# BIOECOLOGY AND CONTROL OF BLACK HEADED HAIRY CATERPILLAR, *Spilosoma obliqua* Walker (LEPIDOPTERA : ARCTIIDAE) ON SUNFLOWER

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**AGRICULTURAL ENTOMOLOGY**

By

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## CERTIFICATE

This is to certify that the thesis entitled "**Bioecology and Control of Black headed hairy caterpillar, Spilosoma obliqua (Walker) on sunflower**" submitted by **Mr. S.M. Kadapatti** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in AGRICULTURAL ENTOMOLOGY of the University of Agricultural Sciences, Dharwad, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associateship fellowship or other similar titles.

Dharwad

December, 1993

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Affectionately Dedicated
To My Beloved Parents
Guide and Indu

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# CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF PLATES

# INTRODUCTION

# I INTRODUCTION

Oil seed crops play an important role in the national economy and rank second after food grains as a farm commodity group. The oils not only form the essential part of the human diet, but also serve as an important raw material for the agrobased industries to manufacture various products.

Sunflower (*Helianthus annuus* L.) is also one of the important oil seed crop grown in the country. It is extensively cultivated in recent years because of its desirable characters like short duration, adoptability to wide agroclimatic conditions, photoinsensitive nature and tolerance to drought. In the world it is cultivated on an area of 16.34 million hectares with productivity of 22.4 million tonnes of produce (Anon., 1991). In India it is cultivated in an area of 1.5 million hectares with a production of 1.18 million tonnes. Among the important sunflower growing states in the country, Karnataka is one which grows on area of 0.586 million hectares and produces 0.255 million tonnes (Anon., 1991).

However, the yield of sunflower in our country is very low when compared to that of developed countries. The

low yields of sunflower can be attributed to variety of factors. Among them, insect pests play an important role in bringing down the yields. Among a number of insect pests that destroy sunflower at various stages. Among them the black headed hairy caterpillar, *Spilosoma obliqua* (Walkar) is a threat to the sunflower production by way of its defoliation when cultivated during rabi/summer seasons.

*Spilosoma obliqua* (Walker), which is sporadic in nature and occurs in large numbers whenever the conditions are favourable. Being a polyphagous pest, feeds on cereals, pulses, oilseeds, vegetables, ornamental, medicinal, plantation and fibre crops, causing moderate to heavy damage in different countries including India (Gargav and Katiyar, 1971).

During 1917, an outbreak of this pest was noticed in the Ilawal village near Mysore, on finger millet (*Eleusine coracana* L.) castor (*Ricinus communis* L.) and field bean (*Lab lab purpureus* L.) where in people burnt about half a cartload of caterpillars (Puttarudraiah, 1975). Fletcher (1926) reported the severe outbreak of this pest at Pusa. During the past few years this insect was noticed to cause severe damage to sunflower, groundnut, (*Arachis hypogaea* L.)

and soyabean (*Glycine max* L. Merril). It has even caused complete defoliation of the sunflower around Raichur.

Considering the seriousness of the pest on sunflower grown in North Karnataka districts, the present study was undertaken to understand more about the pest in sunflower ecosystem and develop management strategies with the following objectives.

1. To study biology under field conditions.
2. To determine the food consumption on important rabi/summer crops.
3. To asses the crop loss due to defoliation behaviour.
4. To study the dispersal behaviour of larvae.
5. To evolve a schedule of management practices.

The results of these investigations are presented and discussed in the study.

# REVIEW OF LITERATURE

# II REVIEW OF LITERATURE

*Spilosoma obliqua* (Walker) belongs to the family, Arctiidae and order Lepidoptera. Walker described it for the first time in 1885 from Australia. Further in 1901, Hampson described it in detail. In 1907, Lefroy added some more identifying characters. Later, the same author in 1909 synonymised this species with *Spilosoma todara* (Moore), *Spilosoma bifascia* (Hampson) and *Spilosoma delbergiae* (Moore) and reported from Bihar and Poona.

*Spilosoma obliqua* (Walker) is commonly referred as black headed hairy caterpillar (BHHC) or Bihar hairy caterpillar (BHC). Locally it is known as "Kori Hula " and "Kambli Hula" in North and South Karnataka, respectively.

## 2.1 The field biology :

Enough information is available on biology of BHHC carried out under laboratory conditions. On the contrary, the literature regarding its biology studied under field conditions is very much lacking, especially on sunflower. Therefore, the information available on the other hosts is also reviewed and presented below.

Lefroy (1906) reported that the eggs are laid in clusters on the under surface of the leaves of sunflower. Subramanyam Iyer (1921) observed the larval period to lasting, for 24.3 days, pupal period 12 to 19 days and the total life cycle of 2 to 2 1/2 months on horsegram (*Dolichos biflorus* L.). The pupation took place in the dry leaves.

Djou (1938) studied in detail biology of BHHC on limabean (*Phaseolus lunatus* L. ) in China. According to him the fecundity ranged from 342 to 1356. Incubation period was 6 to 11 days and percentage of hatching varied from 82.96 to 91.00. The larval and pupal period occupied 29 to 38 and 15 to 18 days, respectively, during April and May.

According to Patel (1940) and Beeson (1941), the egg, larval and pupal periods of BHHC ranged from 4.00 to 6.00, 24 to 25 and 9.00 to 15.00 days, respectively in June-July months on jute (*Corchorus capsularis* L.). The field observations made by Usman (1954) reveals that the caterpillars are yellow with ends being black and pupate in the loose silken cocoon and leaffolds of jute.

Trehan and Bagal (1958) studied the biology of BHHC on sweet-potato (*Ipomoea batatas* Lamb) and reported that the

eggs were minute, circular, yellowish green in colour and measured 0.60 mm thick. Incubation period was 5.50 days and 9.00 days and larval period was 11.70 days and 11.40 days during October-November and December-January months, respectively. According to Kabir and Khan (1969) incubation period was 5.0 to 6.0 days and 13 to 14 days, pupal period was 9.0 to 10.0 and 20.0 to 22.0 days during winter and monsoon seasons on jute, respectively.

Singh and Gangrade (1974) reported the biology of *S. obliqua* on soyabean from Jabalpur (M.P). According to them, the moths laid spherical eggs in large groups on the lower side of the leaves. The incubation period was 6.0 to 9.0 days, larval period was 34.0 to 35.0 days with an average of 42.80 days. The duration of first to seventh instar was 7.21, 5.43, 5.02, 4.56, 6.30, 6.29 and 9.25 days, respectively. Each instar measured 1.25, 3.85, 5.38, 11.79, 14.40, 21.40 and 32.60 mm in length and 0.28, 0.56, 1.20, 1.32, 2.17, 2.35, and 5.18 mm in breadth, respectively. The prepupal period occupied 2 to 4 days with an average of 2.76 days and pupal period 16 to 22 days with an average of 19.23 days. The life cycle was completed in 59 to 76 days during October to February. The fecundity was 533 to 1287 eggs per female. The longevity varied from 4 to 8 days and 3.0 to 5.0 days in

female and male moths, respectively when fed on ten per cent honey.

The studies on the biology of *S. obliqua* on mulberry (*Morus alba* L.) at Mysore indicated that the fecundity was 1000 to 1200 eggs.Incubation period was 4 to 6 days. The larval instars from 1st to 7th, respectively, ranged from 3 to 4, 4 to 5, 3 to 4, 3 to 4, 4 to 5, 5 to 6 and 6 days; Each instar measured, 2.00, 3.00, 7.00 to 9.00, 10.00 to 12.00, 13.00 to 15.00, 24.00 to 28.00 and 35.00 to 40.00 mm, respectively. Pupation occured in silken cocoons in absence of the soil. In presence of the soil pupation occured in the top layer. The pupal period ranged from 12 to 15 days. The mating took place after 48 hours of emergence. (Narasimhan and kariappa 1974).

Basavaraja (1976) studied the biology of BHHC on castor at Dharwad over 4 generations. The incubation period was 6.40, 7.00, 7.30 and 8.50 days during May-July, July-September, September-November, 1974 and November, 1974 to January 1975 respectively, with 86.90 (68.50-100.00) per cent hatching under laboratory conditions. The larval period varied from 27 to 31, 28 to 33, 30 to 34 and 42 to 45 days with an average of 29.50, 30.60, 31.20 and 43.60 days, in the months of May and June, August and September,

September and October and December and January, respectively. The average pupal period was 10.60, 11.40. 13.20 and 15.50 days in the months of July, September, October, November and January, respectively. Total life cycle was 48.6 days during May-July.

According to Rangaswami *et al.* (1976), *S. obliqua* was responsible for highest damage to mulberry plants. The caterpillars were voracious feeders on leaf and devour the leaf very fast causing extensive damage and hardship during silkworm rearing. The fecundity was 1000-1200 eggs which were green metallic shiny and were laid in small batches on lower side of the leaves. The incubation period, larval period, pupal period and total life cycle occupied 5 to 7, 30, 12 to 14 and 48 days, respectively. Final instar larva measured 4.50 to 5.00 cm and lasted for 5 to 7 days.

Puttarudraiah (1977) reported that the BHHC acts as a severe defoliator of mulberry. Female laid 1000 eggs on the lower surface of the leaves. The eggs were round, yellowish green and hatch in 3 to 4 days. Larval development was completed in 45 days, grown up larva measured 2.00 to 2.50 inches, pupates in loose silken cacoon made out of hairs

derived from the body and also between the dried leaves. Pupal period occupied 10 to 15 days.

According to Ullal and Narasimhana (1981) total life cycle of BHHC occupied 48 days, while active feeding period occupied 30 days on mulberry.

Kotikal (1982) studied the biology of BHHC on three varieties of mulberry under laboratory conditons, for three seasons at Dharwad. According to him, the eggs were greenish yellow, later changed to black before hatching. The incubation period was 6.60 days in September-October, 6.80 days in November-December and 6.40 days in January-February. Percentage hatching ranged from 37.35 to 92.47. Total larval period ranged from 21.56 to 26.62 days. The prepupal period and pupal period ranged from 1.30 to 2.20 and 11.00 to 17.76 days, respectively. Total life cycle occupied 43.58 to 51.00 days. Pupation occured in cocoon made out of silken thread and body hairs. Female lived longer (4.70 to 5.80 days) than male (3.90 to 5.30 days). Average eggs laid by female ranged from 610.90 to 828.50 in November-December, 789.90 to 847.50 in September-October and 710.50 to 849.90 in January-February.

Studies on the biology of BHHC on winged bean (*Psophocarpus tetragonalobus* L.) under laboratory conditions by Chaudhary *et al.*, (1986) with respect to development and findings revealed that the mean larval developmental period, total life cycle and fecundity were 23.5 days, 42.2 days and 618.04, respectively.

2.2 Food Preference and Suitability :

Pandey *et al.* (1968) studied the effect of 12 host plants on the larval and post larval development of *S. obliqua.* Based on survival percentage, growth index, gain in weight of the larvae, pupal weight, percentage of adult emergence, size and fecundity of moths, til (*Sesamum indicum* Linn,) was considered to be the most prefered food plant. Average larval period was maximum (26.50 days) on sunhemp (*Crotalaria juncea* L.) and minimum (17.00 days) on castor (*Ricinus communis* L). Percentage of pupation was highest (95.00) on til and lowest (12.50) on sunhemp. Pupal period was 7.75 days (minimum) on cotton (*Gossypium* sp L.) and 10.00 days (maximum) on sunhemp. Thus the maximum growth index of 5.42 was recorded on til and minimum on sunhemp (0.47).

The beans (*Dolichos lab lab* L.) and radish (*Raphanus sativus* Sazonira) were prefered hosts out of twenty economic

plants tested against BHHC according to Chand (1977). Based on larval survival rate, duration and weight gain on sixth and twelth day after hatching, Yadav and Singh (1977) listed urd, (*Vigna mungo* L. Hepper) sweet-potato, soybean, sunflower, cowpea, (*Vigna sinensis* L.) mung, (*Vigna mungo* L. Hepper) clerodendron (*Clerodendron inerme* L.) and groundnut in the descending order of suitability.

Yadav *et al.* (1977) studied the survival and growth potential of *S. obliqua* larva on 15 promising varieties of blackgram (*Vigna mungo* L. Hepper) and reported that the variety G-104 is most suitable. The average larval period, pupal period, percentage pupation and growth index were 17 days, 9 days, 86.60 and 5.10, respectively. Papaya (*Carica papaya* L.), squash (*Cucurbita maxima* L.), cotton (*Gossypium* spp), clusterbean (*Cyamopsis tetragonaloba* L. Tanb.), mustard (*Brassica juncea* L.), maize (*Zea mays* L.), soybean and *Lufa acutangula* Lin. were found more suitable food plants as evidenced by higher BHHC larval survival rate (Desmukh *et al.*, 1979). Chand (1979) observed that the quantity of food consumed was found to increase with age of BHHC larvae except during last three days. The quantity of soybean, rice (*Oryza sativa* L.), fieldbean and blackgram consumed by the larvae was 962.50, 1171.40 and 893.10 mg on

dry weight basis, respectively. In the host preference studies made by Gupta *et al.*, (1979) indicated that sesamum was found to be preferred host followed by castor, groundnut, greengram (*Vigna radiata* L. Wilczek), mothbean (*Phaseolus aconitifolius* L.), pearl millet (*Pennisetum typhoides* L.), cluster bean, pigeonpea (*Cajanus cajan* L. Millsp) and sunhemp tested for BHHC. In the food consumption studies made by Prasad and Chand (1980) indicated that highest quantity (8063.14 ± 634.83 mg) of sunflower was consumed by BHHC larvae and least (2622.85 ± 469.26 mg), on lucerne. It was also noted that the most favourable food plants were responsible for larval survival, rapid development of the pest and more female production. Similar observations were also reported by Prasad and Premchand (1980). Based on their observations sunflower was most suitable and cowpea being least. On the basis of growth index, order of suitability of six food plants for BHHC was sunflower > cotton > bengal gram (*Cicer arietinum* L.) > lucerne (*Medicago sativa* L.) > cowpea.

The report of Kumar (1983) indicates that females consumed more food (Sunflower) than males and daily excretion was proportional to the consumption. The shorter larval period, higher growth rate and higher efficacy of conversion of ingested and digested food were found on groundnut var.

M-145 (Tiwari *et al.*, 1984). *Spilosoma obliqua* was found diurnal in habit with respect to feeding on sunflower (Goel *et al.*, 1986).

Srivastava and Pandey (1987) recorded sunflower as most suitable host with maximum survival of BHHC (55 per cent), fecundity (614 eggs) per female and shortest larval duration (49.31 days).

