	I	8.96	6.08	6.82	5.68	6.84	6.81
14		II	9.23	7.23	6.12	5.91	5.21	
15	January-2014	I	10.45	6.89	7.75	6.45	6.94	8.30
16		II	11.15	9.11	8.23	7.11	8.95	
17	February	I	11.76	9.73	8.07	7.77	7.16	9.37
18		II	12.25	10.17	9.64	8.25	8.92	
19	March	I	15.29	13.85	10.37	9.20	10.57	11.86
20		II	13.89	11.72	11.29	10.89	11.54	
21	April	I	12.18	9.09	9.68	9.18	8.56	8.66
22		II	9.25	7.81	8.30	7.25	5.26	
23	May	I	8.51	9.26	8.14	7.90	5.80	8.75
24		II	11.83	10.38	9.72	8.31	7.62	
	Mean		8.59	6.84	7.09	5.53	5.70	

*At new orchard, Agriculture college, Dharwad

** At KVK, Saidapur farm, Dharwad

Table-15 Correlation co- efficient between sapota bud borer, *Anarsia achrasella* and weather parameters

Weather data / Varieties	Maximum temperature (^{o} c)	Minimum temperature (^{o} c)	Morning relative humidity (%)	Evening relative humidity (%)	Rain fall (cm)
Cricket ball	0.546**	-0.154	-0.691**	-0.639**	-0.429*
Kalipatti	0.606**	-0.051	-0.687**	-0.622**	-0.342
DHS-1	0.652**	0.02	-0.665**	-0.578**	-0.269
DHS-2#	0757**	-0.096	-0.813**	-0.759**	-0.455*
DHS-2##	0.578**	-0.15	-0.728**	-0.676**	-0.412*

* Correlation is significant at 0.05 level (2-tailed)
** Correlation is significant at 0.01 level (2-tailed)

New orchard, Agriculture College, Dharwad
KVK, Saidapur Farm, Dharwad

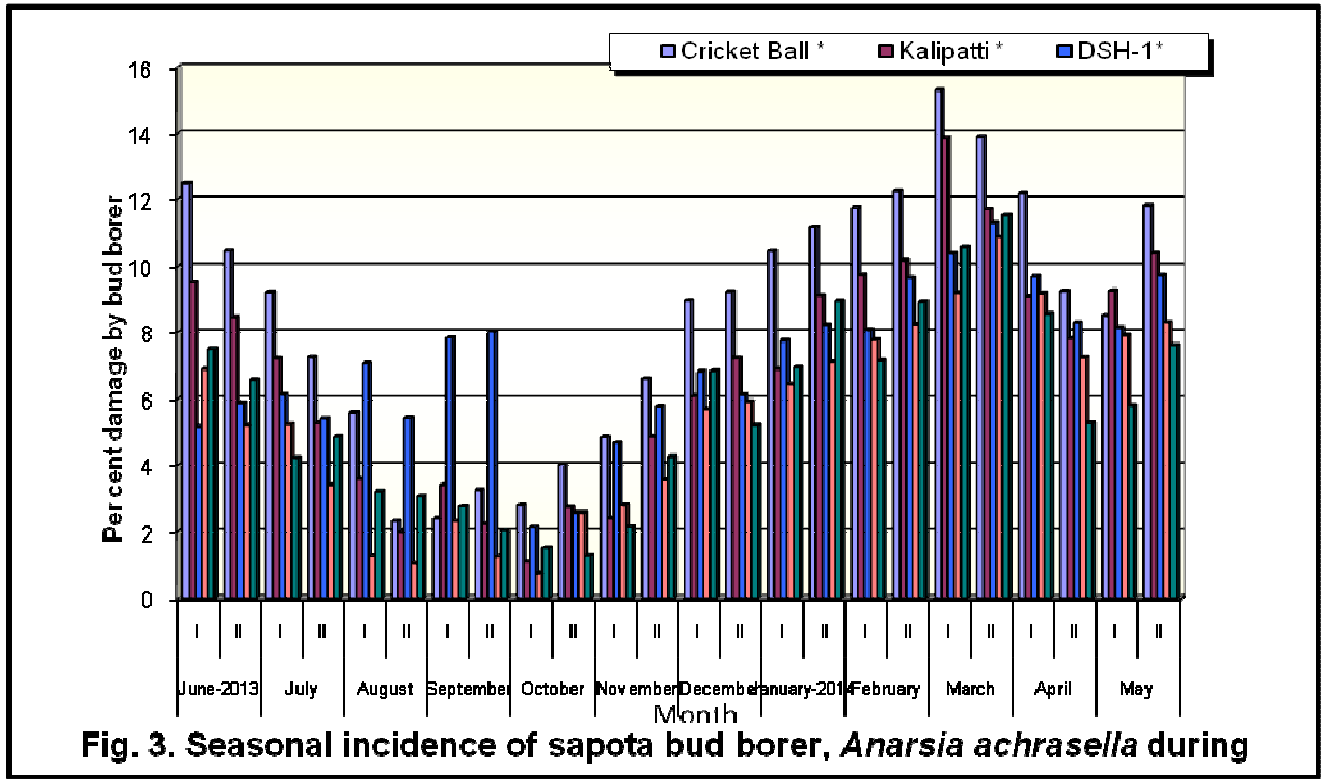

Fig. 3. Seasonal incidence of sapota bud borer, *Anarsia achrasella* during

Fig. 3. Seasonal incidence of sapota bud borer, *Anarsia achrasella* during 2013-14 on different genotypes

Table-16: Seasonal incidence of sapota bud borer, *Anarsia achrasella* damage on fallen flower buds during 2013-14 in different genotypes

Sl. No.	Month	Fortnight	Per cent damage					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	1.84	2.88	2.75	1.68	3.52	2.74
2		II	3.70	3.69	2.62	2.56	2.17	
3	July	I	2.52	3.81	1.12	2.90	3.45	2.74
4		II	3.30	3.34	2.92	2.41	1.58	
5	August	I	2.08	4.76	4.08	3.73	1.83	3.02
6		II	3.53	1.57	2.72	2.70	3.20	
7	September	I	4.75	1.08	3.40	3.06	2.78	3.14
8		II	2.57	2.47	3.12	5.54	2.61	
9	October	I	4.61	3.25	2.76	2.57	3.32	3.17
10		II	2.04	4.35	1.79	2.41	4.64	
11	November	I	3.46	1.24	2.81	1.02	2.75	2.57
12		II	3.06	2.06	3.84	1.81	3.60	
13	December	I	1.76	2.39	2.73	3.06	2.82	2.27
14		II	2.01	2.21	2.41	2.22	1.11	
15	January-2014	I	2.28	3.02	3.70	1.57	3.29	2.51
16		II	1.35	2.40	3.12	2.33	2.05	
17	February	I	2.82	3.74	2.06	3.98	2.56	2.48
18		II	2 88	2.34	1.17	3.12	1.10	
19	March	I	2.35	1.91	2.62	2.83	2.58	2.85
20		II	3.04	2.40	3.58	3.94	3.25	
21	April	I	2.17	1.49	2.83	2.39	3.86	2.84
22		II	3.58	2.92	3.08	3.47	2.58	
23	May	I	3.12	1.96	2.35	1.90	2.61	2.48
24		II	2.58	2.57	2.60	2.24	2.84	
	Mean		2.81	2.66	2.76	2.73	2.75	

*At new orchard, Agriculture college, Dharwad ** At KVK, Saidapur farm, Dharwad

Among four different genotypes of sapota, the incidence of bud borer did not vary much. However it was more in Cricketball (2.81 per cent) followed by DSH-1(2.76 %), DSH-2(2.75 %) and Kalipatti (2.66 %).

The mean percentage of bud damage across the genotypes in different months did not vary much which ranged from 2.27 to 3.17 per cent.

The incidence of bud borer on fallen flower buds in Cricket ball variety ranged from a minimum of 1.35 per cent during second fortnight of January followed by 1.76 per cent during first fortnight of December to a maximum of 4.75 per cent during first fortnight of September followed by 4.61 per cent (first fortnight of October).

In Kalipatti variety it varied from a minimum of 1.24 per cent (First fortnight of November) followed by 1.08 per cent (first fortnight of September) damage to a maximum of 4.76 per cent during first fortnight of August followed by 4.35 per cent during second fortnight of October.

In DSH-1 hybrid it varied from a minimum of 1.12 per cent during first fortnight of July followed by 1.17 per cent during second fortnight of February to a maximum of 4.08 per cent during first fortnight of August followed by 3.84 per cent during November second fortnight.

In DSH-2 hybrid the pest incidence which ranged from a minimum of 1.02 per cent during first fortnight of November followed by 1.68 per cent during first fortnight of August to a maximum of 5.54 per cent during second fortnight of September followed by 3.94 per cent during second fortnight of March bud damage in new orchard of college of Agriculture, Dharwad.

At KVK, saidapur farm, Dharwad the incidence of bud borer on fallen flower buds in DSH-2 hybrid ranged from a minimum of 1.10 per cent during second fortnight of February followed by 1.11per cent during December second fortnight to a maximum of 4.64 per cent during second fortnight of October followed by 3.86 per cent during first fortnight of April.

Larval population of Bud borer

The mean larval population of bud borer in four different genotypes (Fig-4) indicated that, the population was more in cricket ball variety (2.29 larvae/50 flower buds) followed by DSH-1(2.21), Kalipatti (1.83) and DSH-2(1.67 to 1.83) (Table-17).

Across the genotypes the mean larval population of bud borer ranged from 0.60 to 3.90 /50 flower buds. The lowest larval population of 0.60 was noticed in October and followed by 1.20 larval population in September and maximum of 3.90 larval population was recorded during March followed by 2.60 per cent in January.

The seasonal fluctuation of bud borer larval population per fifty flower buds in Cricket ball variety ranged from 0.0 to 4 larvae/50 flower buds. The lowest 1 larva/50 flower buds was noticed during second fortnight of September and maximum of 4 larvae populations was recorded during first fortnight of March and June.

The larval population of bud borer in Kalipatti variety ranged from 0.0 to 5 larvae/50 flower buds. The lowest bud borer larval population of 1 was noticed during second fortnight August and October and first fortnight of September, November, April and May. Maximum of 4 larvae/50 flower buds was recorded during first fortnight of March and June.

The bud borer larval population per fifty flower buds in DSH-1hybrid which ranged from 0.0 to 4 larvae. The lowest bud borer larval population of 1 was noticed in June and first fortnight August and October. Maximum of 4 larvae/50 flower buds was recorded during the month of March.

The bud borer larval population per fifty flower buds in DSH-2 hybrid ranged from 0.0 to 4 larvae. The lowest bud borer larval population of 1 was noticed in the month of July, November and second fortnight August, October, May and first fortnight of September. Maximum of 4 larvae/50 flower buds was recorded during second fortnight of March in new orchard of College of Agriculture, Dharwad.

The bud borer larval population per fifty flower buds in DSH-2 hybrid ranged from 0.0 to 5 larvae. The lowest bud borer larval population of 1 was noticed during second fortnight of July, first fortnight of August, September and October, first fortnight of November and May. Maximum of 5 larvae/50 flower buds was recorded during second fortnight of March.

Table-17: Larval population of sapota bud borer, *Anarsia achrasella* in flower buds during 2013-14 in different genotypes

Sl. No.	Month	Fortnight	Larval population/fifty flower buds					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	4	3	1	2	3	2.40
2		II	3	3	1	2	2	
3	July	I	3	2	2	1	2	1.90
4		II	3	2	2	1	1	
5	August	I	2	2	3	0	1	1.30
6		II	0	1	1	1	2	
7	September	I	1	1	3	1	1	1.20
8		II	1	0	2	2	0	
9	October	I	0	0	1	0	1	0.60
10		II	2	1	0	1	0	
11	November	I	2	1	2	1	1	1.40
12		II	2	1	2	1	1	
13	December	I	3	2	3	1	2	2.10
14		II	2	2	2	2	2	
15	January-2014	I	2	2	2	2	3	2.60
16		II	3	3	3	3	3	
17	February	I	3	2	2	2	2	2.40
18		II	3	2	3	3	2	
19	March	I	4	3	4	3	3	3.90
20		II	4	5	4	4	5	
21	April	I	3	1	3	2	2	2.40
22		II	2	3	3	2	3	
23	May	I	1	1	2	2	1	1.40
24		II	2	1	2	1	1	
	Mean		2.29	1.83	2.21	1.67	1.83	

*At new orchard, Agriculture college, Dharwad

** At KVK, Saidapur farm, Dharwad

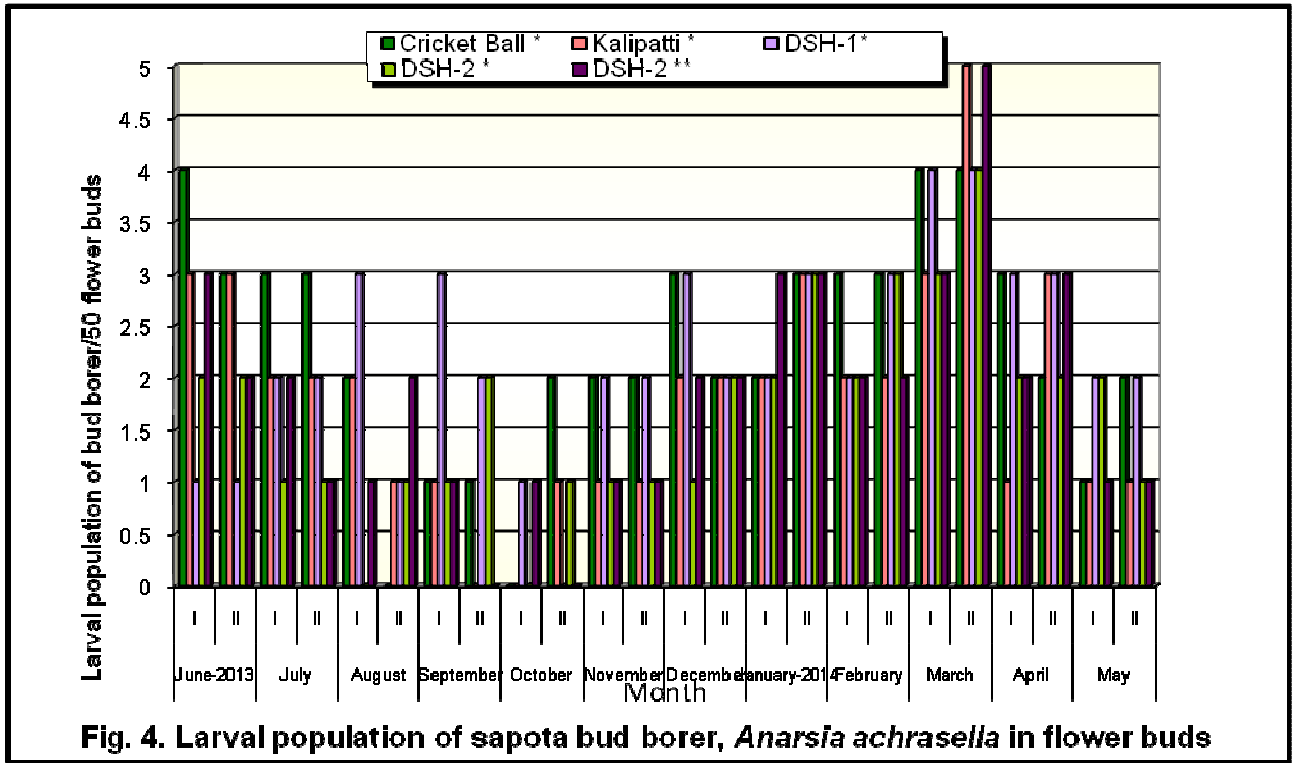

Fig. 4. Larval population of sapota bud borer, *Anarsia achrasella* in flower buds during 2013-14 in different genotypes

Fruit borer, *Phycita erythrolophia* Hampson

The larva of sapota fruit borer, *P. erythrolophia* damages by boring into fruits and feeding on pulp. A bored hole is seen on sapota fruits and due to continuous feeding the excretory pellets are seen on bored holes. Usually one larva was found in each affected fruit. Larva in its entire period feeds on fruits only but sometimes early larval instars rearly feeds on flower buds by scarping the petals.