As reported by Tiwari *et al.*, (1989) the order of preference of the suitable host for development of BHHC were toria (*Brassica compestris* var. *toria* L.) >sugarbeet (*Beta vulgaris* L.) >castor bean > blackgram. Nagia *et al.* (1991) reported the biology and population multiplication potential of *S. obliqua* and reported that castor was most suitalbe for development of all the stages.

2.3 Crop loss estimation :

Singh and Gangrade (1974) studied the effect of chlorophyll loss due to *S. obliqua* on the pod and grain of soybean. Yield loss resulted because of reduced photosynthesis consequent to reduced chlorophyll (85 per cent) of the infested leaves. The healthy plants produced 2.5-2.7 per cent more pods and 3-4.5 per cent more in the weight of seeds compared to infested plants. Size of the seeds was

also smaller in infested plants. Due to infestation no change was resulted in the carbohydrate, protien and oil contents of the infested plants.

Gangrade *et al.* (1977) reported the yield losses in soybean in response to varying levels of damage by three lepidopterous larvae at preflowering stage. The significant reduction in the grain wieght of "Bragg" variety was noticed due to consumption of leaf area by *S. obliqua* to the extent of 40 per cent, when larval population was ten per metre row.

Rizzo (1978) from Argentina reported that infestation slows down the plants development in late sown sunflower and reduces the yield.

Studies on the economic threshold of *S. obliqua* on groundnut indicated that 15 or more larvae caused significantly more damage than 5 or fewer larvae per metre row. The economic injury level was 2 larvae per plant, causing an economic loss of about 43 per cent foliage and 27 per cent yield ( Pachori *et al.*, 1980). Singh (1991) reported that infestation by *S. obliqua* on soybean resulted in the reduction of 75.17 per cent pod number, 82.32 per cent in pod weight, 77.02 per cent in grain number and 77.08 per cent grain wieght.

2.4 Dispersal behaviour :

Other than the report of Sethi *et al.* (1976), no other references are available on the dispersel behaviour of *S. obliqua*. According to them the upsurge of *S. obliqua* was seen on sunflower at Delhi, India. The descendence of larvae from the plants and crawling on the ground was attributed to shortage of the leaves as a food.

2.5 Management of S. obliqua :

2.5.1 Control by synthetic insecticides :

Tripathi (1967) conducted an experiment to test four insecticides against the BHHC larvae of 4.00 cm length and found that endosulfan was 1.16 times as toxic as endrin on jute under field conditions. Singh (1968) obtained good control of BHHC on soybean in field when sprayed with 0.05 per cent endosulfan. Bakhetia and Sindhu (1971) recorded 71.70 per cent kill of the 4th and 5th instar larvae with 0.05 per cent endosulfan spray in field plots on Indian rape crop at Ludhiana. According to Gargov and Katiyar (1971), 0.05 per cent endosulfan gave 100 per cent control of 3rd instar larvae after 72 hours of treatment under laboratory test. Saxena (1972) recomended 0.07 per cent endosulfan for the control of BHHC larvae on soybean, while in contrast the recommendation of Singh (1973) against the advanced stage of caterpilla

on soybean was lower (0.05%). Of the 9 chemicals tested by Sharma and Chowdhary (1976) against BHHC on jute under field conditions. Endosulfan at 0.035 per cent gave 44 to 60 per cent increased yeild compared to untreated control. According to Basavaraja (1976), endosulfan 0.07 per cent spray gave 100.00 per cent mortality of 1st to 5th instar larvae of BHHC and 87.50 and 89.00 per cent mortality of 6th and 7th instars, respectively after 72 hours of treatment on castor under laboratory conditions.

Grewal *et al.* (1978) opined that 0.1 per cent endosulfan spray applied at 520 litres per hectare had strong knockdown effect on the third instar larvae of BHHC on sesame. The laboratory test made by Somadher and Verma (1979) revealed that endosulfan at 0.05 per cent spray gave 100 per cent mortality of grown up caterpillars after 48 hours of treatment on sugarbeet. Adsule and Kadam (1979) considered that 0.05 per cent endosulfan spray was effective against BHHC on sunflower in field plot tests.

Sidhu and Dhawan (1980) reported the sprays containing monocrotophos, quinalphos and endosulfan at 0.3 kg/ha was most effective against young larvae of BHHC on cotton. Highest mortality of 73.33 per cent of BHHC was

obtained by 0.05 per cent dichlorvos (DDVP), followed by cypermethrin (66.67), monocrotophos (20.00) and phasalone (6.67%), 24 hours after the treatment, on cotton under field conditions. Quickest knockdown was caused by dichlorvos. Mrig and Singh (1981) in field plot tests got highest mortality (98-100%) by applying 0.025 per cent quinalphos after 72 hours of treatment on garden bean. (*Lab lab purpureus* L.). Similar results were obtained by Sagar and Ramzan (1981) with quinalphos at 0.05 per cent resulting 100 per cent mortality after 24 hours of treatment on cowpea under laboratory conditons. Qninalphos and endosulfan maintained their effectiveness, giving complete mortality of the larvae even 6 days after the treatment. Gudip and Grewal (1982) obtained best results with endosulfan at 1.29 l/ha (as Thiodan 35 EC) and quinalphos at 1.13 l/ha (as Ekalux 25 EC) causing 100 and 87 per cent mortality, respectively on castor after 24 hours of treatment in field. In field plot tests Sinha *et al.*, (1984) found endosulfan (0.07 per cent) as most effective against late instar larvae of BHHC feeding on the treated leaves of sweet potato followed by 0.05 per cent chlorfenvinphos and 0.05 per cent dicholrvos.

The laboratory test results of katiyar and Mukherji (1985) indicated that, monocrotophos was most effective

causing highest mortality followed by carbaryl, phosphamidon, fenitrothion, malathion, dimethoate and fenthion against fourth instar larvae of BHHC on brinjal (*Solanum melongena* L.). Prasad and Sachan (1985) tried the toxicity of 4 synthetic pyrethroides under laboratory conditions against larvae of *S. obliqua* by three methods on castor. Deltamethrin was most toxic in all the 3 methods of administration. Topical application was found to be the most effective method, producing a toxic response in the larvae. Singh *et al.* (1985) reported that decamethrin and cypermethrin were found most effective to BHHC after 24 hours, on greengram in the field.

Yadav and Lal (1986) in the laboratory tests observed that methomyl was most toxic to 1st and 4th instar larvae of BHHC on castor, followed by quinalphos, endosulfan and methyl parathion with respect to knock down and residual toxicity effects.

Singh *et al.* (1989) reported that endosulfan 0.07 per cent was most effective in laboratory experiments against all the instars of BHHC on soybean. Nagia *et al.* (1990) obtained good control of BHHC larvae by application of deltamethrin, cypermethrin and fenvalerate at 0.016 per cent active ingradient and endosulfan 0.08 per cent active

ingradient on castor under laboratory conditions.

Goel and Kumar (1991) reported that, the deltamethrin was most effective followed by cypermethrin and both were effective for 15 days after spraying on sesame under field conditons. As per reports of Singh (1991), cypermethrin and deltamethrin gave quickest effect on the population of BHHC. However, after 72 hours of treatment cypermethrin, decamethrin, fenvalerate and deltamethrin recorded 93.33-100.00 per cent mortality of fourth instar larvae on soyabean. Among dusts quinalphos gave best results (93.33 per cent) after 24 hours of treatment under field conditions.

2.5.2 Control by Botanicals :

Due to the consequences of chemical insecticides, many plant extracts have been tried in recent years for their efficacy against *S. obliqua* by different workers, the literature collected is presented as under.

Prasad *et al.* (1983) reported that exposure of first instar larvae of BHHC to one per cent extract of dried fruits of blackpepper (*Piper nigrum* Linn.) on castor leaves resulted in the 93.00 per cent mortality under laboratory conditions.

Tripathi and Rijvi (1985) reported that castor leaves dipped in the acetone extract of *Ailanthus excelsa* Roxb and fed to the larvae of BHHC gave highest mortality of 89.7 per cent among the 18 plant extracts tested for the antifeedant activity. In the similar studies made by Tripathi *et al.* (1987) under laboratory conditions revealed that castor leaf discs dipped in extract of *Lindenbergia grandiflora* All. showed the highest antifeedant activity (82.75 per cent ) followed by *Passiflora mollisima* Linn. (71.84 per cent) out of 26 plant extracts tested. The extracts of *Schima khasiana* Rheeda (61.1 per cnet) and *Ehretia canarensis* Roxb. (60.71 per cent) showed moderate activity.

Parmar and Srivastava (1986) in the laboratory evaluated three neem formulations against second and fifth instar larvae of *S. obliqua* at 28°C and 75 per cent relative humidity. All the three formulations viz., a water dispersible powder (25% w/w), a dust preparation (10% w/w) and emulsifiable concentrate (25% w/w) based on neem seed oil, controlled larvae.

Agarwal and Mall (1988) evaluated insecticidal and antifeedant activity in neem extract (fraction C and

thionemone) and in *Calophyllum inophyllum* (Linn.) seeds against third instar larvae of *S. obliqua* at 1.0,2.5 and 5.0 per cent by contact and oral application. The results indicated that there was a positive correlation between concentration and mortality. Better results were obtained by contact method (33.33-100.00% mortality) than with the feeding method (2.66-80.00% mortality). None of the extracts showed antifeedant activity.

Chaudhari and Tripathi (1989) opined that hexane extract of bark of *Echinops echinatus* Roxb. at 200 ppm showed 97.21 per cent protection to castor from BHHC on the leaves of castor under laboratory. Similarly, Jha and Roychaudhary (1990) reported that extracts of *Ricinus communis, Zanthoxyhum budrunga* Linn. and *Zanthoxyhum alatum* Linn. at 2.5 per cent and 5.00 per cent petroleum ether extracts gave antifeedant activity against 5th instar larvae of *S. obliqua*.

Tripathi *et al.* (1990) concluded that, the tylophorine obtained from methanolic extracts from leaves of *Tylophora asthamatica* Wt. and Arn, inhibited feeding completely under laboratory conditions and persisted in field trials for 2 days.

Jain and Tripathi (1991) concluded that the most active compound from *Balanites roxburghii* Rlanch. caused 74 per cent feeding inhibition at 0.02 per cent concentration under laboratory conditions.

# MATERIAL AND METHODS

# III MATERIALS AND METHODS

Studies on various aspects of bio-ecology and management of Bihar-hairy caterpillar, *Spilosoma obliqua* Wlk. were carried out under laboratory and field conditions during 1992-93 both at the college of Agriculture, Raichur and Dharwad, Karnataka. Raichur is situated in the north eastern dry zone (Zone-2) of Karnataka between 16° 15' N latitude, and 77° 20' E longitude and at an altitude of 389 metres above the mean sea-level. The college of Agriculture, Dharwad is situated at 15° 17' N latitude, 75° 05' E longitude and at an altitude of 731.8 metres above the mean sea-level.

The materials and techniques employed for conducting each experiment are presented below.

## 3.1 Field biology of Bihar hairy caterpillar :

Biology of *S. obliqua* was studied for one gerneration from January to February, 1993 on sunflower (Var: Morden dwarf) under field conditions at the Regional Research Station, Raichur. The culture was maintained in rearing cages of size 46 x 35 x 35 cm (plate-1) which was collected from the infested fields. Daily fresh leaves were provided as food for

Plate 1 : Rearing cage used under laboratory conditions

Plate 1

the culture. From this culture, a mating pair was released into the cage to maintain further for field studies.

Sunflower crop was raised under field conditions in about 150 sq m. area by following package of practices excepting plant protection measures. Ten plants were selected at random and were caged with cotton nets (3.0 x 4.0 x 1.8 m). The egg mass developed from pure culture was transfered to the central leaf of the caged plant. This was done when the crop was twenty days old. The life stages of the pest were studied for various biological parameters.

3.1.1 Incubation and hatching :

Each of the transfered egg mass was observed for number of eggs in it, incubation period and percentage of hatching. After complete hatching of the particular egg mass, only twenty, first instar larvae were retained on the leaf for further observations. This was followed for all the ten cages.

3.1.2 Larval period :

From the date of hatching, twenty larvae in each cage were observed daily till they pupated to know the total larval period.

3.1.3 Pupal period :

Regular observatons were made under field conditions on the grownup larva after completing their larval development to work out the pupal period. From the day of pupation to the emergence of moth, daily observations were made to know the total pupal period. Percentage of pupation was determined by counting number of larvae pupated. Before pupation number of larvae which were alive were recorded.

3.1.4 Adult longevity :

From the day of moth emergence to the death, observations were recorded to know the adult longevity. Male and female were identified based on the antennal characters. Percentage of adult emergence was determined by counting the number of moths emerged out of total number of pupae formed.

3.1.5 Field activity :

Observations were made regularly on the presence of BHHC on various host plants grown in the place of study. The host plants were observed for presence of egg mass or larvae to know its first appearance under field conditions. After its appearance, daily observations were made till the disappearance of the larval infestation on various hosts.

The adult activity was also recorded through light-trap data during the period of study.

During the period of investigation, maximum and minimum temperatures, relative humidity and rainfall were recorded (Appendix-I).

3.2 Food consumption by *S. obliqua* on important rabi/summer crops :

The important rabi/summer crops namely sunflower, groundnut, redgram and sorghum were raised in pots under green house conditions during November-December, 1992. Each crop was raised in twenty pots to get sufficient fresh foliage for further studies. To asses the quantum of food consumed, fresh leaves were fed to five larvae enclosed immediately after hatching in a petricage of 15x2 cm size. Each crop was replicated five times. The leaf petiole was wrapped in wet cotton wad to keep turgidity. The observations were recorded daily on the actual leaf area of leaves before and after providing for feeding to the larvae and was traced on the paper to asses the actual area fed. To measure the leaf area " Albert " planimeter was used and the leaf area was expressed in square centimeters. Values so obtained in square centimeters were converted into gramme by standardizing

the weight of leaf discs of one sq cm. The procedure of changing the food, recording leaf area fed was followed daily till the larvae entered pupation. Finally the data was averaged and percentage leaf area consumed by larvae in each instar per day was calculated for each crop under study by using the formula given below.

$$\text{Per cent leaf area consumed by larva in each instar/day} = \frac{\text{Total leaf area fed during particular instar}}{[\text{Number of larvae}] \times [\text{Number of days to complete given instar}] \times [\text{original leaf area provided}]} \times 100$$

3.3 Crop loss estimation :

The crop loss assessment of sunflower was made by releasing differential level of BHHC larval population. This was achieved by raising Morden-dwarf sunflower variety under field conditions by following package of practices excepting plant protection measures. The experiment conducted in two sets included six treatments with a plot size of 3.0 x 3.0 m, laid out in randomised block design in four replicates.

Differential density of second instar larvae population as indicated below was released under caged conditions at two different stages of crop growth viz., 30 days (vegetative phase) and 50 days (flowering stage)

separately in order to know the extent of damage to foliage and consequential yield reduction.

The following are the treatment details :

$T_1$ - No larva per plant

$T_2$ - One larva per plant

$T_3$ - Two larvae per plant

$T_4$ - Three larvae per plant

$T_5$ - Four larvae per plant

$T_6$ - Five larvae per plant

The crop was caged with cotton nets of size 2.0 x 1.5 x 1.2 m size before the release of larvae. The cages were staked with bamboo sticks to maintain their structure (Plate-2). For the release, the required number of second instar larvae were maintained in the laboratory synchronising the stage of the release on the crop.

The following were the stages of the crop growth at which the release of larvae were made.

I - At 30 days after emergence (DAE) of the crop (peak vegetative stage)

II - At 50 days after the emergence (DAE) of the crop (Flowering stage).

Plate 2 : Sunflower plants caged under field conditions for release of *S.obliqua* larvae

Plate 2

After the release of the larvae, the observtions were made on five randomly selected plants per treatment in each replication in both setts of experiment. Before senesence the foliage damage was recorded per plant. At maturity, the plant height, head size and head weight was recorded. The yield of five plants selected at random was recorded individually and mean yield per plant was recorded as also the whole plot.

Further the correlation regression equation was also established taking into consideration the grain loss per plant and differential larval population.

3.4 Migration behaviour under field conditions :

Sunflower crop was raised by follwoing all the package of practices excepting plant protection measures in an area of 400 square metres. Ten plants were selected at random maintaining enough distance between selected plants, each for pinning one and two egg masses per plant. At the vegetative stage (30 DAE) of the crop, egg mass obtained from stock culture maintained in the laboratory was pinned to the central leaf of randomly selected plants. To ascertain the factor responsible for their dispersal, one egg mass per plant and two egg masses per plant was pinned as the case may be. The

observations were made on the dispersal behaviour of the larvae from site of hatching till their disapperance (pupation) in field. The observations were recorded daily on the distance moved by the larvae from the site of hatching to assess the extent of migration and possibly the factor responsible for their dispersal from plant. The plant to which the larvae moved was tagged with thread daily to know the distance moved.

3.5 Management of *Spilosoma obliqua* :

3.5.1 Under laboratory conditions: By spray method.

3.5.1.1 On second instar larvae :

As mentioned in the Table-1, the treatment efficacy was assessed by spray method (host + larvae) under laboratory conditions. The second instar larvae maintained on sunflower leaves under laboratory conditions were used for this experiment. Twenty five larvae along with sunflower leaf were placed in a petriplate (19 x 3 cm) and were treated with known quantity of respective treatments, with the help of atomiser. Each treatment was replicated three times.

Freshly treated leaves were provided to the larvae daily. Observation on the mortality was recorded after 24, 48, and 72 hours of treatment.

Further the data on mortality was converted into percentage and analysed statistically.

3.5.1.2 On fourth instar larvae :

The efficacy of the above treatments was assessed by using fourth instar larvae. The methodology adopted here was same as above.

3.5.2 By dip method :

3.5.2.1 On second instar larvae :

Efficacy of chemical insecticides and plant extract (Table-1) was assessed by following the dip method (only leaf). Second instar larvae maintained under laboratory conditions were used for this experiment. Twenty five caterpillars were used for each treatment and replicated three times. Fresh leaves of the sunflower were dipped in the treatmental solution and air dried for ten seconds. The treated leaves were placed first in the container and then the larvae were released. The leaves dipped in water acted as untreated check. Freshly treated leaves were provided daily.

Observations on the mortality after 24, 48 and 72 hours of treatment were recorded and analysed statistically after suitable transformation of data.

3.5.2.2 On fourth instar larvae :

The efficacy of the above treatments was assessed to fourth instar larvae following the method above.

3.5.3 Under field conditions :

Sunflower crop was raised in 3.0 x 3.0 m size plots by following package of practices excepting plant protection measures. The experiment included eleven treatments (Table-1) replicated three times. The artificial infestation was made by releasing three larvae per plant on five plants selected at random per plot at 30 DAE. The required number of larvae (second and fourth instars) were maintained under laboratory conditions for further use. Spraying was done with knap-sack high volume sprayer while dusting was with hand rotary belly mounted duster. Treatment application was made after ten minutes of release of larvae on the plants selected. Untreated check was sprayed with water. In order to asses the efficacy of the treatments, two sets of experiments were conducted involving only second instar and fourth instar larvae, seperately.

3.5.3.1 Effect on second instar larvae :

After imposing the treatments, the observations were recorded on the mortality of larvae after 24, 48, 72 hours and 5 days after the treatment. Further, the data was converted into percentage and analysed statistically.

3.5.3.2 Effect on fourth instar larvae :

Observations were recorded on the mortality of larvae after 24, 48, 72 hours and 5 days after imposing the treatments. Further, the data was converted into percentage and analysed statistically.

Table-1 Details of treatments tested for the control of BHHC both in the laboratory and field.

| Sl. No. | Treatment | Formulation | Dosage(a.i/ha)/ concentration(%) |
|---|---|---|---|
| 1. | Endosulfan (Thiodan 35 E.C.) | Spray | 525 g (0.07%) |
| 2. | Endosulfan (Endosulfan 4% dust) | Dust | 1 kg (4%) |
| 3. | Fenvalerate (Sumicidin 20 E.C.) | Spray | 75 g (0.01%) |
| 4. | Fenvalerate (Fenval 0.4% D.P.) | Dust | 0.08 kg (0.4%) |
| 5. | Dichlorvos (Nuvan 76% E.C.) | Spray | 570 g (0.76%) |
| 6. | Methomyl (Lannate 12.5 L.) | Spray | 187.5 g (0.025%) |
| 7. | Carbaryl (Sevin Flo 42 m/m.) | Spray | 630 g (0.084%) |
| 8. | Acephate (Ortain 75% S.P.) | Spray | 562.5 g (0.75%) |
| 9. | Chlorpyriphos (Durmet 20 E.C.) | Spray | 300 g (0.04%) |
| 10. | Monocrotophos poison bait* (Luphos 36% S.L.) | Bait | 125 kg/ha |
| 11. | Endosulfan poison bait** (Thiodan 35 E.C.) | Bait | 125 kg/ha |
| 12. | *Prosophis julifera* extract*** | Spray | 500g fresh leaf /l.of water (5%) |
| 13. | Untreated check (Water spray) | Spray | - |

-Recommended spray fluid of 750 litres/ha was used.

-Treatment number 8 and 12 were deleted under field.

-The names in the parantheses under the treatment indicate trade names.

* Monocrotophos poison bait:

Monocrotophos poison bait was prepared using 250 ml of monocrotophos 36 SL, 50 kg rice bran and 4 kg jaggery in 10 litres of water. The ingradients were thoroughly mixed and allowed to ferment for 48 hours before use.

** Endosulfan poison bait:

Endosulfan poison bait was prepared by procedure narrated above using 250 ml of endosulfan 35 EC instead of monocrotophos.

*** *Prosophis julifera* extract:

500 g fresh leaves of *P. julifera* was mascerated in an electric grinder. The ground material was wrapped in muslin cloth and was soaked in 500 ml of water for 24 hours. The content was squeezed thoroughly, filtered,and volume was made up to 1.0 litre to get 5 per cent spray solution.

# EXPERIMENTAL RESULTS

# IV EXPERIMENTAL RESULTS

Results of the investigations carriedout on the biology, food consumption, croploss estimation, dispersal behaviour and management of black headed hairy caterpillar (BHHC), *Spilosoma obliqua* Walker during the year, 1992-1993 are presented below:

## 4.1 Biology under field conditions :

Life history of BHHC was studied on sunflower var; Mordendwarf under field conditions during the months, January to March, 1993. The average temperature ranged from 17.75°C to 34.19°C with an average relative humidity of 12.78% to 44.09% (Appendix-I).

### 4.1.1 Egg :

In general the female moths laid the eggs in cluster both in captivity and under field conditions. In captivity, the eggs were laid on leaves, paper strips, cloth and also on glass sheets of rearing cages. Under field conditions, the eggs were laid on the under surface of the leaves. The freshly laid eggs were greenish yellow in colour. Eggs changed from greenish yellow to black before hatching. The incubation

Table-2 Life history of *S. obliqua* on sunflower under field conditions during January-March, 1993.

| Sl. No. | Stage | Range (days) | Average* (days) |
|---|---|---|---|
| 1. | Incubation period | 5-7 | 6.0 ± 0.66 |
| 2. | Larval period | 22-26 | 23.9 ± 1.44 |
| 3. | Pupal period | 10-14 | 12.3 ± 1.41 |
| 4. | Adult longevity | | |
| | a) Male | 3-4 | 3.9 ± 0.06 |
| | b) Female | 5-6 | 5.4 ± 0.51 |
| 5. | Total life cycle | 42-53 | 47.6 ± 2.06 |

* Average of ten observations

period varied from 5.0 to 7.0 days with an average of 6.0 days (Table-2).

Percentage of hatching varied from 54.78 to 82.12 with an average of 67.91 (Table-2). The fecundity ranged fom 386 to 527 with an average of 467.1 eggs.

**4.1.2. Larva :**

The newly emerged larva is tiny, cylindrical and pale greenish in colour with prominent tubercles and setae. Head is black with dark brown to black pronotum with semicircular shape. Prolegs posses brown uni-ordinal crochets. As the larva grows the tubercles on prothorax, mesothorax, ninth and tenth abdominal segments become more prominent. There is also considerable increase in length and width of the larval body. The colour of the body changes from pale greenish to yellow with age of the larva. In fully grown up larva, the plates of thoracic, first and last abdominal segments are dark brown to black in colour with black setae, but rest of the abdominal segments bear reddish brown setae (Plate-3).

The total larval period varied from 22 to 26 days with an average of 23.9 days (Table-2).

Plate 3 : Different larval instars of *S.obliqua*

Plate 3

4.1.3 Pupa :

The fully grown larva stops feeding before entering into pupation. Further, it prepares pre-pupal case by spinning with the silk and shed body hairs. Pupation was found to occur both on the surface and inside the soil. Pupation in the soil occurs at a depth of 1.5 to 3.5 cm without making silken cocoon. When pupated on the surface of the soil, it formed a cocoon with the help of silken threads, body hairs, soil particles and dry leaves (Plate-4).

Pupa is of obtect type, medium sized with more or less round cephalic end and pointed anal end. At the posterior end, the cast skin of the final moult and head capsule are loosely attached to the pupa (Plate-5).

The pupal period varied from 10 to 14 days with an average of 12.3 days (Table-2).

The per cent pupation was found to vary from 85 to 90 with an average of 87.00 per cent (Table-3).

4.1.4 Adult longevity :

Adult moths were observed to emerge during the late hours (18.30 h) in the evening and continued till night (22.00 h). They started flying actively after two to three hours of

Plate 4 : Pre-pupa of *S.obliqua*

Plate 4

Plate 5 : Pupa of *S.obliqua*

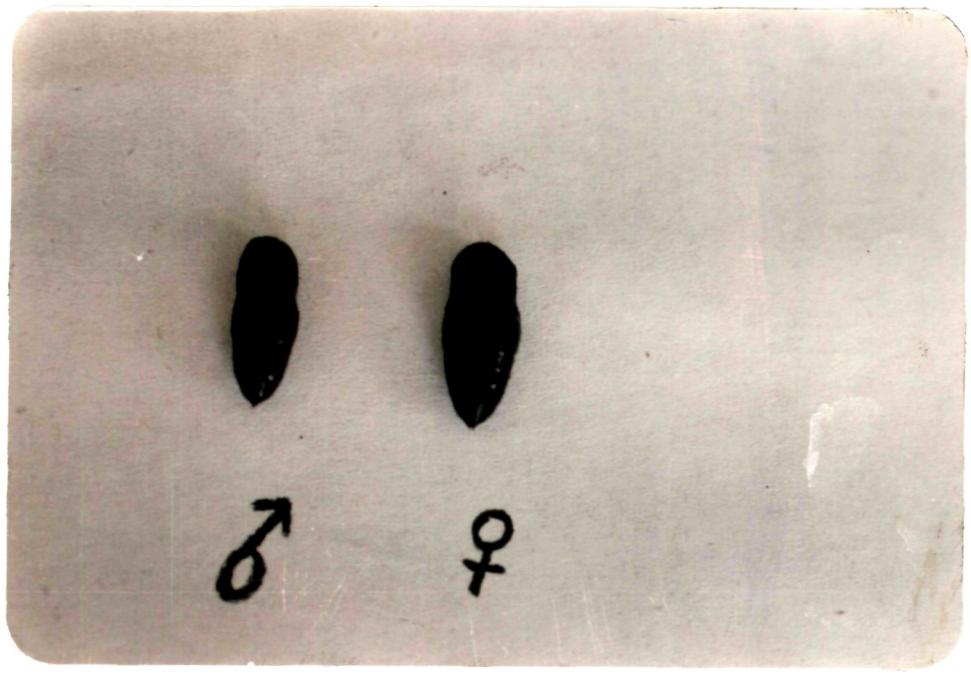


Plate 5

Table-3 Percentage success of different stages of *S. obliqua* under field conditions during January-March, 1993.

| Sl. No. | Stage | Range | Average* |
|---|---|---|---|
| 1. | Fecundity | 386-527 | 467.1 ± 55.21 |
| 2. | Per cent hatching | 54.78-82.12 | 67.91± 8.41 |
| 3. | Per cent pupation | 85-90 | 87.00± 2.58 |
| 4. | Per cent adult emergence | 88.88-94.11 | 90.31± 2.62 |

* Average of ten observations.

emergence, but observed resting on the nets during day time. They were found hiding on undersurface of the sunflower leaves also. Moths were extremely sluggish and could be easily caught during day time.

Female moth is stouter than male and moth has bipectinate antennae while male possess setaceous antennae (Plate-6).Male survived for shorter period (3.9 days) than female (5.4 days) (Table-2). The adult emergence varied from 88.88 to 94.11 per cent with an average of 90.31 per cent (Table-3).

4.1.5 Total life cycle :

The total life cycle from egg to adult was found to vary from 42 to 53 days with an average of 47.6 days (Table-2).