The incidence of sapota fruit borer, *P. erythrolophia* on fruits (Fig-5) was observed throughout the year in new orchard, Agriculture College, Dharwad and KVK, saidapur farm on Cricket ball, Kalipatti, DSH-1 and DSH-2 genotypes (Table-18).

Among four different genotypes of sapota the incidence of fruit borer damage was more in cricket ball (10.24 %) followed by Kalipatti' (9.64 %) varities whereas, on hybrids it ranged from 7.33 to 9.64 per cent.

Across the genotypes, the mean percentage of fruit damage in different months ranged from 3.92 to 16.18. Highest incidence of 16.18 per cent was noticed in March whereas, it was lowest in September. Further, the data reveals that the pest incidence was more during dry period *i.e.* from November to April and less during rainy season (July to October).

The incidence of fruit borer in Cricket ball variety ranges from 3.58 to 19.25 per cent. Minimum incidence of 3.58 per cent was recorded during first fortnight of September followed by 4.26 per cent during second fortnight of August. Maximum incidence of 19.25 per cent was recorded during first fortnight of March followed by 17.23 per cent fruit damage in the same month.

On Kalipatti variety it varied from 3.52 to 17.91 per cent. Lowest incidence of 3.52 per cent was recorded during first fortnight of August followed by 3.63 per cent during the same month. Highest incidence of 17.91 per cent was recorded during first fortnight of March followed by 16.58 per cent during the same month.

The fruit borer damage in DSH-1hybrid varied from 2.63 to 14.58 per cent. Minimum of 2.63 per cent was recorded during first fortnight of September followed by 2.81 per cent during first fortnight of August. Maximum of 14.58 per cent incidence was recorded during second fortnight of February followed by 13.95 per cent in same month.

The infestation of fruit borer in DSH-2 hybrid ranged from 2.56 to 16.50 per cent at new orchard, college of Agriculture, Dharwad. Minimum of 2.56 per cent was recorded during second fortnight of October followed by 3.09 per cent during second fortnight of September. Maximum of 16.50 per cent incidence was recorded during first fortnight of March followed by 15.55 per cent damage in the same month. At KVK, Saidapur farm, Dharwad the incidence of fruit borer in DSH-2 hybrid which ranged from a minimum of 3.62 per cent during first fortnight of September to a maximum of 15.49 per cent during second fortnight of March.

The correlation studies made between the incidence of fruit borer (*P.erythrolophia*) and weather parameters (Table-19) showed that there was a significant and positive correlation between fruit borer damage and maximum temperature in all four genotypes. Whereas, it was significantly negatively correlated with morning and evening relative humidity and rainfall.

Fruit borer damage on fallen flower buds

Seasonal incidence of *P.erythrolophia* damage on fallen flower buds on different geneotypes was recoded at new orchard Agriculture College, Dharwad and KVK, saidapur farm, Dharwad (Table-20).

Among four different genotypes of sapota the overall incidence of fruit borer on fallen flower buds was almost same ranging from 0.25 to 0.28, except that the incidence was more on DSH-2 (0.55%) at new orchard, College of Agriculture, Dharwad.

The overall mean incidence of the pest throughout the year irrespective of the genotypes ranged from 0.14 (June) to 0.60 (September).

The incidence of *P.erythrolophia* on fallen flower buds in Cricket ball variety ranged from 0.00 to 0.85 per cent. Minimum of 0.30 per cent was recorded during second fortnight of July, August and April. Maximum of 0.85 per cent was recorded during second fortnight of December.

Table-18: Seasonal incidence of sapota fruit borer, *Phycita erythrolophia* during 2013-14 on different genotypes

Sl. No.	Month	Fortnight	Per cent fruit damage to fallen flower buds					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	12.33	9.93	7.41	8.33	9.56	7.90
2		II	5.61	7.50	6.54	5.28	6.54	
3	July	I	5.40	6.53	5.26	6.07	5.35	5.32
4		II	5.22	4.85	4.01	5.30	5.25	
5	August	I	5.16	3.52	2.81	4.48	5.54	4.09
6		II	4.26	3.63	2.63	3.85	4.98	
7	September	I	3.58	4.07	3.09	3.15	3.62	3.92
8		II	4.87	5.24	3.80	3.09	4.71	
9	October	I	6.13	8.78	4.18	4.07	5.65	5.74
10		II	7.89	6.41	7.91	2.56	3.83	
11	November	I	10.22	7.75	6.76	5.82	6.15	8.24
12		II	13.46	8.23	8.29	7.02	8.65	
13	December	I	11.11	9.64	7.52	8.18	10.86	9.38
14		II	10.82	11.25	6.38	8.52	9.48	
15	January-2014	I	13.82	11.61	9.54	9.91	11.56	11.50
16		II	12.74	11.85	11.25	10.37	12.30	
17	February	I	17.56	13.32	12.26	10.55	11.74	13.63
18		II	15.29	14.13	14.58	12.40	14.45	
19	March	I	19.25	17.91	13.95	16.50	14.93	16.18
20		II	17.23	16.58	14.36	15.55	15.49	
21	April	I	14.81	15.26	13.95	8.07	11.66	11.26
22		II	10.52	14.30	9.80	6.12	8.11	
23	May	I	9.30	8.63	8.15	5.33	6.84	7.90
24		II	9.25	10.50	9.28	5.50	6.26	
	Mean		10.24	9.64	8.07	7.33	8.48	

*At new orchard, Agriculture college, Dharwad
** At KVK, Saidapur farm, Dharwad

Table-19 Correlation co- efficient between sapota fruit borer, *Phycita erythrolophia* and weather parameters

Weather data / Varieties	Maximum temperature (^{o} c)	Minimum temperature (^{o} c)	Morning Relative humidity (%)	Evening Relative humidity (%)	Rain fall (cm)
Cricket ball	0.597**	-0.450*	-0.874**	-0.878**	-0.668**
Kalipatti	0.750**	-0.253	-0.865**	-0.868**	-0.689**
DHS-1	0.742**	-0.221	-0.880**	-0.865**	-0.618**
DHS-2#	0.432*	-0.404	-0.738**	-0.752**	-0.521**
DHS-2##	0.506*	-0.440*	-0.820**	-0.827**	-0.624**

** Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

New orchard, Agriculture College, Dharwad

KVK, Saidapur Farm, Dharwad

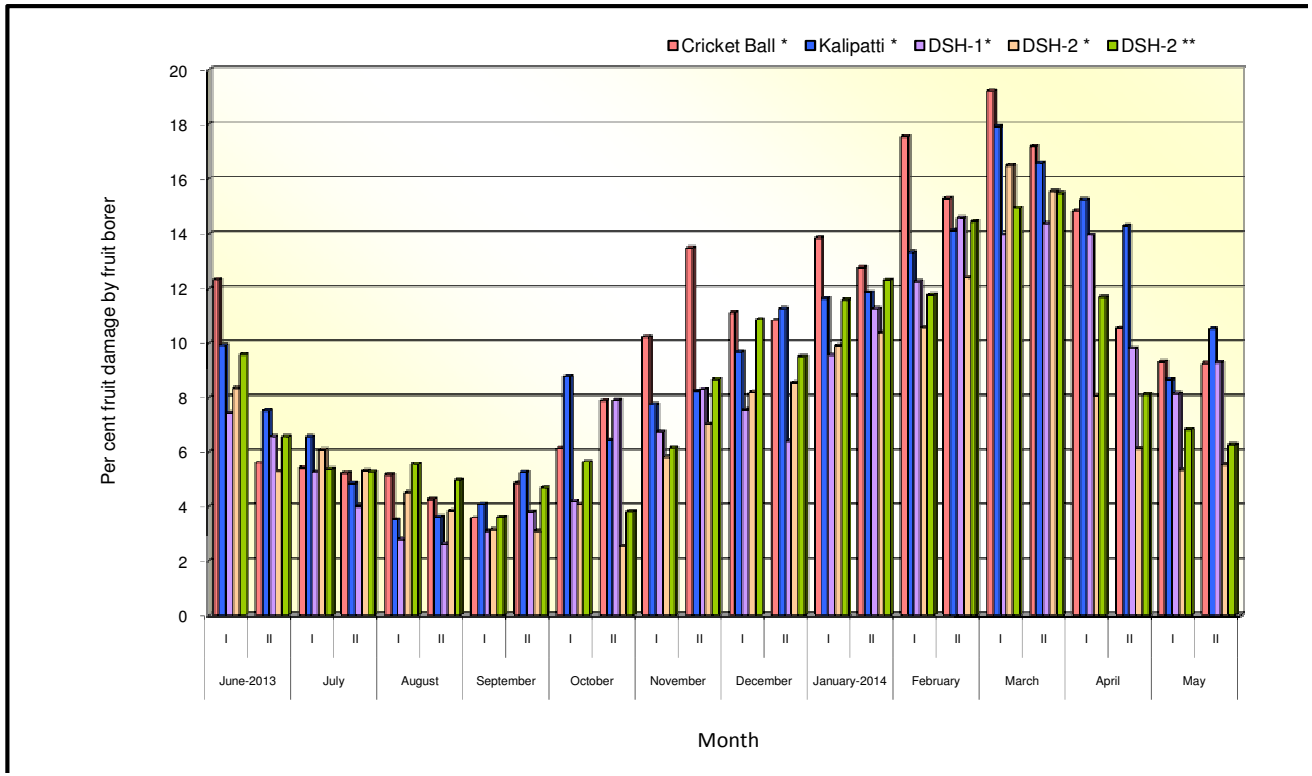

Fig. 5. Seasonal incidence of sapota fruit borer, *Phycita erythrolophia* during 2013-14 on different genotypes

Table-20: Seasonal incidence of sapota fruit borer, *Phycita erythrolophia* on fallen flower buds during 2013-14 on different genotypes

Sl. No.	Month	Fortnight	Per cent damage to fallen flower buds					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	0.00	0.00	0.62	0.00	0.00	0.14
2		II	0.00	0.76	0.00	0.00	0.00	
3	July	I	0.00	0.83	0.30	2.90	0.00	0.43
4		II	0.30	0.00	0.00	0.00	0.00	
5	August	I	0.68	0.00	0.00	0.00	0.00	0.42
6		II	0.30	1.33	0.00	0.62	1.26	
7	September	I	0.00	0.0	1.52	3.06	0.62	0.60
8		II	0.00	0.58	0.22	0.00	0.00	
9	October	I	1.33	0.00	0.00	0.00	0.65	0.38
10		II	0.00	0.00	0.36	1.11	0.36	
11	November	I	0.36	0.28	0.93	0.38	0.00	0.29
12		II	0.00	0.35	0.00	0.61	0.00	
13	December	I	0.00	0.00	0.00	0.00	0.00	0.20
14		II	0.85	0.00	0.00	0.00	1.11	
15	January-2014	I	0.00	0.30	0.00	1.30	0.86	0.38
16		II	0.00	0.40	0.48	0.42	0.00	
17	February	I	0.00	0.00	0.60	0.56	0.00	0.28
18		II	0.80	0.00	0.86	0.00	0.00	
19	March	I	0.00	0.00	0.00	0.00	0.00	0.18
20		II	0.00	0.00	0.00	0.85	0.91	
21	April	I	0.66	0.30	0.33	0	0.00	0.32
22		II	0.30	0.82	0.00	0.36	0.43	
23	May		0.00	0.80	0.00	0.00	0.00	0.29
24			0.00	0.00	0.92	0.00	0.64	
Mean			0.25	0.27	0.28	0.55	0.28	

*At new orchard, Agriculture college, Dharwad

** At KVK, Saidapur farm, Dharwad

In Kalipatti variety the damage ranged from 0.00 to 1.33 per cent. Minimum of 0.28 per cent was recorded during first fortnight of November. Maximum of 4.76 per cent was recorded during second fortnight of August.

The *P.erythrolophia* damage on fallen flower buds in DSH-1hybrid varied from 0.00 to 1.52 per cent. Minimum of 0.22 per cent was recorded second fortnight of September. Maximum of 1.52 per cent was recorded during first fortnight of September.

In DSH-2 hybrid it ranged from 0.00 to 3.06 per cent. Minimum of 0.36 per cent was recorded during second fortnight of April. Maximum of 3.06 per cent was recorded during first fortnight of September.

At KVK, Saidapur farm, Dharwad the incidence of *P.erythrolophia* on fallen flower buds in DSH-2 hybrid which ranged from 0.00 to 1.26 per cent. Minimum of 0.36 per cent was recorded during second fortnight of October. Maximum of 1.26 per cent was recorded during second fortnight of August.

Fruit borer damage on fallen fruits

The seasonal incidence of sapota fruit borer on fallen fruits on different genotypes indicated that the mean percentage of fruit damage on four different genotypes remained more or less same which ranged from 2.05 to 2.81 (Table-21).

The mean percentage of fruit borer damage in different months irrespective of the genotypes ranged from 1.20 (September) to 3.69 (April).

The incidence of fruit borer on fallen fruits in Cricket ball variety ranged from a minimum of 1.06 per cent during first fortnight of December to a maximum of 5.84 per cent during first fortnight of April.

In Kalipatti variety it ranged from a minimum of 0.55 per cent during second fortnight of August to maximum of 4.45 per cent during second fortnight of March.

In DSH-1 hybrid it varied from a minimum of 0.26 per cent during second fortnight of September to a maximum of 3.84 per cent during first fortnight of April.

In DSH-2 hybrid it ranged from a minimum of 0.57 per cent during second fortnight of August to a maximum of 4.16 per cent during second fortnight of April at new orchard, College of Agriculture, Dharwad.

At KVK, Saidapur farm, Dharwad, the incidence of fruit borer on fallen fruits of DSH-2 ranged from a minimum of 0.81 per cent during second fortnight of August to a maximum of 3.57 per cent during first fortnight of April.

Larval population of Fruit borer on flower buds

The mean larval population of *P.erythrolophia* on four different genotypes recorded throughout the year from June 2013 to May 2014 indicated that there was no much variation among the four genotypes which ranged from 1.40 to 1.89 (Table-22)

The overall larval population per fifty flower buds irrespective of the genotypes recorded from June 2013 to May 2014 ranged from 0.95 (January) to 2.75 (August).

The larval population per fifty flower buds in Cricket ball variety ranged from 0.0 to 4 larvae. The lowest of 1 larva were noticed in October, Second fortnight January and first fortnight of February, April, May and maximum of 4 larvae was recorded during first fortnight of August.

The larval population of fruit borer, in Kalipatti variety ranged from 0.0 to 3 larvae. The lowest bud borer larval population of 1 was noticed during first fortnight of December and Second fortnight of November, April and May. Maximum of 3 larvae was recorded August.

The fruit borer on larval population per fifty flower buds in DSH-1 hybrid ranged from 0.0 to 3 larvae. The lowest bud borer larval population of 1 was noticed during first fortnight March and second fortnight of September, November, February, April and May. Maximum of 3 larvae were recorded during first fortnight of August and December.

The fruit borer on larval population per fifty flower buds in DSH-2 hybrid ranged from 0.0 to 3 larvae. The lowest fruit borer larval population of 1 was noticed during first fortnight of March and

second fortnight of September, November, February and April. Maximum of 3 larvae was recorded during second fortnight of August and December at new orchard, College of Agriculture, Dharwad.

The fruit borer larval population per fifty flower buds in DSH-2 hybrid ranged from 0.0 to 3 larvae. The lowest bud borer larval population of 1 was noticed during first fortnight of January and second fortnight of June, September and December. Maximum of 3 larvae were recorded during the first fortnight of October at KVK, Saidapur farm, Dharwad.

Larval population of Fruit borer on fruits

The mean larval population of fruit borer in four different genotypes indicated that there was no variation which ranged from 4.54 to 5.08/fifty fruits (Table-23).

The mean larval population in different months irrespective of the genotypes ranged from 1.50 (May) to 11.30 (March).the data revealed that the larval population was high from November to April (5.20 to 11.32) and it was low from May to October (1.50 to 4.10).

The fruit borer on larval population per fifty fruits in Cricket ball variety ranged from lowest 2 (second fortnight of August and first fortnight of September) to 11 (first fortnight of March).

The larval population of fruit borer in Kalipatti variety ranged from a minimum of 2 (second fortnight of July, September and May) to a maximum of 11 larvae during the first fortnight of March.

In DSH-1 hybrid it ranged from lowest of 2 larvae during second fortnight July and May to a maximum of 10 larvae during first fortnight of March.

In DSH-2 hybrid it varied from minimum of 1 larva during May to a maximum of 11 larvae populations during second fortnight of March at new orchard, college of Agriculture, Dharwad.

In DSH-2 hybrid ranged from lowest larval population of 1 during second fortnight of May to a maximum of 10 larvae during the second fortnight of March and first fortnight of May.

Extent of fruit damage on harvested fruits

The mean percentage of fruit damage from harvested fruits of four genotypes (Fig-6) indicated no much variation which ranged from 8.53 to 9.20 (Kalipatti). Irrespective of the genotypes, the mean percentage of fruit borer damage in different months ranged from 5.30 (September) to 14.43 (March). The data further indicated higher incidence (12.32 to 14.43) from February to April and lower (5.30 to 8.09) during August to January months. (Table-24)

Leaf webber, *Nephopteryx eugraphella* Ragonot

The lavae of leaf webber, *N.eugraphella* feed on leaves by webbing the leaves and feed on leaf tissues by feeding on chlorophyll content of leaf . It remains hidden within the webbed leaves.

The percentage of damaged leaves on four different genotypes of sapota was high (2.17%) on Cricket ball and it was low on DSH-1 (1.35%) (Table-25)

The overall mean percentage of damaged leaves irrespective of the genotypes varied from 0.00 (May) to 3.79 (October). In general the incidence of pest was high (2.27 to 3.79%) during August to November. Whereas, it was low (0.00 to 1.58%) during December to July.

The incidence of leaf webber on Cricket ball variety ranged from 0.00 to 7.80 per cent. Minimum of 0.50 per cent was recorded during second fortnight of April followed by 0.53 per cent during first fortnight of June. Maximum of 7.80 per cent was recorded during second fortnight of September followed by 5.31 per cent during first fort night of November.

In Kalipatti variety it ranged from 0.00 to 4.80per cent. Minimum of 0.51 per cent was recorded during first fortnight of January followed by 0.68 per cent during first fortnight of July. Maximum of 4.80 per cent was recorded during first fortnight of November followed by 3.71 per cent during second fortnight of September.

In DSH-1 hybrid it varied from 0.00 to 3.52 per cent. Minimum of 0.52 per cent was recorded during second fortnight of January followed by 0.58 per cent during first fortnight of March. Maximum of 3.52 per cent was recorded during second fortnight of October followed by 2.94 per cent during first fortnight of November.

Table-21: Seasonal incidence of Sapota fruit borer, *Phycita erythrolophia* on fallen fruits during 2013-14 on different genotypes

Sl. No.	Month	Fortnight	Per cent fruit damage					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	2.25	2.06	1.44	2.45	3.70	2.04
2		II	2.76	1.80	0.26	2.16	1.54	
3	July	I	3.33	3.75	2.86	3.26	2.12	2.92
4		II	2.76	2.88	2.23	2.14	3.83	
5	August	I	2.00	1.50	2.45	1.60	2.39	1.53
6		II	1.55	0.55	1.83	0.57	0.81	
7	September	I	1.63	0.75	1.12	1.26	1.70	1.20
8		II	1.68	1.34	0.26	1.05	1.22	
9	October	I	2.14	1.40	0.88	1.25	2.40	1.72
10		II	1.34	2.88	1.26	1.14	2.54	
11	November	I	3.45	2.60	2.25	2.88	3.12	2.85
12		II	2.86	2.75	3.84	2.55	2.16	
13	December	I	1.06	2.60	2.75	2.88	1.53	2.31
14		II	3.18	3.14	1.56	3.58	0.84	
15	January-2014	I	2.53	3.00	1.00	2.06	1.83	2.28
16		II	2.89	3.06	2.25	2.58	1.60	
17	February	I	3.82	2.70	1.88	3.16	1.90	2.75
18		II	3.16	3.45	3.45	1.84	2.16	
19	March	I	3.50	2.25	1.54	1.14	3.43	2.89
20		II	3.70	4.45	2.60	3.89	2.39	
21	April	I	5.84	4.06	2.55	2.45	3.57	3.69
22		II	4.89	2.80	3.84	4.16	2.75	
23	May	I	2.56	1.95	2.92	3.64	1.90	2.59
24		II	2.48	2.27	2.15	3.93	2.08	
	Mean		2.81	2.50	2.05	2.40	2.23	

*At new orchard, Agriculture college, Dharwad

** At KVK, Saidapur farm, Dharwad

Table-22: Larval population of sapota fruit borer, *Phycita erythrolophia* on flower buds during 2013-14 on different genotypes

Sl. No.	Month	Fortnight	Larval population/fifty flower buds					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	0	2	0	2	1	1.83
2		II	0	2	0	0	0	
3	July	I	2	0	0	0	2	2.00
4		II	2	0	2	2	2	
5	August	I	4	3	3	3	0	2.75
6		II	0	3	0	0	2	
7	September	I	0	0	0	2	1	1.50
8		II	0	2	0	1	0	
9	October	I	1	0	1	0	3	2.00
10		II	1	0	0	0	2	
11	November	I	0	0	2	0	0	1.50
12		II	0	1	0	1	0	
13	December	I	0	1	0	3	1	1.58
14		II	0	2	1	0	0	
15	January-2014	I	2	0	0	0	0	0.95
16		II	1	0	0	2	1	
17	February	I	1	0	0	2	1	1.38
18		II	0	2	1	1	1	
19	March	I	0	0	1	1	0	1.00
20		II	0	0	1	0	0	
21	April	I	1	2	1	0	2	1.50
22		II	0	1	0	1	2	
23	May	I	1	0	0	0	0	1.00
24		II	0	0	1	0	0	
Mean			1.60	1.89	1.40	1.73	1.67	

*At new orchard, Agriculture college, Dharwad

** At KVK, Saidapur farm, Dharwad

Table-23: Larval population of sapota fruit borer, *Phycita erythrolophia* on fruits during 2013-14 on different genotypes

Sl. No.	Month	Fortnight	Larval population/fiftyfruits					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	5	4	3	4	5	3.70
2		II	3	4	2	3	4	
3	July	I	4	3	3	3	3	3.00
4		II	4	2	2	3	3	
5	August	I	4	3	3	2	3	3.00
6		II	2	3	3	5	2	
7	September	I	2	4	4	5	5	4.00
8		II	3	2	5	6	4	
9	October	I	3	3	3	4	5	4.10
10		II	3	4	4	4	4	
11	November	I	6	6	4	5	5	6.30
12		II	7	4	6	7	4	
13	December	I	5	6	5	9	4	6.10
14		II	6	7	5	7	5	
15	January-2014	I	4	8	8	6	7	7.40
16		II	9	6	7	5	4	
17	February	I	10	7	4	4	6	8.40
18		II	8	9	9	9	8	
19	March	I	11	11	8	9	7	11.30
20		II	13	9	10	11	10	
21	April	I	3	5	4	5	10	5.20
22		II	3	6	3	4	9	
23	May	I	3	2	2	1	2	1.50
24		II	3	3	2	1	1	
	Mean		5.04	4.96	4.54	5.08	5.00	

*At new orchard, Agriculture college, Dharwad
** At KVK, Saidapur farm, Dharwad

Table-24: Incidence of sapota fruit borer, *Phycita erythrolophia* on harvested sapota fruits in new orchard, Agriculture college, Dharwad 2013-14 in different genotypes

Sl. No.	Month	Per cent fruit damage				Mean
		Cricket Ball	Kalipatti	DHS-1	DHS-2	
1	August-2013	5.93	6.60	5.73	5.17	5.86
2	September	5.24	5.12	5.11	5.74	5.30
3	October	5.86	6.64	6.20	6.04	6.19
4	November	8.09	8.98	7.26	8.03	8.09
5	December	7.70	6.42	5.88	9.53	7.38
6	January-2014	7.32	7.22	7.07	9.07	7.67
7	February	13.38	12.67	12.90	10.34	12.32
8	March	16.25	15.24	14.41	11.80	14.43
9	April	10.93	13.94	13.5	11.02	12.35
Mean		8.97	9.20	8.67	8.53	

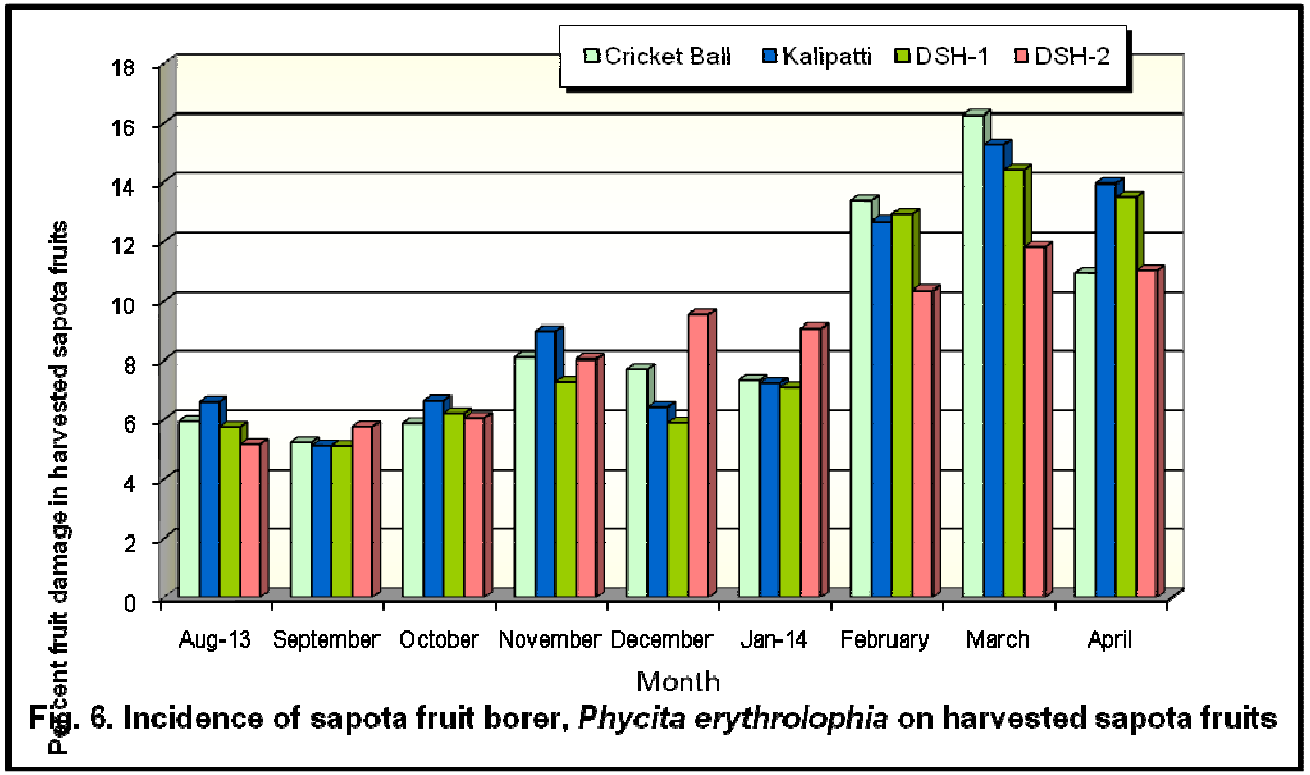

Fig. 6. Incidence of sapota fruit borer, *Phycita erythrolophia* on harvested sapota fruits