4.1.6 Appearance in the field and level of incidence

In order to know the first appearance of BHHC incidence, the field observations were made on diferent crops grown on the Research Station, Raichur and farmers fields near by from November, 1992 to October, 1993. During the period of survey larger number of egg masses and larvae were seen on sunflower, groundnut and soybean from November, 1992 to February, 1993. Larval incidence declined steadily in the

Plate 6 : Adult of *S.obliqua*

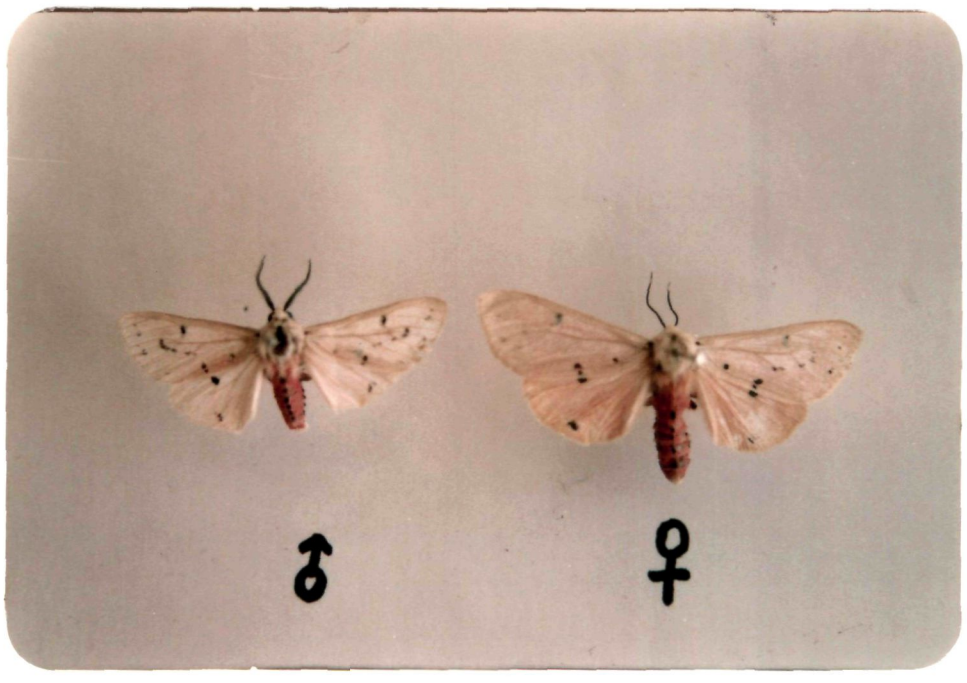


Plate 6

Table-4 Light trap catches *S. obliqua* during different months of 1992-93, at Raichur.

| Month | 1st week | 2nd week | 3rd week | 4th week | Total |
|---|---|---|---|---|---|
| 1992 | | | | | |
| November | 13 | 15 | 10 | 19 | 57 |
| December | 18 | 17 | 19 | 12 | 66 |
| 1993 | | | | | |
| January | 26 | 20 | 18 | 15 | 79 |
| February | 17 | 9 | 10 | 18 | 54 |
| March | 19 | 6 | 11 | 13 | 49 |
| April | 7 | 10 | 9 | 12 | 38 |
| May | 9 | 9 | - | - | 18 |
| June | 2 | 6 | 3 | 3 | 14 |
| July | 2 | - | 4 | 2 | 8 |
| August | 3 | 1 | - | - | 4 |
| September | - | - | - | - | - |
| October | 1 | 2 | - | 4 | 7 |

succeeding months and disappeared totally in September. Light trap catches (Table-4) revealed that during November, December, 1992, January, February, March and April, 1993, the moth catches were 57, 66, 79, 54, 49 and 38, respectively. There was a gradual decline in number of moth catches from May, 1993 (18) to August, 1993 (4). There was no moth catche during September however, 7 moths were attracted during the month, October, 1993.

4.2 Food consumption :

The quantity of the food consumed by each instar of BHHC on different crops was recorded during November to December, 1992. Initially first, second and third instar caterpillar fed by scrapping leaf chlorophyll leaving papery thin skeleton (Plate-7), while fourth, fifth, sixth and seventh instars devoured the leaf.

The food consumed by each instar larva in terms of leaf area and weight was analysed statistically (Table-5) and the linear regression equation was workedout for different crops.

From the Table-5, it is evident that there was no significant difference among four crops fed to the larvae of BHHC with respect to specific instars. However, the quantity

Plate 7 : Scraping of leaf chlorophyll by *S.obliqua* larval mass

Plate 7

Table-5 Food consumption by larval instars of S. obliqua on important rabi/summer crops.

| | Sunflower | | | | | Groundnut | | | | | Redgram | | | | | Rabi sorghum | | | | | Means | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leaf area (Sq cm) | | | Leaf weight (g) | | Leaf area (Sq cm) | | | Leaf weight (g) | | Leaf area (Sq cm) | | | Leaf weight (g) | | Leaf area (sq.cm) | | | Leaf weight (g) | | | |
| Instars | Range | Average* | Per cent | Range | Average* | Range | Average* | Per cent | Range | Average* | Range | Average* | Per cent | Range | Average* | Range | Average* | Per cent | Range | Average* | Area | Weight |
| I | 0.410-0.530 | 0.463 | 0.27 | 0.015-0.019 | 0.017 | 0.400-0.520 | 0.445 | 0.23 | 0.013-0.017 | 0.015 | 0.380-0.500 | 0.428 | 0.21 | 0.011-0.015 | 0.013 | 0.300-0.380 | 0.353 | 0.19 | 0.007-0.009 | 0.008 | 0.422 | 0.013 |
| II | 1.150-2.030 | 1.745 | 1.01 | 0.042-0.075 | 0.064 | 1.050-2.000 | 1.700 | 0.81 | 0.035-0.068 | 0.058 | 1.000-1.830 | 1.585 | 0.77 | 0.031-0.056 | 0.049 | 0.530-1.600 | 1.240 | 0.66 | 0.013-0.041 | 0.032 | 1.567 | 0.050 |
| III | 2.300-6.900 | 5.070 | 2.95 | 0.159-0.255 | 0.206 | 4.000-6.100 | 5.075 | 2.41 | 0.136-0.207 | 0.172 | 3.900-5.980 | 4.840 | 2.35 | 0.120-0.185 | 0.150 | 3.200-5.300 | 4.195 | 2.23 | 0.083-0.137 | 0.109 | 4.797 | 0.159 |
| IV | 15.010-22.000 | 17.753 | 10.32 | 0.555-0.814 | 0.657 | 15.000-21.000 | 17.425 | 8.27 | 0.510-0.720 | 0.594 | 14.500-18.000 | 16.050 | 7.78 | 0.449-0.558 | 0.497 | 12.230-16.900 | 14.340 | 7.62 | 0.317-0.439 | 0.372 | 16.392 | 0.530 |
| V | 42.000-59.200 | 51.050 | 29.67 | 1.554-2.190 | 1.889 | 41.000-58.100 | 49.775 | 23.62 | 1.394-1.975 | 1.692 | 39.000-53.200 | 47.80 | 23.17 | 1.209-1.649 | 1.482 | 36.000-47.300 | 42.470 | 22.57 | 0.936-1.229 | 1.104 | 47.773 | 1.541 |
| VI | 88.000-123.000 | 106.800 | 62.07 | 3.256-4.551 | 3.952 | 83.000-120.000 | 104.000 | 49.35 | 2.822-4.080 | 3.536 | 86.000-118.000 | 103.75 | 50.34 | 2.666-3.658 | 3.216 | 76.300-102.000 | 89.575 | 47.59 | 1.983-2.652 | 2.329 | 101.031 | 3.258 |
| VII | 100.500-180.000 | 146.375 | 85.07 | 3.718-6.660 | 5.416 | 98.300-178.000 | 141.825 | 67.29 | 3.342-6.052 | 4.830 | 97.200-168.000 | 137.10 | 66.52 | 3.013-4.250 | 4.250 | 82.000-150.000 | 124.500 | 66.14 | 2.132-3.900 | 3.237 | 137.450 | 4.433 |
| Total | | 329.256 | | | 12.201 | | 320.245 | | | 10.897 | | 311.561 | | | 9.657 | | 276.678 | | | 7.191 | | |
| Mean | | 47.036 | | | 1.743 | | 45.74 | | | 1.556 | | 44.50 | | | 1.379 | | 39.525 | | | 1.027 | | |

* Average of twenty observations.

| For comparing the means of | S.Em± | C.D. (P=0.05) |
|---|---|---|
| a) Instars on leaf area basis | 3.373 | 9.492 |
| leaf weight basis | 0.319 | 0.898 |
| b) Crops on leaf area basis | 2.550 | N.S. |
| leaf weight basis | 0.241 | N.S. |
| c) Instars x Crop leaf area basis | 6.746 | N.S. |
| leaf weight basis | 0.638 | N.S. |

of food intake varied from crop to crop both with respect to leaf area and weight but was statisticaly not significant.

The data on food consumption by different instars revealed that there was a significant difference in the food intake by the individual instar (Table-5). The food intake gradually increased with the instar. To complete the development of the larva, the total food consumed was 329.2 sq.cm (12.201 g), 320.2 sq.cm (10.897 g), 311.5 sq.cm (9.657g) and 276.6 sq.cm (7.191 g) of sunflower, groundnut, redgram and rabi sorghum, respectively. The instars four to seven consumed significantly more leaf area than first three instars and the similar trend was seen on all four crops tested.

There was no significant difference in the food consumption rate between first to fourth instar larvae.However, fifth to seventh instars differed on all the crops significantly (Table-5). Similar trend was maintained in all the four crops fed to the larvae of BHHC.

In general, there was a significant difference in food intake among the instars, but not among the test hosts.

### 4.3 Estimation of crop loss :

#### 4.3.1 Foliage damage :

4.3.1.1 Vegetative stage (30 DAE) :

The foliage damage at peak vegetative stage of the crop ranged from 0.00 (No larva per plant) to 30.75 (Five larvae per plant) per cent (Table-6). The differential level of larval release created significant foliage damage on the crop and all the treatments differed significantly from each other.

4.3.1.2 Flowering stage (50 DAE) :

The per cent foliage damage followed similar trend as in the previous case but the per cent leaf damage was in less at all levels of pest density tested. Maximum damage (25.75 per cent) was recorded at a density of five/plant and no damage occured in the absence of any larve. All the treatments differed significantly from each other, however, one and two larvae/plant did not induce significant variation in the amount of defoliation caused (Table-6).

4.3.2 Plant height :

4.3.2.1 At vegetative stage (30 DAE) :

The mean height of the plant ranged from 42.25 to 71.40 cm in different treatments (Table-7). The per cent reduction in plant height ranged from 8.96 to 36.62. Maximum height recorded in uninfested treatment was significantly

Table-6 Interaction between foliage damage and pest load under field conditions.

| Sl. No. | Larval load per plant | Per cent leaf damage when released at | |
|---|---|---|---|
| | | Peak vegetative stage (30 DAE) | Flower opening stage (50 DAE) |
| 1. | No larva | 0.00 *(0.00)$^{f}$ | 0.00 (0.00)$^{e}$ |
| 2. | One larva | 2.50 (9.05)$^{e}$ | 1.25 (6.33)$^{d}$ |
| 3. | Two larvae | 4.75 (12.54)$^{d}$ | 1.50 (6.93)$^{d}$ |
| 4. | Three larvae | 15.75 (23.37)$^{c}$ | 13.50 (21.55)$^{c}$ |
| 5. | Four larvae | 21.25 (27.44)$^{b}$ | 15.50 (23.17)$^{b}$ |
| 6. | Five larvae | 30.75 (33.66)$^{a}$ | 25.75 (30.49)$^{a}$ |
| | S.Em± | 0.447 | 0.494 |
| | C.D. (P=0.05) | 1.347 | 1.490 |

* Figures in the parentheses are angular values.

The means superscribed with alfabets indicate the statistical differences.

DAE = Days after emergence.

**Table-7 Effect of differential larval population of *S. obliqua* on plant height**

| Sl. No. | Larvae per plant | Vegetative stage (30 DAE) | | | Flower opening stage (50 DAE) | | |
|---|---|---|---|---|---|---|---|
| | | Range (cm) | Average* (cm) | Per cent** reduction | Range (cm) | Average* (cm) | Per cent** reduction |
| 1. | No larva | 69.80-73.00 | 71.40[a] | - | 70.10-73.40 | 72.20[a] | - |
| 2. | One larva | 60.40-69.40 | 65.00[b] | 8.96 | 70.00-73.20 | 72.00[a] | 0.27 |
| 3. | Two larvae | 57.80-66.80 | 60.60[c] | 15.12 | 69.80-72.90 | 71.20[a] | 1.38 |
| 4. | Three larvae | 54.80-57.00 | 55.75[d] | 21.91 | 69.41-72.55 | 70.90[a] | 1.80 |
| 5. | Four larvae | 51.00-55.00 | 52.10[e] | 27.03 | 68.90-72.20 | 70.10[a] | 2.90 |
| 6. | Five larvae | 43.80-48.20 | 42.25[f] | 36.62 | 67.70-70.70 | 69.90[a] | 3.18 |
| | S.Em± | | 1.13 | | | 1.27 | |
| | C.D. (P=0.05) | | 3.40 | | | N.S. | |

* Average of twenty observations

The means followed by same letter do not differ statistically.

** Per cent reduction over untreated check.

superior to remaining treatments. Lowest plant height was recorded in five larvae per plant (42.25 cm). All the treatments differed significantly from each other.

4.3.2.2 At flowering stage (50 DAE) :

Variation in height at this stage at different larval densities was not significant (Table-7). The mean height of the plant ranged from 69.90 to 72.20 cm. The per cent reduction in the height of the plant over uninfested check ranged from 0.27 to 3.18. Maximum height was recorded in treatments receiving no larva per plant.

4.3.3 Head width :

4.3.3.1 At vegetative stage (30 DAE) :

Consequential effect of defoliation when assessed in terms of per cent reduction in head width was significant. The reduction percentage ranged from 7.05 to 26.57 (Table-8).Largest heads were noticed in unifested plants (14.60 cm) followed by one larva. While differences between 2,3 and 4 larvae per plant were not significant, the width recorded in these treatments was significantly higher than 5 larvae/plant.

**Table-8** Effect of **differential larval population of *S. obliqua*** on **head width** in sunflower.

| Sl. No. | Larvae per plant | Vegetative stage (30 DAE) | | | Flower opening stage (50 DAE) | | |
|---|---|---|---|---|---|---|---|
| | | Range (cm) | Average* (cm) | Per cent** reduction | Range (cm) | Average* (cm) | Per cent** reduction |
| 1. | No larva | 14.20-15.00 | 14.60[a] | - | 14.50-15.70 | 15.00[a] | - |
| 2. | One larva | 12.80-14.80 | 13.57[b] | 7.05 | 14.20-15.40 | 14.90[a] | 0.66 |
| 3. | Two larvae | 12.20-13.20 | 12.75[c] | 12.67 | 14.00-15.40 | 14.85[a] | 1.00 |
| 4. | Three larvae | 12.00-12.80 | 12.45[c] | 14.72 | 13.95-14.90 | 14.60[a] | 2.66 |
| 5. | Four larvae | 11.00-12.60 | 12.00[c] | 17.80 | 13.85-14.80 | 14.47[a] | 3.53 |
| 6. | Five larvae | 10.30-11.40 | 10.72[d] | 26.57 | 13.80-15.20 | 14.30[a] | 4.66 |
| | S.Em± | | 0.245 | | | 0.281 | |
| | C.D. (P=0.05) | | 0.739 | | | N.S. | |

* Average of twenty observations.