Fig. 6. Incidence of sapota fruit borer, *Phycita erythrolophia* on harvested sapota fruits in new orchard during 2013-14 in diffeent genotypes

Table-25: Seasonal incidence of leaf webber, *Nephopteryx eugraphella* during 2013-14 on different genotypes

Sl. No.	Month	Fortnight	Per cent leaves damaged					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	0.53	0.84	1.20	1.25	1.25	1.05
2		II	0.83	1.13	1.58	0.63	1.30	
3	July	I	1.08	0.68	0.93	1.28	0.90	1.01
4		II	1.31	0.93	0.72	1.08	1.20	
5	August	I	2.55	1.82	1.12	1.68	1.35	2.27
6		II	3.72	2.70	1.58	2.51	3.68	
7	September	I	3.84	2.38	1.76	2.97	3.51	3.58
8		II	7.80	3.71	2.24	3.65	3.92	
9	October	I	4.52	3.18	2.61	3.45	4.20	3.79
10		II	4.86	2.94	3.52	4.72	3.92	
11	November	I	5.31	4.80	2.94	4.68	3.47	3.31
12		II	2.60	1.32	1.81	3.56	2.65	
13	December	I	1.24	0.68	0.93	4.08	0.92	1.58
14		II	1.17	1.53	2.56	2.06	0.60	
15	January-2014	I	0.83	0.51	1.55	1.95	1.52	1.06
16		II	0.56	0.82	0.52	1.27	1.08	
17	February	I	1.21	1.10	1.02	1.37	0.93	0.87
18		II	0.68	0.89	0.60	0.56	0.32	
19	March	I	1.02	1.25	0.58	086	0.0	0.43
20		II	0.62	0.0	0.0	0.0	0.0	
21	April	I	0.91	0.0	0.0	0.0	0.0	0.14
22		II	0.50	0.0	0.0	0.0	0.0	
23	May	I	0.0	0.0	0.0	0.0	0.0	0.00
24		II	0.0	0.0	0.0	0.0	0.0	
	Mean		2.17	1.51	1.35	1.98	1.67	

*At new orchard, Agriculture college, Dharwad
** At KVK, Saidapur farm, Dharwad

Table-26 Correlation coefficient between leaf webber, *Nephopteryx eugraphella* and weather parameters

Weather data / Varieties	Maximum temperature (^{o}c)	Minimum temperature (^{o}c)	Morning relative humidity (%)	Evening relative humidity (%)	Rain fall (mm)
Cricket ball	-0.447*	0.058	0.516**	0.44*	0.152
Kalipatti	-0.539**	-0.097	0.517**	0.414*	0.117
DHS-1	-.0597**	-0.286	0.510*	0.337	0.082
DHS-2#	0.086	-0.14	-0.199	-0.219	-0.146
DHS-2##	-0.571**	0.028	0.644**	0.531**	0.232

** Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

New orchard, Agriculture College, Dharwad

KVK, Saidapur Farm, Dharwad

Table-27: Seasonal incidence of leaf miner, *Achrocercops gemoniella* during 2013-14 in different genotypes

Sl. No.	Month	Fortnight	Per cent leaves damage					Mean
			Cricket Ball *	Kalipatti *	DHS-1*	DHS-2 *	DHS-2 **	
1	June-2013	I	0.85	0.84	0.86	0.65	1.25	0.99
2		II	0.71	1.13	0.92	0.82	1.82	
3	July	I	1.58	0.68	1.31	1.05	1.68	1.16
4		II	0.67	0.93	1.12	1.28	1.25	
5	August	I	1.54	1.82	0.85	1.31	1.12	1.62
6		II	1.83	2.70	2.82.	1.52	1.61	
7	September	I	2.60	2.38	2.28	2.05	1.95	2.94
8		II	3.92	3.71	2.65	4.22	3.68	
9	October	I	3.25	3.18	2.15	4.05	2.43	3.02
10		II	4.81	2.94	2.15	3.52	1.72	
11	November	I	3.62	4.80	1.82	3.91	2.65	2.78
12		II	3.59	1.32	1.30	2.67	2.08	
13	December	I	2.56	0.68	0.81	2.69	1.32	1.56
14		II	1.32	1.53	1.32	1.51	1.86	
15	January-2014	I	1.09	0.51	1.54	1.36	1.33	1.02
16		II	0.0	0.82	0.97	1.05	1.54	
17	February	I	0.0	1.10	0.54	0.0	1.23	0.44
18		II	0.0	0.89	0.61	0.0	0.0	
19	March	I	0.53	1.25	0.25	0.0	0.0	0.30
20		II	0.79	0.0	0.20	0.0	0.0	
21	April	I	0.0	0.0	0.00	0.0	0.0	0.00
22		II	0.0	0.0	0.00	0.0	0.0	
23	May	I	0.0	0.0	0.0	0.0	0.0	0.00
24		II	0.0	0.0	0.0	0.0	0.0	
	Mean		1.60	1.51	1.13	1.53	1.39	

*At new orchard, Agriculture college, Dharwad

** At KVK, Saidapur farm, Dharwad

Table-28 Correlation co- efficient between leaf miner, *Achrocercops gemoniella* and weather parameters

Weather data / Varieties	Maximum temperature (^{o}c)	Minimum temperature (^{o}c)	Morning relative humidity (%)	Evening Relative humidity (%)	Rain fall (cm)
Cricket ball	-0.484*	-0.106	0.517**	0.366	0.126
Kalipatti	-0.539**	-0.097	0.517**	0.414*	0.117
DHS-1	-0.701**	-0.081	0.676**	0.557**	0.26
DHS-2#	-0.560**	-0.183	0.541**	0.396	0.088
DHS-2##	-0.736**	-0.193	0.621**	0.525**	0.157

** Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

New orchard, Agriculture College, Dharwad

KVK, Saidapur Farm, Dharwad

In DSH-2 hybrid it ranged from 0.00 to 4.72 per cent in new orchard, College of Agriculture, Dharwad. Minimum of 0.56 per cent was recorded during second fortnight of February followed by 0.63 per cent during second fortnight of June. Maximum of 4.72 per cent was recorded during second fortnight of October followed by 4.68 per cent during November first fortnight.

At KVK, Saidapur farm, Dharwad, the incidence of leaf webber recorded in DSH-2 hybrid which ranged from 0.00 to 4.20 per cent. Minimum of 0.32 per cent was recorded during second fortnight of February. Maximum of 4.20 per cent was recorded during first fortnight of October.

The correlation studies made between the incidence of leaf webber and weather parameters (Table-26) showed that there was a positive correlation between leaf webber damage and maximum temperature in DSH-2 hybrid. Similarly, minimum temperature had positive correlation with leaf webber incidence in Cricket ball and DSH-2 hybrid. The morning relative humidity had positive and significant correlation with leaf webber incidence in Cricket ball, Kalipatti, DSH-1 and DSH-2. The evening relative humidity showed positive and significant correlation with leaf webber incidence. There was positive correlation between rainfall and leaf webber incidence in all the genotypes except DSH-2 hybrid grown in new orchard, College of Agriculture, Dharwad.

Leaf miner, *Achrocercops gemoniella* Stainton

The tiny larva of leaf miner, *A. gemoniella* mined into epidermal layers of young leaves and the affected leaves showed glistering galleries which later distorted dried and ultimately fell down.

The mean percentage of damaged leaves recorded from June 2013 to May 2014 indicated higher incidence (1.60%) in Cricket ball and it was lowest (1.13%) in DSH-1. Whereas, the pest incidence on other two genotypes varied from 1.39 to 1.53(Table-27)

The overall mean percentage of leaf miner damage irrespective of genotypes indicated higher incidence of the pest from September to November which ranged from 2.78 to 3.02 whereas, in remaining period i.e. from December to August it was low which ranged from 0.30 to 1.62 except that there was no incidence during April and May.

The incidence of leaf miner in Cricket ball variety ranged from 0.00 to 4.81 per cent. Minimum of 0.53 was recorded during first fortnight of March followed by 0.67 per cent during second fortnight of July. Maximum of 4.81 per cent was recorded during second fortnight of October followed by 3.92 per cent during second fortnight of September.

In Kalipatti variety it varied from 0.00 to 4.80 per cent. Minimum of 0.51 per cent was recorded during first fortnight of January followed by 0.68 per cent during July first fortnight. Maximum of 4.80 per cent was recorded during first fortnight of November followed by 3.71 per cent during second fortnight of September.

In 'DSH-1' variety it varied from 0.00 to 2.82 per cent. Minimum of 0.20 per cent was recorded during second fortnight of March followed by 0.25 per cent in the same month. Maximum of 2.82 per cent was recorded during second fortnight of August followed by 2.65 per cent during second fortnight of September.

In DSH-2 hybrid ranged from 0.00 to 4.22 per cent. Minimum of 0.82 per cent was recorded during second fortnight of June followed by 0.65 per cent in the same month. Maximum of 4.22 per cent was recorded during second fortnight of September followed by 4.05 per cent during first fortnight of October at new orchard, College of Agriculture, Dharwad.

At KVK, Saidapur farm, KVK, Dharwad the incidence of leaf miner recorded in DSH-2hybridranged from 0.00 to 3.68 per cent. Minimum of 1.12 per cent was recorded during first fortnight of February followed by 1.25 per cent during second fortnight of July. Maximum of 3.68 per cent incidence was recorded during Second fortnight of August followed by 2.65 per cent during first fortnight of November.

The correlation studies made between the incidence of leaf miner and weather parameters (Table-28) showed that there was a significant and negative correlation between leaf miner damage and maximum temperature. Negative but non-significant correlation existed between minimum temperature and leaf miner incidence in all the genotypes. Morning relative humidity had positive and significant correlation with pest incidence in all genotypes. Whereas, this correlation was significantly positive between evening relative humidity and pest incidence in Kalipatti, DSH-1 and DSH-2 hybrid (KVK, saidapur farm) while in remaining two genotypes it was non-significant. In all the genotypes rainfall had positive correlation with the pest incidence.

4.3 Management of sapota fruit borer, *Phycita erythrolophia* Hampson

4.3.1 Field efficacy of insecticides against sapota fruit borer, *Phycita erythrolophia* in Kalipatti variety.

Investigation was carried out to find out the efficacy of different insecticides against sapota fruit borer on Kalipatti variety (Fig-7) at new orchard, Agriculture College, Dharwad during 2013-14. (Table-29)

Fruit borer damage, *Phycita erythrolophia* Hampson

The per cent damage to fruits a day before imposition of treatments was uniform in all the treatments as indicated by non-significant differences (Table-29). Three days after spraying spinosad 45 SC recorded lowest fruit damage of 17.08 per cent being on par with profenophos 50 EC (18.00), DDVP 76 EC (19.12), rynaxypyr 20 SC (21.08) indoxacarb 14.5 SC (22.20) and flubendiamide 480 SC (22.33) and Malathion 50 EC (22.67). However untreated check recorded significantly highest fruit damage of 31.67 per cent being statically on par with emamectin benzoate 5 SG (26.19) and navoluron 10 EC (25.15%).

Seven days after spraying, significantly minimum per cent fruit damage was recorded in spinosad 45 SC (14.30) being on par with profenophos 50 EC (14.50), DDVP 76 EC (18.15), indoxacarb 14.5 SC (19.00), rynaxypyr 20 SC (19.11) and flubendiamide 480 SC (20.48). Whereas the untreated check recorded highest fruit damage of 33.36 per cent.

Twenty days after spraying spinosad 45 SC recorded lowest fruit damage of 9.73 per cent which is statistically on par with profenophos 50 EC (10.20), DDVP 76 EC (13.08). The highest fruit damage was recorded in untreated check (38.91) per cent.

The mean per cent fruit damage in different treatments ranged from 13.70 to 34.65 per cent. spinosad 45 SC proved to be very effective in recording lowest fruit damage of 13.70 per cent. This was followed by profenophos 50 EC (14.23), DDVP 76 EC (16.78), rynaxypyr 20 SC (18.77) and indoxacarb 14.5 SC (18.78) whereas, the remaining treatments were less effective. However, highest fruit damage was noticed in untreated check (34.65%). Highest reduction in fruit damage over untreated check was recorded by spinosad 45 SC (60.46%), followed by profenophos 50 EC (58.93), DDVP 76 EC (51.57). Emamectin benzoate 5 SG prove to be less effective as it registered lowest reduction in fruit damage (29.40%). However by navoluron 10 EC (33.53 %) and NSKE 5 % (34.57%).

Larval population

The larval population one day before spraying was uniform in all the treatments which ranged from 7.53 to 10.17 as indicated by non-significant differences between the treatments (Table-30). Three days after spraying spinosad 45 SC recorded lowest larval population of 5.08/twing being statistically on par with profenophos 50 EC (7.02), flubendiamide 480 SC (7.08), DDVP 76 EC (7.10), indoxacarb 14.5 SC (7.18), rynaxypyr 20 SC, (7.41), *Bacillus thuringiensis* (7.73), Malathion 50 EC (7.89) and navoluron 10 EC (8.04). Maximum larval population of 10.29 / twig was recoded in untreated check.

Seven days after spraying, all the chemical treatments were found to be effective in recoding the larval population revealed by non-significant differences which ranged from 4.77 to 8.70. Untreated check recorded highest larval population of 10.73/twig.

Twenty days after spraying, spinosad 45 SC recorded lowest number of larvae (3.65/twig) being statistically on par with profenophos 50 EC (3.75), DDVP 76 EC (4.13), indoxacarb 14.5 SC (4.90), rynaxypyr 20 SC (5.07), and flubendiamide 480 SC (5.56). Highest larval population was registered in untreated check (11.77/twig). The overall mean larval population/twig was lowest in spinosad 45 SC (4.50) followed by profenophos 50 EC (5.75), DDVP 76 EC (5.90), indoxacarb 14.5 SC (6.31), rynaxypyr 20 SC (6.48) and flubendiamide 480 SC (6.49).

The per cent reduction in larval population was maximum in spinosad 45 SC (60.00) over in untreated check; this was followed by profenophos 50 EC (48.88) and DDVP 76 EC (47.55). Emamectin benzoate 5 SG however proved to be less effective as it recorded lowest reduction in larval population (42.90).