The means followed by same letter do not differ statistically.

** Per cent reduction over untreated check.

4.3.3.2 At flowering stage (50 DAE) :

The per cent reduction in width of head ranged from 0.66 to 4.66 in different treatments. The mean width of the head ranged from 14.30 to 15.00 cm in different treatments (Table-8). Maximum head width was recorded in uninfested check (15.00 cm) and lowest was in treatment receiving five larvae per plant (14.30 cm). However, the treatments did not differ significantly from each other.

4.3.4 Head weight per plant :

4.3.4.1 At vegetative stage (30 DAE) :

The mean head weight ranged from 42.98 (five larvae/plant) to 45.38 g (No larva/plant) in different treatments (Table-9). The per cent reduction ranged from 1.20 to 5.27. The treatments receiving 0,1,2 larvae/plant did not induce significant variation among themselves and so did 3,4,5/plant. However difference between these two groups was significant except overlapping of treaatment receiving 2 and 3 larvae/per plant.

4.3.4.2 At flowering stage (50 DAE) :

The average weight of the head which ranged from 44.89 g to 46.90 g was more than the head weight recorded when defoliation was caused at vegetative stage in all the

**Table-9** Effect of **differential larval** population **of *S. obliqua*** **on head** weight in sunflower.

| Sl. No. | Larvae per plant | Vegetative stage (30 DAE) Range (g) | Average* (g) | Per cent** reduction | Flower opening stage (50 DAE) Range (g) | Average* (g) | Per cent** reduction |
|---|---|---|---|---|---|---|---|
| 1. | No larva | 44.81-46.18 | 45.38[a] | - | 46.11-48.10 | 46.90[a] | - |
| 2. | One larva | 43.12-45.79 | 44.87[a] | 1.20 | 46.10-47.13 | 46.46[a] | 0.94 |
| 3. | Two larvae | 43.01-45.21 | 44.27[ab] | 2.43 | 45.76-46.89 | 46.07[a] | 1.76 |
| 4. | Three larvae | 42.98-44.01 | 43.75[bcd] | 3.59 | 45.19-46.10 | 45.96[a] | 1.99 |
| 5. | Four larvae | 42.75-43.36 | 43.01[cd] | 5.21 | 45.11-46.10 | 45.81[a] | 2.31 |
| 6. | Five larvae | 41.97-43.18 | 42.98[c] | 5.27 | 44.19-45.22 | 44.89[a] | 4.29 |
| | S.Em± | | 0.36 | | | 0.41 | |
| | C.D. (P=0.05) | | 1.10 | | | N.S. | |

* Average of twenty observations.

The means followed by same letter do not **differ statistically.**

** Per cent **reduction** over untreatd check.

treatments. It ranged from 44.89 g to 46.90 g in different treatments (Table-9). The per cent reductioin in head weight was marginally less compared to previous stage. All treatments were on par with each other.

4.3.5 Plant yield :

4.3.5.1 At vegetative stage (30 DAE) :

It was observed that the mean grain weight per plant ranged from 32.99 to 35.23 g (Table-10). Further, the per cent loss in the grain yield, due to differential larval load ranged from 1.02 to 6.35. The highest yield was recorded in uninfested treatment (35.23 g) which was on par with treatments receiving two and three larvae per plant, but differed significantly from the rest of the treatments. Similarly, infestation with 2, 3 and 4 larvae failed to bring significant variation among the treatment and the later two levels reduced as much yield as highest level of pest density.

4.3.5.2 At flowering stage (50 DAE) :

The grain yield per plant was more compared to peak vegetative stage in all the respective treatments. The mean grain yield ranged from 35.89 to 38.15 g (Table-10). Reduction in grain yield ranged from 2.49 to 5.92 due to differential larval load. The highest grain yield was recorded in treatment

Table-10 Effect of differential larval population of *S. obliqua* on grain yield (single plant).

| Sl. No. | Larvae per plant | Vegetative stage (30 DAE) Range (g) | Average* (g) | Per cent** reduction | Flower opening stage (50 DAE) Range (g) | Average* (g) | Per cent** reduction |
|---|---|---|---|---|---|---|---|
| 1. | No larva | 34.81-36.30 | 35.23$^{a}$ | - | 37.21-39.10 | 38.15$^{a}$ | - |
| 2. | One larva | 33.00-35.81 | 34.87$^{ab}$ | 1.02 | 36.81-37.98 | 37.20$^{a}$ | 2.49 |
| 3. | Two larvae | 33.00-35.00 | 34.22$^{abc}$ | 2.86 | 35.55-37.91 | 37.07$^{a}$ | 2.83 |
| 4. | Three larvae | 33.01-34.01 | 33.75$^{bcd}$ | 4.20 | 36.30-37.10 | 36.98$^{a}$ | 3.06 |
| 5. | Four larvae | 31.90-34.00 | 33.04$^{cd}$ | 6.21 | 36.10-37.10 | 36.97$^{a}$ | 3.09 |
| 6. | Five larvae | 32.80-33.18 | 32.99$^{d}$ | 6.35 | 35.18-36.18 | 35.89$^{a}$ | 5.92 |
| | S.Em± | | 0.40 | | | 0.49 | |
| | C.D. (P=0.05) | | 1.20 | | | N.S. | |

* Average of twenty observations.

The means followed by same letter do not differ statistically.

** Per cent reduction over untreated check.

receiving no larvae per plant (38.15g), least being in five larvae per plant (35.89g). However the variation in the larval density at this stage did not bring about significant changes in grain yield.

4.3.6 Plot yield :

4.3.6.1 At vegetative stage (30 DAE) :

It was observed that the mean grain weight of the whole plot ranged from 1.14 to 1.2 kg in different treatments. Further, the per cent loss in the grain yield due to BHHC differential larval infestation ranged from 0.84 5o 6.57 (Table-11). Comparison of whole plot yield presented in Table 11 revealed that the trend in the treatmental effect was almost similar to the observation made on single plant yield. However, the yield from plot infested at the rate of 3, 4 and 5 per plant caused as much effect as 2 larvae/plant, contrary to the observations made on single plant basis at corresponding stage of the plant growth.

Further from the table-12 is evident that for every unit increase in the larva per plant, induces 0.4902 g reduction in the seed weight per plant.

Table-11 Effect of differential larval population of *S. obliqua* on grain yield (whole plot).

| Sl. No. | Larvae per plant | Vegetative stage (30 DAE) Range (Kg) | Average* (kg) | Per cent** reduction | Flower opening stage (50 DAE) Range (Kg) | Average* (Kg) | Per cent** reduction |
|---|---|---|---|---|---|---|---|
| 1. | No larva | 1.21-1.24 | $1.22^{a}$ | - | 1.30-1.36 | $1.33^{a}$ | - |
| 2. | One larva | 1.15-1.26 | $1.21^{ab}$ | 0.84 | 1.27-1.34 | $1.30^{a}$ | 2.40 |
| 3. | Two larvae | 1.14-1.21 | $1.18^{abc}$ | 2.99 | 1.26-1.32 | $1.29^{a}$ | 2.83 |
| 4. | Three larvae | 1.14-1.17 | $1.16^{bc}$ | 4.39 | 1.26-1.32 | $1.29^{a}$ | 3.07 |
| 5. | Four larvae | 1.10-1.17 | $1.14^{c}$ | 6.43 | 1.25-1.29 | $1.29^{a}$ | 3.08 |
| 6. | Five larvae | 1.10-1.14 | $1.14^{c}$ | 6.57 | 1.22-1.26 | $1.26^{a}$ | 5.54 |
| | S.Em± | | 15.34 | | | 15.65 | |
| | C.D. (P=0.05) | | 0.046 | | | N.S. | |

* Average of four replicates.

The means followed by same letter do not differ statistically.

** Per cent reduction over untreated check.

Table-12 Correlation and regression analysis of plant yield and pest load at vegetative stage (30 DAE)

| X | Y | $X^2$ | $Y^2$ | XY |
|---|---|---|---|---|
| 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.36 | 1.00 | 0.129 | 0.36 |
| 2 | 1.01 | 4.00 | 1.020 | 2.02 |
| 3 | 1.48 | 9.00 | 2.190 | 4.44 |
| 4 | 2.19 | 16.00 | 4.796 | 8.76 |
| 5 | 2.24 | 25.00 | 5.017 | 11.20 |
| Ex | Ey | $Ex^2$ | $Ey^2$ | Exy |
| 15 | 7.28 | 55 | 13.152 | 26.78 |

r = 0.98
a = -0.012
b = 0.4902

Regression model Y = a+bx wherein a = Constant and b= Slope

= -0.012 + 0.4902 x

Where

N = Total number of observations.
X = Larval load of S. obliqua per plant.
Y = Reduction in grain yield per plant.

r = 0.98**

**(Highly significant)

Table-13 Correlation and regression analysis of plant yield and pest load at flowering stage (50 DAE).

| X | Y | $X^2$ | $Y^2$ | XY |
|---|---|---|---|---|
| 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 0.95 | 1.00 | 0.902 | 0.95 |
| 2 | 1.08 | 4.00 | 1.166 | 2.16 |
| 3 | 1.17 | 9.00 | 1.368 | 3.51 |
| 4 | 1.18 | 16.00 | 1.392 | 4.72 |
| 5 | 2.26 | 25.00 | 5.107 | 11.30 |
| **Ex** | Ey | $Ex^2$ | $Ey^2$ | Exy |
| 15 | 6.64 | 55 | 9.935 | 22.64 |

r = 0.89
a = 0.2439
b = 0.3451

Regression model Y = a+bx wherein a = Constant and b= Slope

= 0.2439 + 0.3451 x

Where

N = Total number of observations.
X = Larval load of S. obliqua per plant.
Y = Reduction in grain yield per plant.

r = 0.89**

**(Highly significant)

4.3.6.2 At flower opening stage (50 DAE) :

The maximum yield was recorded by uninfested check (1.33 kg) and minimum by the treatment with five larvae per plant (1.26 kg) but, all the treatments were statistically on par in recording the yield. Further, the per cent loss in the grain yield due to differential larval infestation ranged from 2.48 to 5.54 (Table-11). Further from table 13 it is noticed that every unit increase in larvae per plant reduces 0.3451 g of seed weight per plant.

4.4 Dispersal behaviour :

4.4.1 From single egg mass per plant :

The neonate larvae scrapped the lower surface of the leaves and fed on the chlorophyll content for 2 days at the site of hatching. The scrapping of leaf ultimately resulted into papery skeleton. From 3rd day onwards they moved in group gradually for a considerable distance in search of fresh leaf (Table-14). As the age advanced, the distance moved by the larvae on each day increased gradually from 3rd to 11th day. On 12th and 13th day, they dispersed for considerable distance of 46.9 and 48.0 cm, respectively, as the food requirement at this stage increased. From 14th day onwards their movement of larvae was hastened to cover more distance as they entered into a solitary phase. Until 14th day of hatching each leaf

Table-14 Dispersal of *S. obliqua* larvae under field condition.

| Days after hatching | Distance moved (cm) on each day | |
|---|---|---|
| | One egg mass*/plant | Two egg mass*/plant |
| 1 | 0.0 | 0.0 |
| 2 | 0.0 | 0.0 |
| 3 | 7.5 | 14.0 |
| 4 | 9.0 | 19.0 |
| 5 | 16.0 | 34.0 |
| 6 | 20.2 | 45.0 |
| 7 | 29.8 | 46.0 |
| 8 | 29.9 | 60.0 |
| 9 | 30.2 | 60.5 |
| 10 | 31.0 | 62.5 |
| 11 | 34.5 | 71.0 |
| 12 | 46.9 | 91.8 |
| 13 | 48.0 | 102.1 |
| 14 | 51.0 | 105.1 |
| 15 | 52.0 | 110.0 |
| 16 | 53.0 | 115.0 |
| 17 | 53.5 | 116.7 |
| 18 | 54.0 | 116.8 |
| 19 | 58.0 | 130.0 |
| 20 | 69.0 | 138.0 |
| 21 | 73.0 | 147.1 |
| 22 | 120.0 | 225.0 |
| 23 | 130.0 | 261.0 |
| 24 | 145.0 | 298.0 |
| 25 | 158.0 | 320.0 |
| 26 | 210.0 | 440.0 |
| Total distance moved from site of hatching (m) | 15.113 | 31.384 |

* Average of ten observations.

Plate 8 : Skeletonised sunflower plants due to *S. obliqua* feeding by dispersal behaviour

Plate 8

was inhabitted by more than 10 larvae, but this was drastically reduced to less than five larvae per leaf. On the penultimate day of larval development (26 days after hatching), the larva moved upto a distance of 210 cm in a single day and pupated either in the soil or on the leaf itself. Thus, during their active feeding period, the larvae dispersed to a distance of 15.113 m from site of hatching till pupation.

4.4.2 From two egg masses per plant :

The feeding behaviour and the dispersal rate was similar to that of single egg mass from the day of hatching till pupation. But, the food available per leaf was exhausted due to increased number of larvae per plant (Table-14). It is interesting to note in table 14 that the distance travelled by each larvae nearly doubled at all the intervals of the observation as compared to when one egg mass was infested on each plant. However, the trend in the distance covered by each larva on successive days remained same as in the earlier case.

4.5 Bioefficacy of insecticide :

4.5.1 Under laboratory conditions : by spray method

4.5.1.1 Second instar :

The results on the efficacy of nine insecticides, one plant extract and two poison baits on second instar larva of BHHC by topical spray method have been presented in Table-15. From the table, it is evident that all the toxicants in spray, dust and bait formulation gave good control at 24, 48 and 72 hours after treatment.

All the treatments were superior to untreated check at all intervals of observation. At 24 hours of treatment highest per cent mortality was observed in fenvalerate spray (86.66) followed by fenvalerate dust (83.33) and both were significantly superior to rest of the treatments. Endosulfan dust (75.00) was the next best. Endosulfan spray (60.00) and dichlorvos (56.66) were found to be equally effective however, were inferior to the above (Table-15).