Table-29: Efficacy of different insecticides on fruit damage due to sapota fruit borer, *Phycita erythrolophia* on kalipatti variety during 2013-14

Treatments	Dosage/l	Per cent fruit damage				Mean per cent fruit damage	Per cent reduction in fruit damage over UTC
		1 DBS*	3 DAS**	7 DAS	20 DAS		
Spinosad 45 SC	0.3 ml	22.67	17.08 (24.34)^{ab}	14.30 (22.19)^{a}	9.73 (18.13)^{a}	13.70	60.46
Flubendiamide 480 SC	0.1 ml	23.71	22.33 (28.12)$^{a-d}$	20.48 (26.89)^{ab}	17.28 (24.42)$^{b-e}$	20.03	39.39
Emamectin benzoate 5 SG	0.2 g	25.41	26.19 (30.77)^{de}	24.41 (29.59)^{b}	22.74 (28.46)^{e}	24.45	29.40
DDVP 76 EC	0.5 ml	24.51	19.12 (25.65)$^{a-d}$	18.15 (25.16)^{ab}	13.08 (21.16)^{ab}	16.78	51.57
Profenophos 50 EC	2.0 ml	23.00	18.00 (25.09)^{ab}	14.50 (22.37)^{a}	10.20 (18.53)^{a}	14.23	58.93
Navoluron 10 EC	1.0 ml	27.67	25.15 (30.03)$^{c-e}$	22.67 (28.41)^{d}	21.28 (27.46)^{be}	23.03	33.53
Bacillus thuringiensis	0.002g/l	21.60	23.67 (29.00)$^{b-d}$	22.58 (28.36)^{b}	18.67 (25.38)$^{b-e}$	21.64	37.54
Rynaxypyr 20 SC	0.2ml	22.85	21.08 (27.31)$^{a-d}$	19.11 (25.91)^{ab}	15.15 (22.86)^{bc}	18.77	45.82
Indoxacarb 14.5 SC	0.5ml	23.19	22.20 (28.06)$^{a-d}$	19.00 (25.60)^{ab}	16.12 (23.62)$^{b-d}$	18.78	45.80
NSKE	5%	24.71	24.17 (29.38)$^{b-d}$	23.49 (28.94)^{b}	20.18c (26.65)$^{c-e}$	22.61	34.57
Malathion 50 EC (Standard check)	2.0 ml	24.15	22.67 (28.32)$^{a-d}$	21.72 (27.75)^{b}	19.10 (25.89)$^{c-e}$	21.16	38.93
Untreated check (UTC)	-	34.67	31.67 (34.02)^{e}	33.36 (34.98)^{c}	38.91 (38.52)^{f}	34.65	-
S.Em.±	-	5.22	1.54	1.76	1.47	1.18	-
CD 5%	-	NS	4.52	5.17	4.31	3.48	-
CV %	-		9.40	11.24	10.15	9.58	-

*DBS: Day before spray, **DAS: Days after spray.

*Figures in parentheses are arc sin transformed values

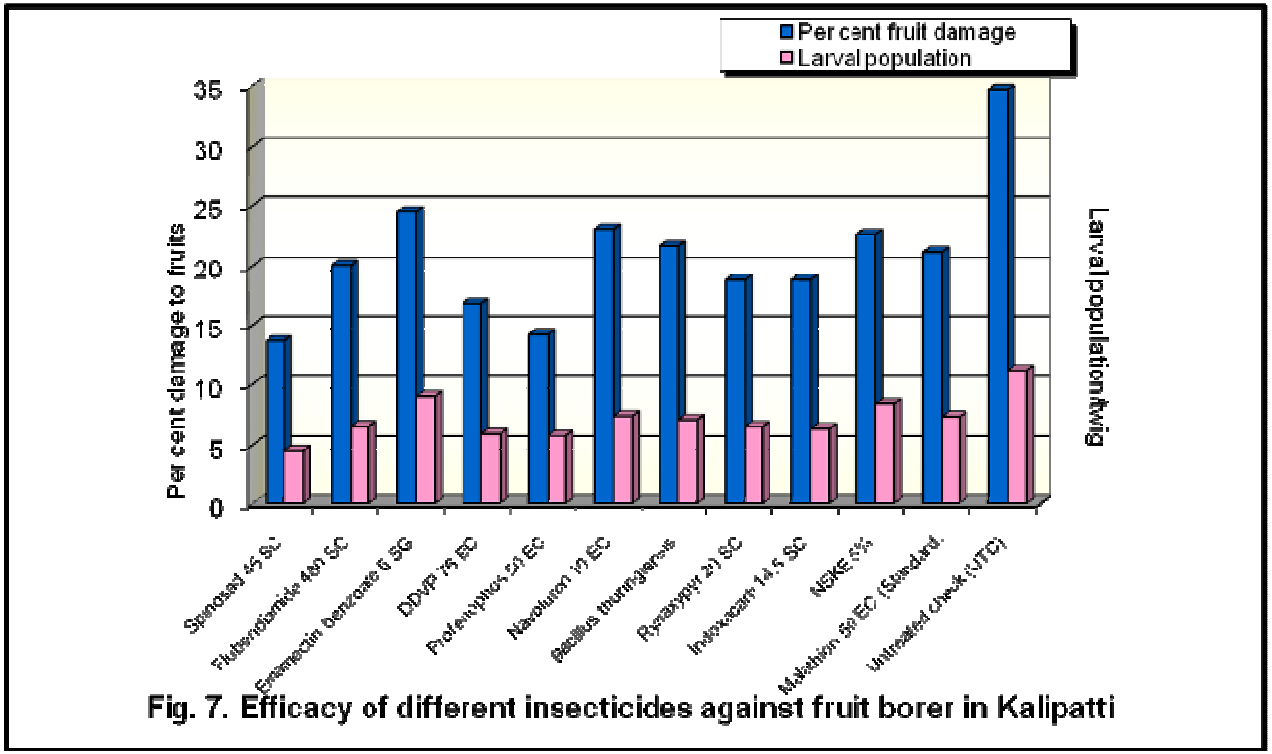

Fig. 7. Efficacy of different insecticides against fruit borer in Kalipatti

Fig. 7. Efficacy of different insecticides against fruit borer in Kalipatti variety during 2013-14

Table-30: Efficacy of different insecticides against larval population of sapota fruit borer, *Phycita erythrolophia* on kalipatti variety during 2013-14

Treatments	Dosage/l	Mean larval population/ twig				Overall mean larval population /twig	Per cent reduction in larval population over UTC
		1 DBS*	3DAS**	7DAS	20DAS		
Spinosad 45 SC	0.3 ml	7.79	5.08 (13.01)^{a}	4.77 (12.58)^{a}	3.65 (10.87)^{a}	4.50	60.00
Flubendiamide 480 SC	0.1 ml	7.53	7.08 (15.45)^{ab}	6.83 (15.13)^{ab}	5.56 (13.52)^{abc}	6.49	42.31
Emamectin benzoate 5 SG	0.2 g	9.18	9.52 (17.17)^{b}	8.70 (14.87)^{ab}	8.76 (17.16)^{de}	8.99	20.08
DDVP 76 EC	0.5 ml	8.67	7.10 (15.50)^{ab}	6.48 (15.86)^{ab}	4.13 (11.45)^{a}	5.90	47.55
Profenophos 50 EC	2.0 ml	8.41	7.02 (15.32)^{ab}	6.45 (13.65)^{ab}	3.77 (11.17)^{a}	5.75	48.88
Navoluron 10 EC	1.0 ml	8.12	8.04 (16.44)^{ab}	7.08 (15.33)^{ab}	6.99 (15.24)^{cd}	7.35	34.66
Bacillus thuringiensis	0.002g/l	7.74	7.73 (16.15)^{ab}	6.98 (15.21)^{ab}	6.41 (14.65)^{bcd}	7.04	37.42
Rynaxypyr 20 SC	0.2ml	9.08	7.41 (15.82)^{ab}	6.97 (15.29)^{ab}	5.07 (12.29)^{ab}	6.48	42.40
Indoxacarb 14.5 SC	0.5ml	9.74	7.18 (15.45)^{ab}	6.84 (15.18)^{ab}	4.90 (12.77)^{abc}	6.31	43.91
NSKE	5%	9.67	9.19 (17.54)^{b}	8.32 (16.77)^{ab}	7.56 (15.89)^{d}	8.36	25.68
Malathion 50 EC (Standard check)	2.0 ml	9.67	7.98 (16.22)^{ab}	7.01 (15.37)^{b}	6.81 (15.11)^{cd}	7.29	35.20
Untreated check (UTC)	-	10.17	10.29 (22.01)^{c}	10.73 (18.75)^{b}	11.77 (19.61)^{d}	11.25	-
S.Em.±		1.80	1.26	1.51	0.91	0.53	-
CD 5%	-	NS	3.70	6.00	2.66	1.57	-
CV %	-		13.22	17.41	11.06	13.29	-

*DAS: Day after spray, **DAS: Days after spray.*Values in the parentheses are √x+0.5 transformed values.

Table-31: Efficacy of different insecticides on fruit damage due to sapota fruit borer, *Phycita erythrolophia* on DHS-2 hybrid during 2013-14

Treatments	Dosage/l	Per cent of fruit damage/twig				Mean per cent fruit damage	Per cent reduction on fruit damage
		1 DBS*	3 DAS**	7 DAS	20 DAS		
Spinosad 45 SC	0.3 ml	23.22	20.75 (26.95)^{a}	15.35 (23.13)^{a}	7.50 (15.88)^{b}	14.53	62.25
Flubendiamide 480 SC	0.1 ml	25.32	20.32 (26.77)^{a}	17.53 (24.60)^{ab}	14.11 (22.09)$^{b-d}$	17.32	55.01
Emamectin benzoate 5 SG	0.2 g	24.18	23.14 (28.71)^{a}	22.67 (28.35)^{b}	20.12 (26.63)^{d}	21.98	42.90
DDVP 76 EC	0.5 ml	24.29	19.33 (25.93)^{a}	17.16 (24.38)^{ab}	11.08 (19.35)$^{a-c}$	15.86	58.80
Profenophos 50 EC	2.0 ml	23.12	18.19 (25.21)^{a}	16.24 (23.61)^{ab}	9.28 (17.46)^{ab}	14.57	62.15
Navoluron 10 EC	1.0 ml	19.29	21.67 (27.60)^{a}	19.10 (25.83)^{ab}	18.78 (25.62)^{d}	19.85	48.44
Bacillus thuringiensis	0.002g/l	21.40	22.25 (28.07)^{a}	20.67 (26.99)^{ab}	19.67 (26.32)^{d}	20.86	45.81
Rynaxypyr 20 SC	0.2ml	19. 26	20.54 (26.91)^{a}	18.10 (25.14)^{ab}	15.20 (22.96)$^{c-d}$	17.95	53.37
Indoxacarb 14.5 SC	0.5ml	24.21	21.08 (27.05)^{a}	18.14 (25.18)^{ab}	14.83 (22.47)$^{b-d}$	18.02	53.19
NSKE	5%	27.29	23.23 (28.77)^{a}	19.19 (25.84)^{ab}	19.05 (25.48)^{d}	20.49	46.77
Malathion 50 EC (Standard check)	2.0 ml	20.24	19.85 (26.32)^{a}	18.48 (25.33)^{ab}	15.21 (22.94)^{cd}	17.39	54.83
Untreated check (UTC)	-	35.33	36.08 (36.91)^{b}	38.06 (38.05)^{c}	41.36 (39.99)^{e}	38.50	-
S.Em.±		3.99	1.23	1.70	1.86	0.95	-
CD 5%	-	NS	3.62	4.99	5.46	2.79	-
CV %	-		7.70	12.31	13.23	7.41	-

*DBS: Day before spray, **DAS: Days after spray *Figures in parentheses are arc sin transformed values.

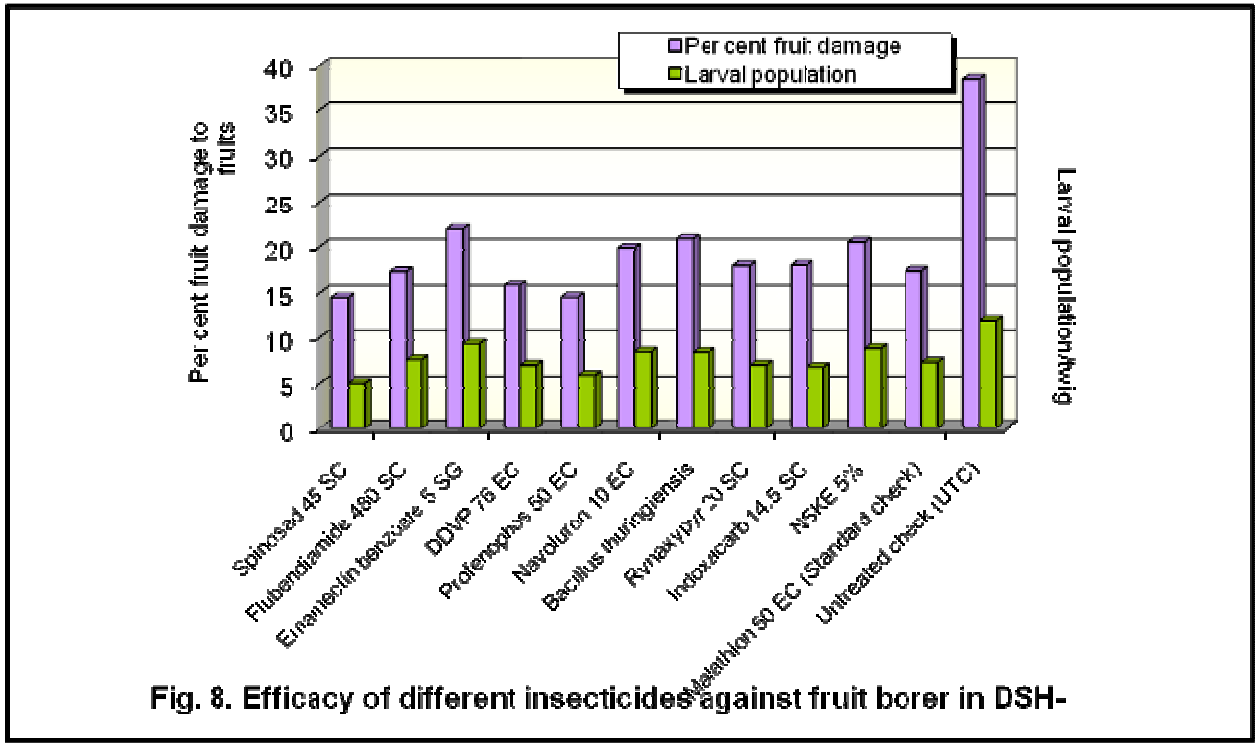

Fig. 8. Efficacy of different insecticides against fruit borer in DSH-

Fig. 8. Efficacy of different insecticides against fruit borer in DSH-2 hybrid during 2013-14

4.3.2 Field efficacy of insecticides against sapota fruit borer,*Phycita erythrolophia* in DSH-2 hybrid

Investigation was carried out to find out the efficacy of different insecticides against in sapota fruit borer on DSH-2 variety (Fig-8) at Saidapur farm KVK, Dharwad during 2013-14(Table-31).

Fruit borer damage, *Phycita erythrolophia* Hampson

The per cent damage to fruits a day before imposition of treatments was uniform in all the treatments as indicated by non-significant differences (Table-31). Three days after spraying profenophos 50 EC 480 SC recorded lowest fruit damage of 18.19 per cent being on par with DDVP 76 EC (19.33), Malathion 50 EC (19.85), flubendiamide 480 SC (20.32), rynaxypyr 20 SC (20.54) spinosad 45 SC (20.75), indoxacarb 14.5 SC (21.08), navoluron 10 EC (21.67), *Bacillus thuringiensis* (22.25), emamectin benzoate 5 SG (23.14) and NSKE 5% (23.23) and However, untreated check recorded significantly highest fruit damage of 36.08 per cent being statically on par with and

Seven days after spraying, significantly minimum per cent fruit damage was recorded in spinosad 45 SC (15.35) being on par with profenophos 50 EC (16.24), DDVP 76 EC (17.16), flubendiamide 480 SC (17.53) and rynaxypyr 20 SC (18.10). Whereas the untreated check recorded highest fruit damage of 38.06 per cent.

Twenty days after spraying spinosad 45 SC recorded lowest fruit damage of 7.50 per cent which is statistically on par with profenophos 50 EC (9.28) and DDVP 76 EC (11.08). The highest fruit damage was recorded in untreated check (39.99) per cent.

The mean per cent fruit damage in different treatments ranged from 15.86 to 38.50 per cent. spinosad 45 SC proved to be very effective in recording lowest fruit damage of 147.53 per cent. This was followed by profenophos 50 EC (14.57), DDVP 76 EC (15.86), flubendiamide 480 SC (17.32) and rynaxypyr 20 SC (17.95). Whereas the remaining treatments were less effective. However, highest fruit damage was noticed in untreated check (38.50%). Highest reduction in fruit damage over untreated check was recorded by spinosad 45 SC (62.25%), followed by profenophos 50 EC (62.15) and DDVP 76 EC (58.80). Emamectin benzoate 5 SG prove to be less effective as it registered lowest reduction in fruit damage (42.90%). However, by *Bacillus thuringiensis* (45.81%) and NSKE 5 % (46.77%).

Larval population

The larval population one day before spraying was uniform in all the treatments which ranged from 7.31 to 11.08 as indicated by non-significant differences between the treatments (Table-32). Three days after spraying spinosad 45 SC recorded lowest larval population of 7.31/twing being statistically on par with profenophos 50 EC (7.67), flubendiamide 480 SC (7.08), indoxacarb 14.5 SC (8.19), navoluron 10 EC (9.61) and Maximum larval population of 11.08 / twig was recoded in untreated check.

Seven days after spraying, spinosad 45 SC recorded lowest larval population of 5.41/twing being statistically on par with profenophos 50 EC (6.33) and Maximum larval population of 11.52/twig was recoded in untreated check.

Twenty days after spraying, spinosad 45 SC recorded lowest number of larvae (2.33/twig) being statistically on par with profenophos 50 EC (3.72), navoluron 10 EC (7.28), *Bacillus thuringiensis* (7.76), indoxacarb 14.5 SC (4.67) and NSKE 5 % (7.89)

The overall mean larval population/twig was lowest in spinosad 45 SC (5.02) followed by profenophos 50 EC (5.91),DDVP 76 EC (6.99), indoxacarb 14.5 SC (.76) and rynaxypyr 20 SC (7.00)

The per cent reduction in larval population was maximum in spinosad 45 SC (57.52) over in untreated check, this was followed by profenophos 50 EC (50.00) and indoxacarb 14.5 SC (42.80). Emamectin benzoate 5 SG however proved to be less effective as it recorded lowest reduction in larval population (20.81).

Yield (kg/ha) in Kalipatti variety

Spinosad 45 SC proved to be highly effective in recording highest fruit yield of 5327 kg/ha. This was followed by profenophos 50 EC (5298 kg/ha), DDVP 76 EC (5093 kg/ha) and flubendiamide 480 SC (4991 kg/ha). The lowest fruit yield was recorded in untreated check (4331 kg/ha).The perusal of the data clearly indicates that highest net returns was registered in profenophos

50 EC (₹ 1, 53,842/ha), this followed by spinosad 45 SC (₹ 1, 52,162/ha) and flubendiamide 480 SC (₹ 1, 42,002/ha). profenophos 50 EC registered highest B: C ratio of 3.65 for every one rupee spent (Fig-9) followed by spinosad 45 SC (3.50) and flubendiamide 480 SC (3.46) (Table-33)

Yield (kg/ha) in DSH-2 hybrid

spinosad 45 SC proved to be highly effective in recording highest fruit yield of 6238 kg/ha. This was followed by profenophos 50 EC (51178 kg/ha), indoxacarb 14.5 SC (5102 kg/ha), DDVP 76 EC (4862) and rynaxypyr 20 SC (4849). The lowest fruit yield was recorded in untreated check (4562 kg/ha).The perusal of the data clearly indicates that highest net returns was registered in spinosad 45 SC (₹ 1, 88,602/ha), this followed by profenophos 50 EC (₹ 1, 46,602/ha) and indoxacarb 14.5 SC (₹ 1, 46,536/ha). spinosad 45 SC registered highest B: C ratio of 4.10 for every one rupee spent (Fig-9) followed by indoxacarb 14.5 SC (3.55), profenophos 50 EC(3.92), (3.52) and rynaxypyr 20 SC (3.40) (Table-34)

Table-32: Efficacy of different insecticides against larval population of sapota fruit borer, *Phycita erythrolophia* on DHS-2 hybrid during 2013-14

Treatments	Dosage/l	Mean larval population/twig					Per cent reduction in larval population over UTC
		1 DBS*	3DAS**	7DAS	20DAS	Overall mean larval population /twig	
Spinosad 45 SC	0.3 ml	9.08	7.31 (8.66)^{a}	5.41 (13.46)^{a}	2.33 (12.10)^{a}	5.02	57.52
Flubendiamide 480 SC	0.1 ml	9.05	8.30 (9.90)^{cde}	7.94 (16.34)^{abcd}	6.50 (17.37)^{cd}	7.58	35.87
Emamectin benzoate 5 SG	0.2 g	10.33	10.05 (10.10)^{cde}	9.97 (18.38)^{de}	8.06 (17.40)^{cd}	9.36	20.81
DDVP 76 EC	0.5 ml	8.08	8.17 (10.36)^{de}	7.86 (16.26)^{abcd}	4.95 (18.09)^{cd}	6.99	40.86
Profenophos 50 EC	2.0 ml	9.14	7.67 (8.45)^{ab}	6.33 (14.55)^{ab}	3.72 (11.52)^{ab}	5.91	50
Navoluron 10 EC	1.0 ml	10.20	9.61 (9.20)^{abc}	8.66 (17.11)^{cd}	7.28 (14.29)^{abc}	8.52	27.91
Bacillus thuringiensis	0.002g/l	9.67	9.52 (10.24)^{de}	8.00 (16.42)^{bcd}	7.76 (16.26)^{abc}	8.43	28.68
Rynaxypyr 20 SC	0.2ml	9.19	8.41 (9.57)^{bcde}	7.52 (15.98)^{bc}	5.08 (16.86)^{bc}	7.00	40.77
Indoxacarb 14.5 SC	0.5ml	9.27	8.19 (9.37)^{abcd}	7.41 (15.85)^{bc}	4.67 (16.26)^{abc}	6.76	42.80
NSKE	5%	10.18	9.99 (1.00)^{cde}	8.67 (16.98)^{cd}	7.89 (15.23)^{abc}	8.85	25.12
Malathion 50 EC (Standard check)	2.0 ml	9.04	8.33 (9.65)^{bcde}	7.33 (16.06)^{cd}	6.28 (16.84)^{bc}	7.31	38.15
Untreated check	-	11.00	11.08 (10.44)^{e}	11.52 (19.55)^{e}	12.86 (21.85)^{d}	11.82	-
S.Em.±		1.82	034	1.01	1.70	0.86	-
CD 5%	-	NS	1.01	2.29	4.98	2.52	-
							-
CV %	-		6.17	10.63	18.17	19.43	-

*DAS: Day after spray, ** DAS: Days after spray. * Values in the parentheses are √x+0.5 transformed value

Table-33: Cost economics of sapota fruit borer, *Phycita erythrolophia* on kalipatti variety during 2013-14 on sapota

Sl. No.	Treatments	Dosage/l	Yield Kgs/ha	Cost of plant protection Rs/ha	Total cost of production Rs/ha	Gross returns Rs/ha	Net returns Rs/ha	B: C ratio
1	Spinosad 45 SC	0.3 ml	5327	4780.00	60918.23	213080	152162	3.50
2	Flubendiamide 480 SC	0.1 ml	4991	1500.00	57638.23	199640	142002	3.46
3	Emamectin benzoate 5 SG	0.2 g	4530	2420.00	58558.23	181200	122642	3.09
4	DDVP 76 EC	0.5 ml	5093	8250.00	64388.23	203720	139332	3.16
5	Profenophos 50 EC	2.0 ml	5298	1940.00	58078.23	211920	153842	3.65
6	Navoluron 10 EC	1.0 ml	4593	2020.00	58158.23	183720	125562	3.16
7	*Bacillus thuringiensis*	0.002g/l	4692	1000.00	57138.23	187680	130542	3.28
8	Rynaxypyr 20 SC	0.2ml	4837	840.00	56978.23	193480	136502	3.40
9	Indoxacarb 14.5 SC	0.5ml	4709	1406.00	57544.23	188360	130816	3.27
10	NSKE	5%	4627	800.00	56938.23	185080	128142	3.25
11	Malathion 50 EC (standard check)	2.0 ml	4738	2340.00	58478.23	189520	131042	3.24
12	Untreated check	-	4331	0.0000	56138.23	173240	117102	3.09

Table-34 Cost economics of of sapota fruit borer, *Phycita erythrolophia* on DHS-2 variety during 2013-14 on sapota

Sl. No	Treatments	Dosage/l	Yield Kg/ha	Cost of plant protectionRs/ha	Total cost of productionRs/ha	Gross returns Rs/ha	Net returns Rs/ha	B:C ratio
1	Spinosad 45 SC	0.3 ml	6238	4780.00	60918.23	249520	188602	4.10
2	Flubendiamide 480 SC	0.1 ml	4756	1500.00	57638.23	190240	132602	3.30
3	Emamectin benzoate 5 SG	0.2 g	4621	2420.00	58558.23	184840	126282	3.16
4	DDVP 76 EC	0.5 ml	4862	8250.00	64388.23	194480	130092	3.02
5	Profenophos 50 EC	2.0 ml	5117	1940.00	58078.23	204680	146602	3.52
6	Navoluron 10 EC	1.0 ml	4765	2020.00	58158.23	190600	132442	3.28
7	*Bacillus thuringiensis*	0.002g/l	4627	1000.00	57138.23	185080	127942	3.24
8	Rynaxypyr 20 SC	0.2ml	4849	840.00	56978.23	193960	136982	3.40
9	Indoxacarb 14.5 SC	0.5ml	5102	1406.00	57544.23	204080	146536	3.55
10	NSKE	5%	4756	800.00	56938.23	190240	133302	3.34
11	Malathion 50 EC (standard check)	2.0 ml	4845	2340.00	58478.23	193800	135322	3.31
12	Untreated check	-	4562	0.0000	56138.23	182480	126342	3.25

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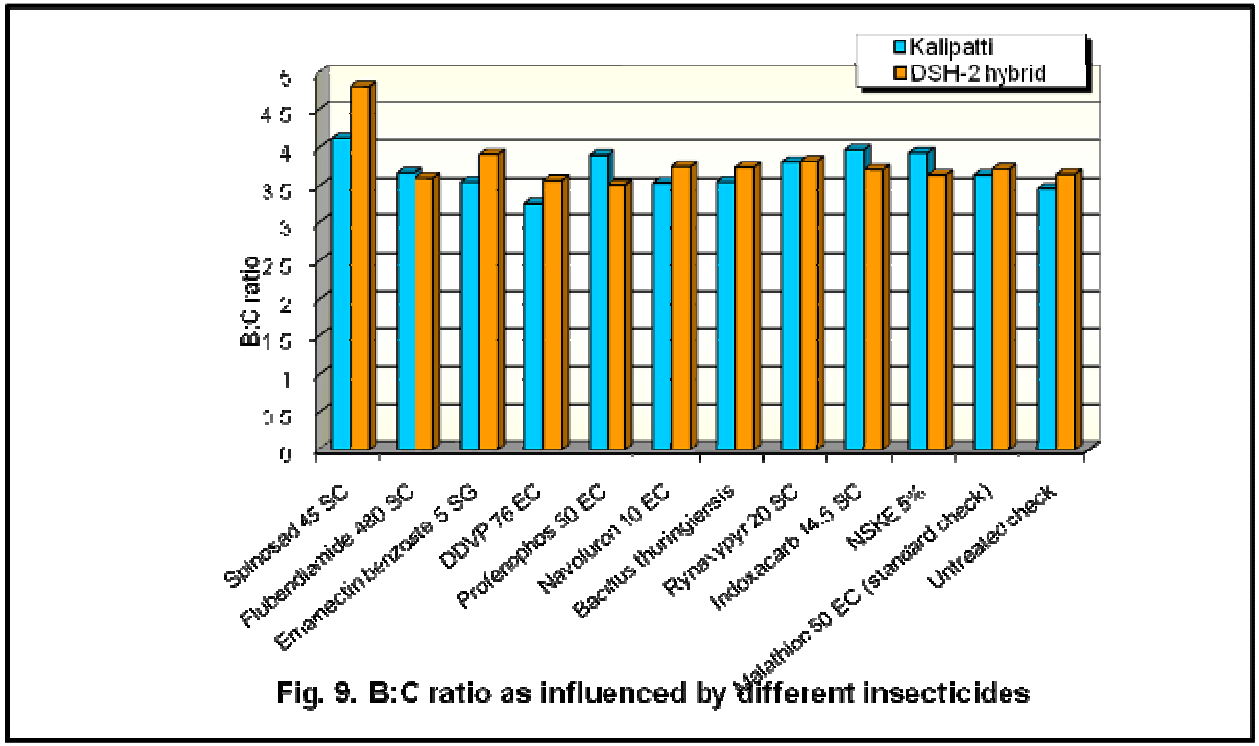

Fig. 9. B:C ratio as influenced by different insecticides

Fig. 9. B:C ratio as influenced by different insecticides

DISCUSSION

During the present investigation on the insect pests of sapota, an attempt has been made to study the major insect pests infesting sapota with special reference to sapota fruit borer *Phycita erythrolophia* Hampson, their seasonal incidence and management of fruit borer. The results are discussed in the following pages.