At 48 and 72 hours of treatment, fenvalerate dust and spray and endosulfan dust were significantly superior to rest of the treatments and were on par with each other by recording cent per cent mortality (Table-15). Dichlorvos which recorded 78.33 and 85.00 per cent mortality at 48 and 72 hours after treatment, respectively was proved to be

Table-15 Efficacy of Insecticide formulations to second instar larva on sunflower under laboratory conditions (Topical Spray).

| Sl. No. | Treatment | | Dosage | Per cent mortality after | | |
|---|---|---|---|---|---|---|
| | | | | 24 hours | 48 hours | 72 hours |
| 1. | Endosulfan | 35 E.C. | 2ml/lit. | 60.00 *(50.79)$^{c}$ | 100.00 (90.00)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 2. | Endosulfan | 4% Dust | 10 kg/ac. | 75.00 (60.07)$^{b}$ | 100.00 (90.00)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 3. | Fenvalerate | 20 E.C. | 0.5ml/lit. | 86.66 (68.66)$^{a}$ | 100.00 (90.00)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 4. | Fenvalerate | 0.4% Dust | 8 kg/ac. | 83.33 (65.95)$^{a}$ | 100.00 (90.00)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 5. | Dichlorvos | 76 E.C. | 1 ml/lit. | 56.66 (48.83)$^{c}$ | 78.33 (62.28)$^{b}$ | 85.00 (67.40)$^{b}$ |
| 6. | Methomyl | 12.5 L. | 2 ml/lit. | 41.66 (40.19)$^{d}$ | 60.00 (50.79)$^{c}$ | 71.66 (57.98)$^{c}$ |
| 7. | Carbaryl | 42 m/m | 2 ml/lit. | 40.00 (39.21)$^{d}$ | 63.33 (52.77)$^{c}$ | 71.66 (57.98)$^{c}$ |
| 8. | Chlorpyrphos | 20 E.C. | 2 ml/lit. | 43.33 (41.16)$^{d}$ | 63.33 (52.77)$^{c}$ | 73.33 (59.00)$^{c}$ |
| 9. | Acephate | 75 S.P. | 1 gm/lit. | 25.00 (30.00)$^{e}$ | 46.66 (43.08)$^{d}$ | 53.33 (46.91)$^{d}$ |
| 10. | *Prosophis julifera* Extract 5% | | | 21.66 (27.71)$^{e}$ | 45.00 (42.12)$^{d}$ | 45.00 (42.12)$^{e}$ |
| 11. | Endosulfan Poison Bait | | 50 kg/ac. | 21.66 (27.71)$^{e}$ | 38.33 (38.24)$^{e}$ | 38.33 (38.24)$^{e}$ |
| 12. | Monocrotophos Poison Bait | | 50 kg/ac. | 20.00 (26.45)$^{e}$ | 33.33 (35.16)$^{e}$ | 33.33 (35.16)$^{e}$ |
| 13. | Untreated check (Water spray) | | | 0.00 (0.00)$^{f}$ | 0.00 (0.00)$^{f}$ | 0.00 (0.00)$^{f}$ |
| | S.Em± | | | 1.281 | 1.163 | 1.463 |
| | C.D. (P=0.05) | | | 3.739 | 3.394 | 4.270 |

* Figures in the parenthesis are angular values.
The means followed same letter do not differ statistically.
Liquid formulation were evaluated by topical spray method.

significantly superior to remainders. Methomyl, carbaryl and chlorpyriphos were on par with each other at both intervals of observation. Bait formulations of both the insecticides were significantly inferior to other treatments.

4.5.1.2 On fourth instar :

As seen from the table 16, despite fenvalerate dust recording highest mortality at 24 hours was at par with fenvalerate spray. These treatments differed significantly from endosulfan dust, endosulfan spray and dichlorvos. Methomyl, carbaryl and chlorpyriphos were on par with each other and were superior to acephate and endosulfan poison bait which were on par with each other. Least mortality was observed in monocrotophos poison bait, (16.66 per cent). No mortality was seen in untreated check.

At 48 and 72 hours after treatment endosulfan dust and spray and fenvalerate spray and dust were on par with each other causing significantly higher mortality over rest of the treatments. Fenvalerate dust recorded highest mortality of 90.00 and 100.00 per cent at 48 and 72 hours after treatment, respectively (Table-16). However, 72 hours after treatment, fenvalerate dust, fenvalerate spray and endosulfan dust were on par with each other and differed significantly from the

**Table-16** Efficacy of Insecticide formulations to fourth instar larva on sunflower under laboratory conditions (Topical Spray).

| Sl. No. | Treatment | Dosage | Per cent mortality after | | |
|---|---|---|---|---|---|
| | | | 24 hours | 48 hours | 72 hours |
| 1. | Endosulfan 35 E.C. | 2ml/lit. | 55.00 *(47.87)$^{c}$ | 85.00 (67.40)$^{a}$ | 93.33 (77.71)$^{b}$ |
| 2. | Endosulfan 4% Dust | 10 kg/ac. | 58.33 (49.80)$^{b}$ | 86.66 (68.66)$^{a}$ | 96.66 (83.85)$^{ab}$ |
| 3. | Fenvalerate 20 E.C. | 0.5ml/lit. | 65.00 (53.73)$^{a}$ | 86.66 (68.66)$^{a}$ | 96.66 (83.85)$^{ab}$ |
| 4. | Fenvalerate 0.4% Dust | 8 kg/ac. | 68.33 (55.77)$^{a}$ | 90.00 (71.57)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 5. | Dichlorvos 76 E.C. | 1 ml/lit. | 43.33 (41.16)$^{b}$ | 60.00 (50.77)$^{b}$ | 73.33 (58.93)$^{c}$ |
| 6. | Methomyl 12.5 L. | 2 ml/lit. | 33.33 (35.25)$^{e}$ | 55.00 (47.87)$^{b}$ | 66.66 (54.75)$^{cd}$ |
| 7. | Carbaryl 42 m/m | 2 ml/lit. | 33.33 (35.25)$^{e}$ | 46.66 (43.07)$^{c}$ | 55.00 (47.88)$^{de}$ |
| 8. | Chloropyrphos 20 E.C. | 2 ml/lit. | 31.66 (34.18)$^{e}$ | 45.00 (42.09)$^{c}$ | 55.00 (47.88)$^{de}$ |
| 9. | Acephate 75 S.P. | 1 gm/lit. | 20.00 (26.57)$^{f}$ | 30.00 (33.21)$^{de}$ | 36.66 (37.25)$^{f}$ |
| 10. | *Prosophis julifera* Extract 5% | | 11.66 (19.88)$^{h}$ | 25.00 (29.92)$^{e}$ | 35.00 (36.15)$^{f}$ |
| 11. | Endosulfan Poison | 50 kg/ac. | 21.66 (27.71)$^{f}$ | 35.00 (36.23)$^{d}$ | 41.66 (40.17)$^{ef}$ |
| 12. | Monocrotophos Poison Bait | 50 kg/ac. | 16.66 (22.79)$^{g}$ | 26.66 (31.07)$^{e}$ | 28.33 (32.14)$^{f}$ |
| 13. | Untreated check (Water spray) | | 0.00 (0.00)$^{i}$ | 0.00 (0.00)$^{f}$ | 0.00 (0.00)$^{g}$ |
| | S.Em± | | 0.867 | 1.546 | 3.101 |
| | C.D. (P=0.05) | | 2.531 | 4.513 | 9.051 |

* Figures in the parenthesis are angular values.
The means followed same letter do not differ statistically.
Liquid formulation were evaluated by topical spray method.

endosulfan spray. Dichlorvos and methomyl were on par with each other at both the intervals after treatment while, at 72 hours of treatment methomyl, carbaryl and chlorpyriphos were on par with each other. Once again monocrotophos poison bait at both 48 and 72 hour after treatment failed to inflict mortality and hence was proved most inferior to all the chemicals tested.

4.5.2 Dip method :

4.5.2.1 On second instar larva :

From the table-17, it is evident that at 24 hours after treatment, fenvalerate spray by recording 71.66 per cent mortality emerged as most effective treatment. This was followed by fenavalerate dust (61.66 per cent), endosulfan spray (55.00 per cent) and endosulfan dust (53.33 per cent) but, the later two differed significantly from the former. Other treatments in the decreasing order of efficacy were dichlorvos, carbaryl, methomyl, chlorpyriphos, *Prosophis julifera* extract, acephate, endosulfan poison bait and monocrotophos poison bait. Acephate, *Prosophis julifera* extract, endosulfan poison bait and monocrotophos poison bait were least effective upto 24 hours after treatment. No other cause was responsible for larval mortality as untreated check recorded no mortality.

**Table-17** Efficacy of Insecticide formulations to second instar larva on sunflower under laboratory conditions (Leaf dip method).

| Sl. No. | Treatment | | Dosage | Per cent mortality after | | |
|---|---|---|---|---|---|---|
| | | | | 24 hours | 48 hours | 72 hours |
| 1. | Endosulfan | 35 E.C. | 2ml/lit. | 53.33 *(46.91)$^{c}$ | 90.00 (71.57)$^{b}$ | 100.00 (90.00)$^{a}$ |
| 2. | Endosulfan | 4% Dust | 10 kg/ac. | 55.0 (47.87)$^{c}$ | 88.33 (70.11)$^{b}$ | 100.00 (90.00)$^{a}$ |
| 3. | Fenvalerate | 20 E.C. | 0.5ml/lit. | 71.66 (57.86)$^{a}$ | 100.00 (90.00)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 4. | Fenvalerate | 0.4% Dust | 8 kg/ac. | 61.66 (51.75)$^{b}$ | 90.00 (71.57)$^{b}$ | 100.00 (90.00)$^{a}$ |
| 5. | Dichlorvos | 76 E.C. | 1 ml/lit. | 38.33 (38.24)$^{d}$ | 70.00 (56.84)$^{c}$ | 88.33 (70.11)$^{b}$ |
| 6. | Methomyl | 12.5 L. | 2 ml/lit. | 28.33 (32.14)$^{f}$ | 51.66 (45.95)$^{d}$ | 71.66 (57.86)$^{d}$ |
| 7. | Carbaryl | 42 m/m | 2 ml/lit. | 33.33 (35.25)$^{e}$ | 63.33 (52.74)$^{c}$ | 80.00 (63.54)$^{c}$ |
| 8. | Chloropyrphos | 20 E.C. | 2 ml/lit. | 28.33 (32.14)$^{f}$ | 51.66 (45.95)$^{d}$ | 71.66 (58.06)$^{d}$ |
| 9. | Acephate | 75 S.P. | 1 gm/lit. | 20.00 (26.27)$^{gh}$ | 38.33 (38.24)$^{e}$ | 50.00 (45.00)$^{e}$ |
| 10. | *Prosophis julifera* Extract 5% | | | 21.66 (27.51)$^{g}$ | 43.33 (41.16)$^{e}$ | 51.66 (45.95)$^{e}$ |
| 11. | Endosulfan Poison Bait | | 50 kg/ac. | 20.00 (26.27)$^{gh}$ | 33.33 (31.91)$^{f}$ | 43.33 (41.15)$^{e}$ |
| 12. | Monocrotophos Poison Bait | | 50 kg/ac. | 16.66 (23.95)$^{h}$ | 26.66 (30.99)$^{f}$ | 33.33 (35.16)$^{f}$ |
| 13. | Untreated check (Water spray) | | | 0.00 (0.00)$^{i}$ | 0.00 (0.00)$^{g}$ | 0.00 (0.00)$^{g}$ |
| | S.Em± | | | 0.959 | 1.463 | 1.509 |
| | C.D. (P=0.05) | | | 2.799 | 4.272 | 4.402 |

* Figures in the parenthesis are angular values.
The means followed same letter do not differ statistically.
Liquid formulation were evaluated by leaf dip method.

Fenvalerate spray (100%), in the next 24 hours after the observation followed similar trend. Fenvalerate dust (90.00 per cent), endosulfan spray (90.00 per cent) and endosulfan dust (88.33 per cent) once again emerged as best treatments (Table-17).

At 72 hours after treatment both the formulations of fenvalerate and endosulfan were at par without sparing any larva. The treatments (Table-17) in the order of decreasing efficacy were dichlorvos, carbaryl, methomyl, chlorpyriphos, *Prosophis julifera* extract, acephate, and baits of endosulfan and monocrotophos. There was no much variation in the efficacy pattern noticed at this interval from the earlier two.

4.5.2.2 Fourth instar :

At 24 hours after treatment, fenvalerate dust (63.33 per cent) and fenvalerate spray (61.66 per cent), maintained their superiority to the growing larvae as they did to early instar. Endosulfan spray and dust (50.00 per cent) were found next best and were superior to remaining treatments. Other treatments recorded less than 33.33 per cent larval mortality yet were superior to untreated check (Table-18).

At 48 and 72 hours after the treatments, fenvalerate spray and dust and endosulfan dust failed to differ from each

**Table-18** Efficacy of Insecticide formulations to fourth instar larva on sunflower under laboratory conditions (Leaf dip method).

| Sl. No. | Treatment | | Dosage | Per cent mortality after | | |
|---|---|---|---|---|---|---|
| | | | | 24 hours | 48 hours | 72 hours |
| 1. | Endosulfan | 35 E.C. | 2ml/lit. | 50.00 *(45.00)$^{b}$ | 80.00 (63.93)$^{b}$ | 88.33 (73.54)$^{b}$ |
| 2. | Endosulfan | 4% Dust | 10 kg/ac. | 50.0 (45.00)$^{b}$ | 83.33 (65.95)$^{ab}$ | 95.00 (79.55)$^{ab}$ |
| 3. | Fenvalerate | 20 E.C. | 0.5ml/lit. | 61.66 (51.75)$^{a}$ | 85.00 (67.40)$^{ab}$ | 96.55 (81.38)$^{ab}$ |
| 4. | Fenvalerate | 0.4% Dust | 8 kg/ac. | 63.33 (52.74)$^{a}$ | 88.33 (70.11)$^{a}$ | 98.33 (85.69)$^{a}$ |
| 5. | Dichlorvos | 76 E.C. | 1 ml/lit. | 33.33 (35.25)$^{c}$ | 55.00 (47.87)$^{c}$ | 60.00 (50.77)$^{c}$ |
| 6. | Methomyl | 12.5 L. | 2 ml/lit. | 30.00 (33.16)$^{c}$ | 50.00 (45.00)$^{cd}$ | 50.00 (45.00)$^{cd}$ |
| 7. | Carbaryl | 42 m/m | 2 ml/lit. | 33.33 (35.25)$^{c}$ | 55.00 (47.87)$^{c}$ | 56.66 (48.83)$^{c}$ |
| 8. | Chloropyrphos | 20 E.C. | 2 ml/lit. | 28.33 (32.14)$^{c}$ | 45.00 (42.13)$^{de}$ | 45.00 (42.13)$^{cd}$ |
| 9. | Acephate | 75 S.P. | 1 gm/lit. | 18.33 (25.31)$^{d}$ | 30.00 (33.16)$^{f}$ | 30.00 (33.16)$^{e}$ |
| 10. | *Prosophis julifera* Extract 5% | | | 20.00 (26.45)$^{d}$ | 38.33 (38.24)$^{e}$ | 38.33 (38.24)$^{f}$ |
| 11. | Endosulfan Poison Bait | | 50 kg/ac. | 13.33 (21.33)$^{e}$ | 23.33 (28.85)$^{f}$ | 23.33 (28.85)$^{fg}$ |
| 12. | Monocrotophos Poison Bait | | 50 kg/ac. | 10.00 (18.43)$^{e}$ | 16.66 (24.04)$^{g}$ | 16.66 (24.04)$^{g}$ |
| 13. | Untreated check (Water spray) | | | 0.00 (0.00)$^{f}$ | 0.00 (0.00)$^{h}$ | 0.00 (0.00)$^{h}$ |
| | S.Em± | | | 1.243 | 1.610 | 3.370 |
| | C.D. (P=0.05) | | | 3.628 | 4.700 | 9.837 |

* Figures in the parenthesis are angular values.
The means followed same letter do not differ statistically.
Liquid formulation were evaluated by leaf dip method.

other but were superior to other treatments. At 48 and 72 hours after the treatment, treatmental efficacy remained similar by and large by inflicting higher larval mortality. Endosulfan spray closely followed but the efficacy was significantly lower than the former.