5.1 Survey of major insect pests of sapota and their natural enemies with special reference to sapota fruit borer, *Phycita erythrolophia*

The survey on the incidence of major pests and their natural enemies was conducted during 2013-14 in five different talukas namely viz., Dharwad, Hubli, Kalghatagi, Khanapur and Bagalkot.

The perusal of comperative data on the incidence of four major pests in five selected talukas clearly indicated that the mean incidence of sapota fruit borer, *P. erythrolophia* was much higher which ranged from 8.53 (Hubli taluk) to 10.54 (Khanapur taluk) per cent which ranked first from among the four major pests infesting sapota. Among the five talukas surveyed Khanapur taluk noticed highest percentage of damage (22.43 %) which may be larger due to sapota area occupied compared to remaining taluks and Belgaum district is one of the major sapota growing areas in karnataka. There is no literature pertaining on survey of sapota fruit borer, *P. erythrolophia* damage. Vishwanath *et al*., (1978) reported the occurrence of *Phycita sp*. as a new pest boring into unopened flower buds feeding on the corolla and gynoecium and the damaged flowers did not set fruits. Sandhu *et al.* (1981) observed an unidentified larva which was damaging the fruits of sapota by boring the fruits and feeding on the pulp of fruit. Further Patil (1986) also reported *P. erythrolophia* as a major pest of sapota damaging sapota flower buds.

Second most economically important pest recorded was bud borer, *Anarsia achrasella* whose mean incidence in five talukas ranged from 6.61(Bagalkot taluk) to 7.43(Khanapur taluk) per cent. The mean comperative data on the incidence of sapota bud borer, *A. achrasella* in five selected talukas reorded higher percentage of damage during the period of February and March. There is no literature pertaining to survey of sapota bud borer, *A. achrasella* damage Bradley (1981) reported that bud borer; *A. achrasella* is the most commonest on flower buds of sapota trees. Thumar *et al*. (2012) reported bud borer, *A. achrasella* is a regular occurring insect pest on sapota in middle Gujarat. Sathish *et al*., (2014) reported that chiku bud borer; *A. achrasella* is a major and regular pest causing damage to the sapota crop under hill zone of Karnataka.

The mean incidence of leaf webber, *Nephopteryx eugraphella* ranged from 2.66Khanapurtaluk) to 3.62 (Dharwad taluk) per cent in five selected talukas.The perusal of comperative data on the incidence of sapota leaf webber,*N. eugraphella* in five selected talukas was maximum in October. The present result is in conformity with the report of Anon. (1989 and 1997) who reported higher percentage of infestation of *N. eugraphella* on buds (17.55%) and leaves (12.21 %) during August to November in south Gujarat. Cherian and Ananthanarayanan (1942) who first noticed at Coimbatore attacking leaves and buds of Chikko and has since been recorded from other parts of India. Shah *et al.* (1982) reported that leaf webber, *N. eugraphella*as a common insect pest occurring in chiku orchard in South Gujarat. Durairaj *et al.* (1991) reported that *N. eugraphella* is an important pest on sapota which causes dense webbing of leaves and buds and bores into buds.

The lowest mean incidence was recorded by leaf miner, *Achrocercops gemoniella* which ranged from 2.43(Khanapur taluk) to 3.04 (Dharwad taluk) per cent in different taluks surveyed. The incidence of sapota leaf miner, *Achrocercops gemoniella* in five selected talukas was maximum during October. The present results are in conformity with the report of Anon. (1985) where the infestation of leaf miner, *A. gemoniella* was high in September in valsad district of Gujarat state. Anon. (1995) also reported the peak the activity of leaf miner during May and September. Shah (1982) reported that leaf miner, *A. gemoniella*as a common insect pest occurring in chiku orchard.

The perusal of comperative data on the incidence of all the four major pests in five selected talukas was higher during dry period i.e. from February and March (7.00 to 9.11%) whereas the incidence of these pests was lower (2.78 to 4.31 %) during August to October which coincides with rainy season.

5.2 Seasonal incidence of major insect pests on sapota with special reference to sapota fruit borer, *Phycita erythrolophia*

Bud borer, *Anarsia achrasella* Bradley

The seasonal activity of bud borer showed a varying degree of incidence throughout the year. The bud borer incidence was more during January to June and it was less during the remaining period. These results are in line with the findings of Bradley (1981) who reported bud borer, *A. achrasella* in sever form from November to February and May to June and least in July and August. Dongre (2011) also reported maximum bud damage by *A. achrasella* during second fortnight of March. Shukla (2011) reported the activity of *A. achrasella* during March to May and Bud borer (*A. achrasella*) is one of the important pests and was active throughout the year. The maximum incidence was recorded from February to April (Anon., 2009). Sathish, *et al.,* (2014 reported minimum incidence during first fortnight of October to maximum during second fortnight of March.

The correlation studies made between incidence of bud borer (*A. achrasella*) and weather parameters showed significant and positive correlation between bud borer damage and maximum temperature in all four genotypes. Whereas morning and evening relative humidity had significant negative correlation with bud borer incidence. In Cricket ball, Kallipatti and DSH-2 genotype there was negative correlation between minimum temperature and the bud borer incidence. There was negative correlation between rainfall and the bud borer incidence but it was significant in Cricket ball and DSH-2 genotype which is in agreement with the findings of Sushil kumar and Bhatt (2002) and Dongre (2011) who reported bud borer infestation had significant positive correlation with maximum temperature. Rest of the weather factors *viz*., minimum temperature, relative humidity and rain fall had negative relationship with pest population during the period of study. However Parvathi and Belavadi (1994) reported that was no influence of abiotic factors on the population of bud borer, which contradicts the present findings which may be due to variation in the genotypes and also the weather parameters.

The seasonal incidence of bud borer on fallen flower buds in various genotypes did not vary much. The mean larval population of bud borer was lowest in September to October and highest from January to March.

Among four different genotypes of sapota the incidence of bud borer did not vary much. However it was more in Cricket ball (2.81 per cent) followed by DSH-1 (2.76 %), DSH-2 (2.75 %) and Kalipatti (2.66 %).The mean percentage of bud damage across the genotypes in different months did not vary much which ranged from 2.27 to 3.17per cent. The mean larval population of bud borer in four different genotypes indicated that, the population was more in cricket ball variety (2.29 larvae/50 flower buds) population followed by DSH-1 (2.21), Kalipatti (1.83) and DSH-2 (1.67 to 1.83).

Across the genotypes the mean larval population of bud borer ranged from 0.60 to 3.90 /50 flower buds. The lowest larval population of 0.60 was noticed in October and followed by 1.20 in September and maximum of 3.90 larvae population were recorded during March followed by 2.60 larvae in January. Patil (1986) reported that larval population of bud borer on flower buds was maximum during September to December and again from April to June and the minimum population from July to August. These findings contradicts the present results which may be due to the variation in the genotypes used in the study.

Fruit borer, *Phycita erythrolophia* Hampson

Among four different genotypes of sapota, the incidence of fruit borer damage was more in cricket ball (10.24 %) followed by Kalipatti' (9.64 %) varities whereas on hybrids it ranged from 7.33 to 8.48 per cent. These results are in line with the findings of Patil (1986) who recorded lowest infestation in Kalipatti (29.4 %). The Cricket ball (35.2 %) and Calcutta round (35.4 %) recorded more infestation.

Across the genotypes, the mean percentage of fruit damage in different months ranged from 3.92 to 16.18. Highest incidence of 16.18 per cent was noticed in March whereas it was lowest in September. Further the data reveals that the pest incidence was more during dry period i.e. from November to April and less during rainy season (July to October).Patil (1986) reported that lowest incidence of bud borers (9 to 15 %) was observed from first fortnight of March to second fortnight of May and maximum incidence (37 %) during first fortnight of November. This finding contradicts to present studies, it may be due to variation in the incidence of the pest, genotype grown, climatic factors. In the present study more damage of fruit borer was noticed during dry season and in the

remaining season pest activity was less. Whereas the pest occurrence coinsides with peak crop harvesting periods (March to June).

The correlation studies made between the incidence of fruit borer (*P.erythrolophia*) and weather parameters showed that there was a significant and positive correlation between fruit borer damage and maximum temperature in all the four genotypes. Whereas it was significantly but negatively correlated with morning and evening relative humidity and rainfall. Patil (1986) reported that all four climatic factors (Maximum and minimum temperature, relative humidity and rainfall) showed no significant correlation with populations of bud borers.

The overall mean incidence of the pest throughout the year irrespective of the genotypes ranged from 0.14(June) to 0.60(September) per cent.

The seasonal incidence of sapota fruit borer on fallen fruits on different genotypes indicated that the mean percentage of fruit damage on four different genotypes remained more or less same which ranged from 2.05 to 2.81.The mean percentage of fruit borer damage in different months irrespective of the genotypes ranged from 1.20 (September) to 3.69 (April).

The mean larval population of *P.erythrolophia* on four different genotypes recorded throughout the year from June 2013 to May 2014 indicated that there was no much variation among the four genotypes which ranged from 1.40 to 1.89larvae/fifty flower buds.

The overall larval population of *Phycita erythrolophia* per fifty flower buds irrespective of the genotypes ranged from 0.95 (January) to 2.75 (August).Patil (1986) reported that larval population of fruit borer on flower buds was maximum during from September to December and was minimum during February and March and again during second fortnight of June to first fortnight of August, This finding contradicts the present studies.

The mean larval population of fruit borer, on fruits in four different genotypes indicated that there was no variation which ranged from 4.54 to 5.08/fifty fruits. The mean larval population in different months irrespective of the genotypes ranged from 1.50 (May) to 11.30 (March). The larval population was high from November to April (5.20 to 11.32) and it was low from May to October (1.50 to 4.10).

The mean percentage of fruit damage from harvested fruits of four genotypes indicated no much variation which ranged from 8.53 (DSH-2) to 9.20 (Kalipatti). Irrespective of the genotypes, the mean percentage of fruit borer damage in different months ranged from 5.30(September) to 14.43 (March). The data further indicated higher incidence (12.32 to 14.43) from February to April and lower (5.30 to 8.09) during August to January months.

Leaf webber, *Nephopteryx eugraphella* Ragonot

The percentage of damaged leaves on four different genotypes of sapota was high (2.17%) on Cricket ball and it was low on DSH-1 (1.35%).The overall mean percentage of damaged leaves irrespective of the genotypes varied from 0.00(May) to 3.79(October). In general the incidence of pest was high (2.27 to 3.79%) during August to November. Whereas it was low (0.00 to 1.58%) during December to July. This result are in line with the findings of Patel *et al.,*(1986) and Patange *et al*., (1997) who reported the peak infestation of chiku moth (*N. eugraphella*) from June to November in Maharashtra. Jhala *et al.,* (1996) reported that infestation of *N. eugraphella* on sapota buds was high 9.36% during June and October. Similarly Anon. (1998) reported that chiku moth was found with peak incidence during the later months of the monsoon, i.e. September-November. Dongre (2011) reported *N. eugraphella* damage on leaves; which recorded 10.15 per cent during October first fortnight

The correlation studies made between the incidence of leaf webber and weather parameters showed that there was a positive correlation between leaf webber damage and maximum temperature in DSH-2 hybrid. Similarly minimum temperature had positive correlation with leaf webber incidence in Cricket ball and DSH-2 hybrid. The morning relative humidity had positive and significant correlation with leaf webber incidence in Cricket ball, Kalipatti, DSH-1 and DSH-2. The evening relative humidity showed positive and significant correlation with leaf webber incidence. There was positive correlation between rainfall and leaf webber incidence in all the genotypes except DSH-2 hybrid grown in new orchard, College of Agriculture, Dharwad. These results are in line with the findings of Patel (1996) who reported that infestation of *N. eugraphella* on buds in middle Gujarat had significant positive correlation with rain fall, morning and evening relative humidity and significant positive correlation with maximum temperature.

Leaf miner, *Achrocercops gemoniella* Stainton

The mean percentage of damaged leaves recorded from June 2013 to May 2014 indicated higher incidence (1.60%) in Cricket ball and it was lowest (1.13%) in DSH-1. Whereas the pest incidence on other two genotypes varied from 1.39 to 1.53

The overall mean percentage of leaf miner damage irrespective of genotypes indicated higher incidence of the pest from September to November which ranged from 2.78 to 3.02 whereas in the remaining period i.e. from December to August it was low (0.30 to 1.62) except that there was no incidence during April and May. These results are in line with the findings of Patel and Jhala (1991) who reported peak incidence of pest during June- July and September-October. Anon. (1995) also reported the activity of leaf miner that it was at its peak in the month of May and September

The correlation studies made between the incidence of leaf miner and weather parameters showed that there was a significant and negative correlation between leaf miner damage and maximum temperature. Negative but non-significant correlation existed between minimum temperature and leaf miner incidence in all the genotypes. Morning relative humidity had positive and significant correlation with pest incidence in all the genotypes. Whereas this correlation was significantly positive between evening relative humidity and pest incidence in Kalipatti, DSH-1 and DSH-2(KVK, saidapur farm) while in remaining two genotypes it was non-significant. In all the genotypes rainfall had positive correlation with the pest incidence. This observation is line with the findings of Patel (1990) who reported that from South Gujarat the incidence of leaf miner *A. gemoniella* had significant negative correlation with maximum temperature and positive correlation with minimum temperature and rainfall. Whereas Dongre (2011) reported that, leaf miner had significant positive correlation with minimum temperature, relative humidity and rainfall.

5.3 Management of sapota fruit borer, *Phycita erythrolophia* Hampson

Kalipatti

Per cent fruit damage

The per cent fruit damage one day before spraying in different treatments was uniform to impose the different treatments as indicated by non-significant differences.