4.5.3 Under field conditions:

4.5.3.1 On second instar larvae:

From the table-19, it is evident that under field conditions fenvalerate spray and dust causing 66.66 and 64.00 per cent mortality were superior to others at 24 hours after treatment. Endosulfan dust (56.00 per cent) was the next best followed by endosulfan spray (45.33 per cent). In the order of decreasing efficacy, the treatments were methomyl (32.00 per cent) carbaryl (25.33 per cent), chlorpyriphos (21.33 per cent), Baits with endosulfan (9.33 per cent) and monocrotophos (5.33 per cent) were totally ineffective, yet recorded significantly higher mortality than in untreated check.

At 48 hours after treatment, the trend in the effectiveness remained unchanged with increased mortality in all the treatments as compared to preceeding interval.

At 72 hours after treatment, all the test insects were found dead in both fenvalerate dust and spray treatments

Table-19 Efficacy of different insecticide formulations to second instar larva of on sunflow under field conditions.

| Sl. No. | Treatment | Dosage | Per cent mortality after | | | |
|---|---|---|---|---|---|---|
| | | | 24 h. | 48 h. | 72 h. | 5 day |
| 1. | Endosulfan 35 E.C. | 2ml/litre | 45.33 *(42.31)$^{c}$ | 70.66 (52.21)$^{c}$ | 89.33 (71.01)$^{b}$ | 100.00 (90.00)$^{a}$ |
| 2. | Endosulfan 4% Dust | 10 kg/acre | 56.00 (48.45)$^{b}$ | 73.30 (58.92)$^{b}$ | 92.00 (73.92)$^{b}$ | 100.00 (90.00)$^{a}$ |
| 3. | Fenvalerate 20 E.C. | 0.5ml/litre | 66.66 (54.74)$^{a}$ | 80.00 (63.43)$^{a}$ | 100.00 (90.00)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 4. | Fenvalerate 0.4% Dust | 8 kg/acre | 64.00 (53.15)$^{a}$ | 80.00 (63.43)$^{a}$ | 100.00 (90.00)$^{a}$ | 100.00 (90.00)$^{a}$ |
| 5. | Dichlorvos 76 E.C. | 1ml/litre | 33.33 (35.25)$^{d}$ | 46.66 (43.08)$^{d}$ | 54.66 (47.69)$^{c}$ | 60.00 (50.81)$^{b}$ |
| 6. | Methomyl 12.5 L | 2ml/litre | 32.00 (34.45)$^{d}$ | 46.66 (43.08)$^{d}$ | 56.00 (48.45)$^{c}$ | 61.33 (51.57)$^{b}$ |
| 7. | Carbaryl 42 m/m | 2ml/litre | 25.33 (30.20)$^{e}$ | 40.00 (39.21)$^{e}$ | 50.66 (45.38)$^{c}$ | 52.00 (46.15)$^{c}$ |
| 8. | Chlorpyriphos 20 E.C. | 2ml/litre | 21.33 (27.49)$^{f}$ | 32.00 (34.42)$^{f}$ | 37.33 (37.62)$^{d}$ | 38.66 (38.43)$^{d}$ |
| 9. | Endosulfan poison bait | 50kg/acre | 9.33 (17.71)$^{g}$ | 14.66 (22.64)$^{g}$ | 16.00 (23.47)$^{e}$ | 16.00 (23.47)$^{e}$ |
| 10. | Monocrotophos poison bait | 50kg/acre | 5.33 (13.17)$^{h}$ | 6.66 (14.61)$^{h}$ | 6.66 (14.45)$^{f}$ | 6.66 (14.45)$^{f}$ |
| 11. | Untreated check (Water spray) | | 0.00 (0.00)$^{i}$ | 0.00 (0.00)$^{i}$ | 0.00 (0.00) $^{g}$ | 0.00 (0.00)$^{g}$ |
| | S.Em± | | 0.896 | 1.140 | 1.570 | 1.187 |
| | C.D. (P=0.05) | | 2.642 | 3.363 | 4.631 | 3.502 |

* Figures in the parenthesis are angular values.

and thus were significantly superior to all other treatments. The next best treatments were endosulfan dust and spray which recorded 92.00 and 89.33 per cent larval mortality, respectively. The performance of other treatments was same as observed at 24 and 48 hours. The mortality was higher at 48 hours after the treatment. Fenvalerate and endosulfan used both as dust and spray differed significantly from the rest of the treatments by recording cent per cent larval mortality (Table-19). Similar trend as at 24 hours after treatment was seen.

4.5.3.2 On fourth instar :

At 24 hours after treatment, highest larval mortality was observed in fenvalerate spray (58.66 per cent) followed by fenvalerate dust (57.33 per cent) and differed signifcantly from the remaining treatments (Table-20). The endosulfan dust (50.66 per cent) was the next best followed by endosulfan spray (41.33 per cent) in recording the larval mortality. The remaining treatments at 24 hours after treatment were found superior to untreated check.

At 48 hours after treatment, fenvalerate both as dust and spray and endosulfan dust were on par with each other and significantly superior to other treatments in their

Table-20: Efficacy of different insecticide formulations to fourth instar larvae of on sunflower under field conditions.

| Sl. No. | Treatment | Dosage | Per cent mortality after | | | |
|---|---|---|---|---|---|---|
| | | | 24 h. | 48 h. | 72 h. | 5 day |
| 1. | Endosulfan 35 E.C. | 2ml/litre | 41.33 *(40.00)$^{c}$ | 62.66 (52.36)$^{b}$ | 76.00 (60.71)$^{c}$ | 81.33 (64.50)$^{b}$ |
| 2. | Endosulfan 4% Dust | 10 kg/acre | 50.66 (45.38)$^{b}$ | 66.66 (54.79)$^{ab}$ | 77.33 (61.59)$^{bc}$ | 84.00 (66.52)$^{ab}$ |
| 3. | Fenvalerate 20 E.C. | 0.5ml/litre | 58.66 (49.99)$^{a}$ | 68.66 (55.57)$^{ab}$ | 82.66 (65.42)$^{ab}$ | 82.66 (65.42)$^{b}$ |
| 4. | Fenvalerate 0.4% Dust | 8 kg/acre | 57.33 (49.22)$^{a}$ | 70.66 (57.21)$^{a}$ | 88.00 (68.80)$^{a}$ | 88.00 (69.90)$^{a}$ |
| 5. | Dichlorvos 76 E.C. | 1ml/litre | 29.33 (32.78)$^{d}$ | 38.66 (38.77)$^{c}$ | 44.66 (41.92)$^{d}$ | 44.66 (41.92)$^{c}$ |
| 6. | Methomyl 12.5 L | 2ml/litre | 25.33 (30.20)$^{de}$ | 34.66 (36.04)$^{c}$ | 40.00 (39.19)$^{dc}$ | 40.00 (39.19)$^{c}$ |
| 7. | Carbaryl 42 m/m | 2ml/litre | 22.66 (28.36)$^{e}$ | 32.00 (34.37)$^{d}$ | 37.33 (37.62)$^{e}$ | 37.33 (37.62)$^{c}$ |
| 8. | Chlorpyriphos 20 E.C. | 2ml/litre | 18.66 (25.57)$^{f}$ | 25.33 (30.20)$^{e}$ | 25.33 (30.20)$^{f}$ | 25.33 (30.20)$^{d}$ |
| 9. | Endosulfan poison bait | 50 kg/acre | 9.33 (17.71)$^{g}$ | 13.33 (21.37)$^{f}$ | 13.33 (21.70)$^{g}$ | 13.33 (21.58)$^{e}$ |
| 10. | Monocrotophos poison bait | 50 kg/acre | 4.00 (11.54)$^{h}$ | 8.00 (16.43)$^{g}$ | 8.00 (16.43)$^{h}$ | 8.00 (16.43)$^{f}$ |
| 11. | Untreated check (Water spray) | | 0.00 (0.00)$^{i}$ | 0.00 (0.00)$^{h}$ | 0.00 (0.00)$^{i}$ | 0.00 (0.00)$^{g}$ |
| | S.Em± | | 0.931 | 1.221 | 1.433 | 1.485 |
| | C.D. (P=0.05) | | 2.747 | 3.601 | 4.228 | 4.379 |

* Figures in the parenthesis are angular values.

The means followed by same letter do not differ statistically.

effectiveness (Table-20). Endosulfan spray (62.66 per cent) was the next best. Same trend was also noticed in the remaining treatments in causing larval mortality as observed at 24 hours after treatment. No mortality was observed in untreated check.

Increased larval mortality was seen at 72 hours after treatment when compared to the level at 48 hours. Both the dust and spray of fenvalerate recorded higher level of larval mortality (88.00 and 82.66 per cent, respectively) and maintained their superiority to endosulfan spray (76.00 per cent). However, the treatment endosulfan dust was on par with the best treatment and differed significantly from rest of the treatments (Table-20).

At 5 days after the treatment, the dust formulation of both fenvalerate and endosulfan proved to be superior to rest of the treatments by recording 88.00 and 84.00 per cent mortality, respectively. However, endosulfan dust (84.00), fenvalerate spray (82.66) and endosulfan spray (81.33) being on par with each other recorded significantly higher larval mortality than in the other treatments (Table-20).

Similar trend was seen with rest of the treatments. The trend in the efficacy of the other treatments remained unchanged as at previous interval of observation.


DISCUSSION

# DISCUSSION

## 5.1 Field biology :

Life history of BHHC was studied on sunflower var; Morden-dwarf under field conditions during months, January to March, 1993. As for the first time the life history of BHHC was studied under field conditon, the reports of the authors who studied its biology in the laboratory conditions have been taken for discussion.

### 5.1.1 Egg:

The female moths laid eggs in cluster both in captivity and under field conditions. In captivity the eggs were laid on leaves, paper strips, cloth and on glass sheets of rearing cages. Under field conditions eggs were laid in clusters on the lower surface of the leaves. Freshly laid eggs were greenish yellow in colour. Later, changed to black before hatching. These findings are in conformity with the observations of Lefroy (1906), Trehan and Bagal (1958), Singh and Gangrade (1974) and Basavaraj (1976).

The incubation period was found to vary from five to seven days with an average of six days. The present findings

are in conformity with the studies of Patel (1940). Beeson (1941), and Kabir and Khan (1969), although the host plant was different (jute). However, the present observations are differing from that of Djou (1938), Trehan and Bagal (1958), Singh and Gangrade (1974) and Basavaraja (1976) who reported the incubation period, 6-11, 5.50-9.00, 6-9 and 8.5 days, respectively. These differences in the duration between the present findings from that of laboratory results of the workers could be due to differences in the conditions prevailed under study, host plant and season of study.

The per cent hatching ranged from 54.78 to 82.12 with an average of 67.91. These findings strongly disagree with the reports of Djou (1938) and Basavaraja (1976) who observed 82.96 to 91.00 and 86.90 per cent hatching, during April-May and November-January months on limabean and castor, respectively. The same reasons as mentioned earlier could account for descrepancy.

The fecundity ranged from 386 to 527 with an average of 467.1 eggs. The results are not in agreement with Djou (1938) and Singh and Gangrade (1974) who reported the high fecundity rate of 342-1356 and 533-1287, respectively. This

difference may be attributed to the host on which the insect was reared and secondly the studies were carried out under laboratory conditions. Often the fecundity as also the biology is influenced by the host. In the earlier studies host plants used were different and did not include sunflower. Though comparable account of fecundity as influenced by host is not available in a single study, on comparison it is noticed that sunflower is less suited to have higher reproductive rate.

5.1.2 Larva:

To complete the development, larvae required 22 to 26 days in present study which is corraborated by the findings of Subramanyam Iyer (1921), Patel (1940), Beeson (1941), Kotikal (1982) and Chaudhary and Bhattacharya (1986) who reported active feeding period of 24.3, 24-25, 21.56 to 26.62 and 23.6 days. In contrast while longer time was required in the studies of Djou (1938) and Singh and Gangrade (1974). The prolonged larval period recorded by Singh and Gangrade (1974) may be due to cooler conditions (October-November) in the laboratory studies.

The colour and feeding behaviour of the fully grown caterpillar was found unchanged when compared with the

already available reports of Usman (1954) and Basavaraj (1976) who studied on jute and castor, respectively.

5.1.3 Pupa :

Prior to pupation the fully grown larva restrained from feeding, reduced in size and shed the body hairs. Further it formed silken cocoon with the leaf folds and other substratum available at the sight of pupation. If pupated in soil, it goes upto a depth of 1.5 to 3.5 cm and forms naked obtect type of pupa. The above observations are in agreement with the reports of Subramanyam Iyer (1921), Patel (1940), Trehan and Bagal (1958), Kabir and Khan (1969), Singh and Gangrade (1974) and Basavaraja (1976).

The pupal period varied from 10-14 days with an average of 12.3 days. But the reports of Subramaniyam Iyer (1921), (12 to 19 days during October-December) and Basavaraja (1976) (15.50 days during November-January) are not in support of the present results. Variation in the seasonal conditions can only account for the reduced pupal period by few days in the present investigation.

The per cent pupation in present study ranged from 85 to 90 with an average of 87.00 per cent. Further, no reports are available on this aspect to make comparison.

5.1.4 Adult longevity:

Emergence of adults commenced from late evening (18.30 h) and continued till night (22.00 h). Virgin moths became active and took to flight 2 to 3 hours of emergence, but were resting on the nets during day time.