In the present study spinosad45 SC proved to be very effective in recording significantly lowest mean fruit damage (13.70%) being on par with profenophos50 EC (14.23%), DDVP 76 EC (16.78%). However malathion50 EC (Standard check) proved to be less effective in managing the pest. Untreated control recorded significantly highest mean percentage of fruit damage (34.65) on Kalipatti variety. Emamectin benzoate 5 SG (24.45%), navoluron10 EC (23.03%), *Bacillus thuringiensis* (21.04%) and NSKE 5 % (22.61%) were significantly inferior to spinosad45 SC in managing the pest. Highest reduction in fruit yield damage (60.46%) was recorded in spinosad45 SC followed by profenophos50 EC (58.93%) and DDVP 76 EC (51.57%)

Larval population

Spinosad 45 SC once again proved to be highly effective in recording significantly lowest mean larval population of 4.50 larvae /twig with a highest per cent reduction in larval population (60.0 %). This was statistically on par with profenophos50 EC (5.75%), DDVP 76 EC (5.95%) and rynaxypyr20 SC (6.48%). Malathion50 EC (Standard check) proved to be less effective in managing the pest which reduced the larval population to the extent of 35.20 over uncontrol check. Emamectin benzoate 5 SG (8.99%) and NSKE 5 %(8.36%) proved to be less effective in managing the pest and were significantly inferior to spinosad45 SC.

Cost Economics

Kalpatti variety

Spinosad 45 SC (5327 kg/ha) proved to be highly effective in recording significantly highest sapota fruit yield being on par with profenophos 50 EC (5298kg/ha), Flubendiamide 480 SC (4991kg/ha). Emamectin benzoate 5 SG (4530kg/ha), navoluron 10 EC (4593kg/ha), *Bacillus thuringiensis* (4692kg/ha) and NSKE 5% (4627kg/ha) were less effective compared to above mentioned insecticides. Malathion 50 EC (Standard check) was found to be less effective in recording higher yield.

Highest net return was recorded in profenophos 50 EC followed by Spinosad 45 SC and Flubendiamide 480 SC. Highest B: C ratio (3.65) was recorded in profenophos 50 EC followed by Spinosad 45 SC (3.50), Flubendiamide 480 SC (3.46) and Rynaxypyr 20 SC (3.40). However Emamectin benzoate 5 SG recorded lowest B: C ratio (3.09) in Kalipatti variety.

DSH-2 hybrid

The efficacy of insecticides on DSH-2 hybrid revealed more or less similar results as that of Kalipatti variety. Spinosad 45 SC proved to be highly effective by recording lowest mean per cent fruit damage of 14.53being on par with profenophos50 EC (14.57%), DDVP 76 EC (15.86%) and flubendiamide480 SC (17.32%). Malathion (standard check) (17.39%) was less effective compared to above treatments. *Bacillus thuringiensis* (20.86%) and NSKE 5 % (20.49%) recorded higher mean percentage of fruit damage of more than 20 being inferior in managing pest.

The highest percent reduction in fruit damage (62.25%) was recorded in spinosad45 SC followed by profenophos50 EC (62.15%), DDVP 76 EC (58.80%) and flubendiamide 480 SC (55.01%). *Bacillus thuringiensis* (45.81%) and NSKE 5 % (46.77%) recorded lower percentage of reduction in fruit damage compared to malathion 50 EC (Standard Check).With regard to efficacy of different insecticides on larval population, Spinosad 45 SC (5.02%) was highly effective in recording lowest mean larval population being on par with profenophos50 EC (5.91%), DDVP 76 EC (6.99 %) and indoxacarb14.5 SC (6.76%) and rynaxypyr20 SC (7.00). The highest percentage reduction in larval population was recorded in spinosad45 SC (57.52%) followed by profenophos50 EC (50.00%)

Cost Economics

On DSH-2 hybrid, spinosad45 SC (6238 kg/ha) recorded significantly highest yield being on par with profenophos50EC (5117 kg/ha) and indoxacarb14.5 SC (5102 kg/ha).Malathion (standard check) was significantly inferior to spinosad45 SC.

Highest net returns was recorded in spinosad 45 SC with maximum B:C ratio of 4.10. The literature on the cost economics of these treatments is not available to compare and discuss the present results. Thus spinosad 45 SC proved to be best candidate in recording lowest fruit damage, minimum larval population, highest sapota fruit yield, highest net returns and highest B: C ratio against sapota fruit borer, *Phycita erythrolophia* on Kalipatti and on DSH-2 hybrid flubendiamide 480 SC proved to be best candidate in recording lowest fruit damage, minimum larval population, highest sapota fruit yield, highest net returns and highest B: C ratio against sapota fruit borer, *Phycita erythrolophia*.

The literatures on the efficacy of insecticides in the present study have not been evaluated by pervious workers. Thus it forms the first study on the evaluation of these new molecules against sapota fruit borer, However Patil (1986) reported the efficacy of conventional insecticides viz., monocrotophos and quinalphos against *Phycita erythrolophia.*

Future line of work:

1. Analysis of pesticides residues used for the management of sapota fruit borer

2. Evaluation of botanicals for the management of sapota fruit borer.

SUMMARY AND CONCLUSIONS

Investigations were carried on survey of major insect pests of sapota in selected taluks of north Karnataka. Seasonal incidence of insect pests of sapota with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson and its management were carried out at new orchard, Agriculture College, Dharwad and KVK, Saidapur farm, Dharwad, respectively.

The roving survey was carried out during peak flowering period *i.e.* from August to October and February to March in selected taluks of each district of Dharwad, Belgaum and Bagalkot.

During the course of study four major species of insect pests of sapota *viz.,* bud borer, *Anarsia achrasella* Bradley, fruit borer, *Phycita erythrolophia* Hampson, leafwebber, *Nephopteryx eugraphella* Ragonot and leaf miner, *Achrocercops gemoniella* Stainton and other pests *viz.,* mid rib folder, *Banisia myrsusalis elearalis* Walker, scales, *Coccus viridis* Green and unidentified species of mealybug. During the survey, natural enemies like coccinellid beetle, *Chelomenes sexmaculata* (Fabricius), chrysopid, *Chrysoperla* sp and an unidentified species of Reduvid bug were recorded. Among four major pests highest mean incidence of 9.17 per cent was recorded by fruit borer followed by bud borer (6.96 %) irrespective of talukas survyed. The minimum incidence was recorded by leaf miner (2.66 %) followed by leaf webber (3.15 %)

The overall mean percentage of damage by all the four major pests indicated that higher incidence (7.00 to 9.4 %) was recorded during February and March months. Whereas, the incidence was low (2.78 to 4.31 %) during August to October months.

The incidence of *P.erythrolophia* on fallen flower buds in five surveyed talukas indicated lower incidence which ranged from 0.58 to 1.86 per cent and the incidence of sapota fruit borer on harvested sapota fruits during period of survey varied from 4.76 to 6.52 per cent in different talukas. However, the fruit borer incidence across the talukas was more in fruits harvested during February and March, whereas the incidence was low on the harvested fruits during August to October months.

The seasonal incidence of bud borer, *Anarsia achrasella* on four different genotypes of sapota was studied throughout the year. The bud borer incidence was more during dry period *i.e.* (January to June) which ranged from (2.15 to 6.85 %).Whereas, the incidence was low during rainy season i.e. from July to October. The correlation between incidence of bud borer (*A. achrasella*) and weather parameters showed significant and positive correlation between bud borer damage and maximum temperature and negative correlation with minimum temperature, morning and evening relative humidity and rainfall in the four genotypes of sapota.

The mean percentage of bud borer damage on fallen flower buds across the genotypes in different months did not vary much which ranged from 2.27 to 3.17 per cent. The bud borer larval population /50 flower buds was lowest (0.60) in October and highest (3.90) during March.

The mean percentage of fruit borer, *P. erythrolophia* damage was highest (16.18 %) in March whereas, it was lowest in September (3.92%). There was a significant and positive correlation between fruit borer damage and maximum temperature and negative correlation with minimum temperature, morning and evening relative humidity and rainfall.

The overall mean incidence of the fruit borer damage on fallen flower buds was less (0.14 to 0.60%) throughout the year irrespective of the genotypes. The incidence of fruit borer damage on fallen fruits in different months irrespective of the genotypes ranged from 1.20 (September) to 3.69 (April).

The mean larval population per fifty flower buds across the four genotypes ranged from 0.95 (January) to 2.75 (August).Larval population of fruit borer on fifty fruits on all four genotypes was high from November to April (5.20 to 11.30) and it was low from May to October (1.50 to 4.10).

The mean percentage of fruit borer damage on harvested sapota fruits indicated higher incidence (12.32 to 14.43) from February to April and lower (5.30 to 8.09) during August to January months.

The overall mean percentage incidence of leaf miner, *N. eugraphella* across different genotypes was high (2.27 to 3.79%) during August to November. Whereas, it was low (0.00 to 1.58%) during December to July. The leaf webber incidence was significantly and negatively correlated with maximum temperature.

The overall mean percentage of leaf miner, *Achrocercops gemoniella* Stainton damage was high from September to November (2.78 to 3.02) whereas in the remaining period i.e. from December to August it was low (0.30 to 1.62). Relative humidity and rainfall had positive and correlation with pest incidence in all the four genotypes. Whereas, maximum and minimum temperature had negative correlation with pest incidence.

Spinosad45 SC proved to be very effective in recording lowest fruit damage of 13.70 per cent followed by Profenophos 50 EC (14.23%), DDVP 76 EC (16.78%) compare to the remaining treatments with 60.46%, 58.93% and 51.57% reduction in fruit damage, respectively on kalipatti variety..

The mean larval population/twig was lowest in spinosad45 SC (4.50) followed by profenophos 50 EC (5.75), DDVP 76 EC (5.90) compare to other treatments.

Spinosad 45 SC proved to be highly effective in recording highest fruit yield of 5327 kg/ha with highest B: C ratio of 3.50. Profenophos 50 EC (5298kg/ha) with B: C ratio of 3.65 and Flubendiamide 480 SC (4991kg/ha) with B: C ratio of (3.46).

On DSH-2 hybrid also spinosad 45 SC proved to be very effective in recording lowest fruit damage of 14.53 per cent followed by Profenophos 50 EC (14.57), DDVP 76 EC (15.86), Flubendiamide480 SC (17.32).The mean larval population/twig was lowest in Spinosad 45 SC (5.02) followed by Profenophos50 EC (5.91), Indoxacarb 14.5 SC (6.76), DDVP 76 EC (6.99), and Rynaxypyr20 SC (7.00). Spinosad 45 SC was highly effective in recording highest fruit yield of 6238 kg/ha with a maximum B: C ratio of 4.10. This was followed by profenophos50 EC (51178kg/ha) with B: C ratio of 3.52 and Indoxacarb 14.5 SC (5102 kg/ha) with B: C ratio of 3.55.

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APPENDIX I

The meteorological data recorded at Main Agricultural Research Station (MARS) Dharwad from June 2013 to May 2014

Sl. No.	Month	Fortnight	Maximum temperature (^{o}c)	Minimum temperature (^{o}c)	Morning relative humidity (%)	Evening relative humidity (%)	Rain fall (mm)
1	June-2013	I	28.53	20.73	92.27	70.93	38.00
2		II	27.54	20.71	93.21	72.93	37.40
3	July	I	26.09	20.39	94.73	78.20	48.40
4		II	24.68	20.35	94.64	88.33	120.60
5	August	I	26.30	20.04	94.00	78.47	75.20
6		II	26.93	19.56	92.00	75.27	23.20
7	September	I	28.68	20.35	94.13	71.00	111.00
8		II	26.93	20.12	94.50	76.00	22.60
9	October	I	28.47	19.73	92.93	65.73	10.20
10		II	28.93	19.17	89.33	57.00	47.60
11	November	I	28.88	15.51	81.73	49.93	0.00
12		II	29.02	16.03	78.36	47.29	2.20
13	December	I	28.72	13.42	70.87	34.87	0.00
14		II	28.17	12.09	72.20	33.80	0.00
15	January-2014	I	29.67	13.79	75.80	35.00	0.00
16		II	29.29	15.53	71.60	36.27	0.00
17	February	I	31.05	15.17	56.07	26.13	0.00
18		II	31.02	17.03	68.17	29.92	0.00
19	March	I	32.14	16.94	64.93	28.20	0.00
20		II	36.41	19.96	59.67	18.07	0.00
21	April	I	36.80	20.75	56.95	32.20	0.00
22		II	35.95	21.60	72.45	41.15	0.00
23	May	I	34.10	20.75	71.75	45.80	46.00
24		II	35.10	20.55	75.70	45.10	10.00

STUDIES ON MAJOR INSECT PESTS OF SAPOTA WITH SPECIAL REFERENCE TO SAPOTA FRUIT BORER, *Phycita erythrolophia* Hampson AND ITS MANAGEMENT

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ABSTRACT

The roving survey was carried out during peak flowering period *i.e* from August to October and February to March in selected taluks of each district of Dharwad, Belgaum and Bagalkot. During the course of study four major species of insect pests of sapota *viz.,* bud borer, *Anarsia achrasella* Bradley, fruit borer, *Phycita erythrolophia* Hampson, leaf webber, *Nephopteryx eugraphella* Ragonot and leaf miner, *Achrocercops gemoniella* Stainton and other pests *viz.,* mid rib folder, *Banisia myrsusalis elearalis* Walker , scales, *Coccus viridis* Green and unidentified species of mealybug were recorded. During the survey, natural enemies *viz.,* coccinellid beetle, *Chelomenes sexmaculata* (Fabricius), chrysopid, *Chrysoperla* sp. and an unidentified species of Reduvid bug were recorded. Among four major pests, highest mean incidence of 9.17 per cent was recorded by fruit borer followed by bud borer (6.96 %) irrespective of talukas surveyed. The minimum incidence was recorded by leaf miner (2.66 %) followed by leaf webber (3.15 %).The seasonal incidence of major pests of sapota *viz.,* bud borer on different genotypes (Kalipatti, Cricketball, DSH-1,DSH-2) was more during dry period *i.e.* (January to June) which ranged from (2.15 to 6.85%) and low during rainy season i.e. from July to October and fruit borer damage was highest (16.18 %) in March and lowest in September (3.92%).The incidence of leaf miner across different genotypes was high (2.27 to 3.79%) during August-November and low (0.00 to 1.58%) during December -July and leaf miner damage was high from September to November (2.78 to 3.02) and in the remaining period *i.e.* from December to August it was low (0.30 to 1.62).Spinosad45 SC0.3 ml/l proved to be very effective in recording lowest fruit damage of 13.70 per cent and highest fruit yield of 5327 kg/ha followed by Profenophos50 EC 2.0 ml/l (14.23%) (5298 kg/ha) compared to the remaining treatments. Spinosad 45 SC recorded highest B: C ratio of 3.50 followed byProfenophos50 EC 3.65 in Kalipatti variety. In DSH-2 hybrid, Spinosad 45 SC was highly effective in recording highest fruit yield of 6238kg/hawith a maximum B: C ratio of 4.10 followed by profenophos 50 EC (51178kg/ha) with B: C ratio of 3.52.