Female is bigger than male and has bipectinate antennae while male has setaceous antennae. These characters have already been documented by Djou (1938) and Singh and Gangrade (1974).

The survival period of 3 to 4 days for male and 4 to 6 days for female are comparable with the reports of Singh & Gangrade (1974) who reported the male moths to survive for 3 to 5 days as against 4 to 8 days in females.

The per cent adult emergence varied from 88.88 to 94.11 with an average of 90.31 per cent. No such information is available to compare this biological characteristic.

5.1.1.5 Total life cycle:

The total life cycle from egg to adult varied from 42 to 53 days with an average of 47.6 days. This finding is comparable to the reports of Basavaraja (1976) on castor (48.6

days) during May-July, and Chaudhury and Bhattacharya (1986) (42.2 days) on winged bean. However, the reports of longer period of 60-70 days on limabean during April-May according to Subramanyam Iyer (1921)and 59-76 days on soybean during October-November according to Singh and Gangrade (1974) are contradicting to the present observations. This may be again attributed to time and the host plant on which the pest was reared.

5.1.6 Pest appearance :

The first appearance of the pest was noticed during September and October on sunflower crop. But, the incidence gradually increased from November to attain peak in December and January and declined thereafter. This peak observation may be attributed to low temperature, moderate relative humidity, bright sunshine hours and few showers of rain which help in the adult emergence. However, very low incidence was observed during kharif season, mainly due to heavy rains. The present findings are in agreement with the reports of Sethi *et al.* (1976) who reported the outbreak of the BHHC during rabi and attributed to unseasonal rains followed by bright sun-shine which resulted in temperature increase and high humidity, which favoured the pest development. The slow

decline in the larval incidence from January onwards may be attributed to the slow rise in the temperature. The emergence of moths was seen from the pupae reared under laboratory conditions throughout the year but, the moth emergence was considerably less during hot summer. No pupal diapause was seen during the course of study. However, this needs further confirmation since the moth emergence was observed only under laboratory conditions. Absence of moths trapped to light trap during September is suggestive of failure of moth emergence during the month which indicates the clue of climatic requirement. In contrast Singh and Gangrade (1974) reported pupal diapause from February to starting of rainy season. Decrease in moth catches from March to reach zero in September indicates that disappearance of sunflower could be main cause. However, this needs to be varified over extensive area.

## 5.2 Food consumption :

Food consumption by various instars of BHHC on sunflower, groundnut, redgram and rabi sorghum was assessed. It was found that there was a significant difference in the rate of ingestion by diffeent instars, but there was no difference among 4 crops evaluated. Quantity of food consumed by the fifth, sixth and seventh instars was significantly more

than by the remaining instars. There are no documentary evidences on food consumption by each instars on any of its host plants excepting for the report of Kotikal (1982) whose results on mulberry support the present findings (Fig.-1).

The results of the present findings reveal that among the four hosts fed, BHHC larvae consumed maximum of 329.256 sq.cm (12.20 g) of sunflower foliage during the entire larval period followed by groundnut, (320.245 sq.cm/10.897 g), redgram (311.561 sq.cm/9.657 g) and rabi sorghum (276.678 sq.cm/7.191 g). Assessment of food consumption on weight basis is also refleced in the pattern of leaf area consumption. Based on the quantity of food consumed, it may be infered that the most suitable host plant is sunflower. This conclusion is supported by Premchand (1980) and Srivastava and Pandey (1987). Prasad and Chand (1980) who recorded total consumption of 8.0631 grams of sunflower lends support to the present findings. However, reduced consumption of 2.6229 grams of lucerne suggests variation caused by host plant species.

5.3 Estimation of crop loss :

Neither the distribution of the pest is uniform nor the pest population in a unit area remains constant,

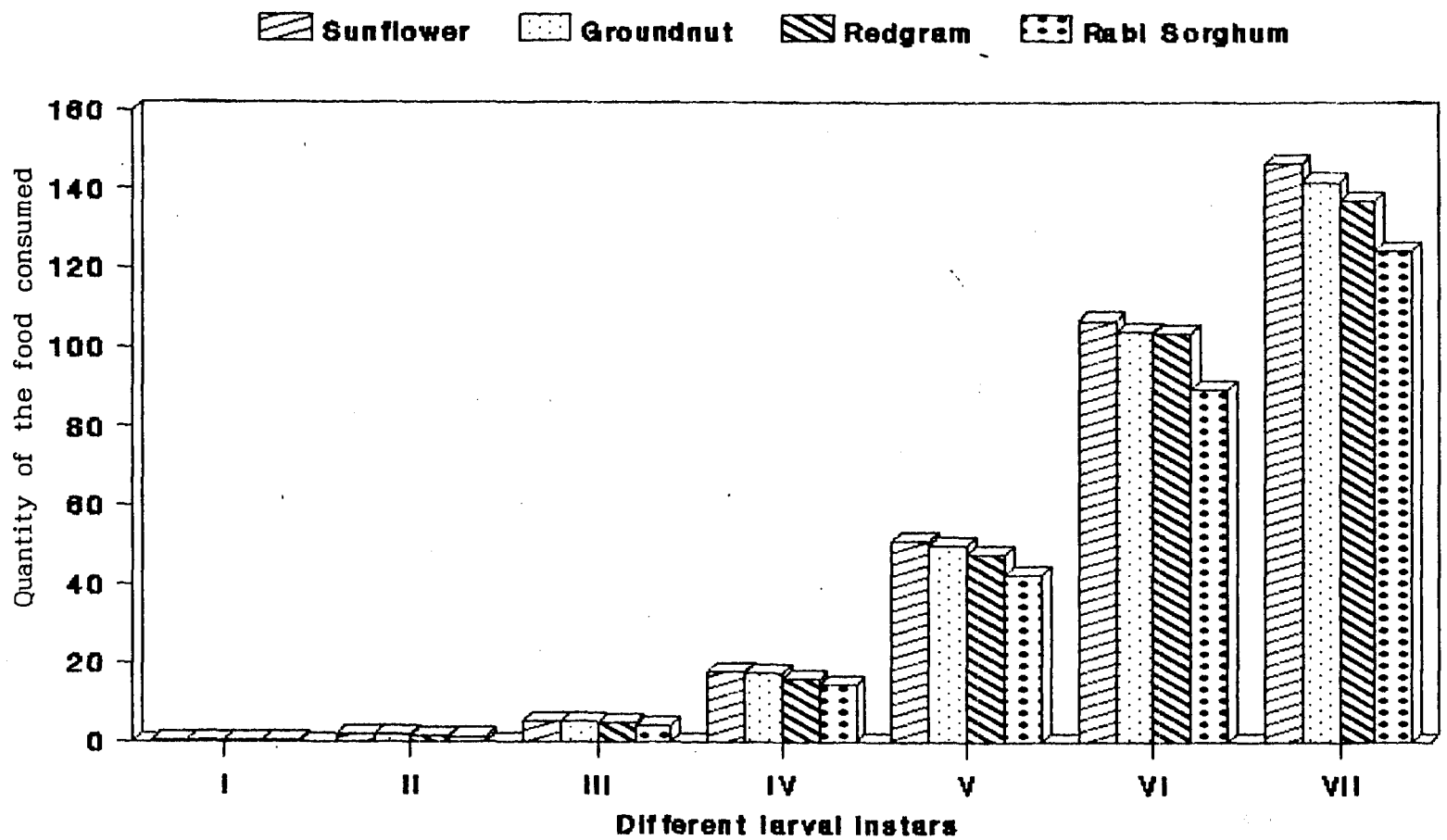


**Fig. 1. Food consumption by larval instars of *S.obliqua* on important rabi/summer crops**

artificial infestation of larvae becomes inevitable under captivity to find out the relationship between pest load and crop loss. Therefore, an experiment was conducted under field conditions by caging sunflower plants with known number of *S. obliqua* larvae.

Positive and significant correlation was observed between the number of larvae per plant and loss in grain weight. The regression equation revealed that every unit increase in the larval number results in the loss of 0.4902 and 0.3451 g of grains per head if the infestation occurs at vegetative stage (30 DAE) and flowering stage (50 DAE), respectively. Naik (1992) established similar relationship and reported an increase in grain loss of 1.0195 g per head due to every unit change in the larva of *H. armigera* on sunflower. Panchabhavi and Krishnamoorthy (1978) reported estimated loss of 120.00 kg per ha. As reported by Margal (1990), individual larva is capable of reducing the plant yield to the tune of 3.262 g. As *H. armigera* directly feeds on yield component (grain) the loss due to it is very high compared to the loss caused by BHHC which is a defoliator which effects yield component indirectly. Thus it is observed that there is a high reduction of grain weight per plant which

differs from present findings. It may be releavant to point out that yield loss is function of both pest load and crop at which infestation occurs.

5.3.1 Foliage damage:

The highest foliage damage of 30.75 and 25.75 per cent for five larvae per plant at vegetative (30 DAE) and flowering stage (50 DAE), respectively. It is in partial agreement with Pachori *et al.* (1980) who reported 43% foliage damage by this pest on groundnut at 15 or more larvae per metre. The descrepancy may be attributed to more number of larvae per metre row and the crop. This indicates the larval load which decides the quantum of foliage damage. The report of Singh and Gangrade (1974) on soyabean revealed 85 per cent of leaf chlorophyll loss under heavy infestation of BHHC.

5.3.2 Width of Head :

The reduction in mean width of head ranged from 7.05 to 26.57 per cent at peak vegetative stage (30 DAE) and 0.66 to 4.66 per cent at flowering stage from one to five larvae per plant, respectively. Although, similar reports are not available to compare the findings there, seems to be a great impact of loss of chlorophyll on development of plant head due

to larval feeding. However, the work done by Rizzo (1978) supported the results of present study and revealed its impact on development of the plant growth.

5.3.3 Plant height :

There seems to be a great impact on plant height due to the larval feeding which reduces the plant height. The extent of height reduction again was influenced by the stage at which defoliation occurred. At vegetative stage the reduction in plant height was considerably more (8.96 to 36.98 cm) than at flowering stage (0.27 to 3.18 cm) at corresponding larval load (Fig.-2). This indicates that damage done to the foliage before flowering has more impact than at flowering stage to the foliage. Similar opinion has also reflected from the report of Rizzo (1978), wherein he observed the slow development of plant due to larval infestation of sunflower by *S. obliqua*.

5.3.4 Head weight :

The per cent reduction in the weight of the head varied at two stages of insect release. Infestation at vegetative stage resulted in higher reduction in head weight than at flowering stage. The report of Singh (1991) on

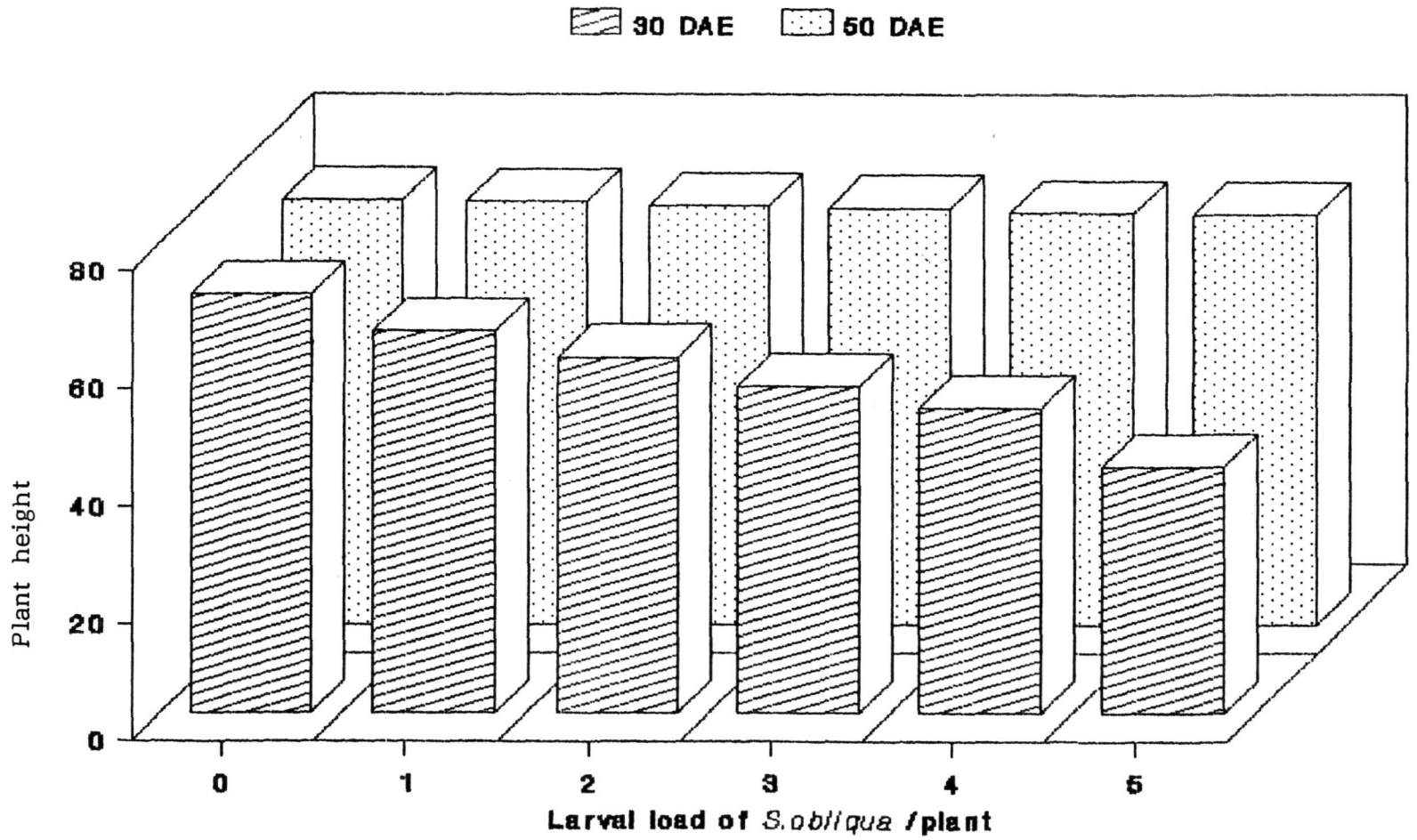


**Fig. 2. Effect of differential larval load of *S.obliqua* on Height of the plant**

soybean indicates 82.32 per cent reduction in the pod weight which may be attributed to the heavy infestation of *S. obliqua* larvae per plant than lower larval number of 5 larvae per plant and also due to change in the crop. This is also in agreement with the report of Naik (1992) who reported 7.43 to 22.06 per cent in head weight reduction.

5.3.5 Grain weight per plant:

The differential larval population reflected the grain loss ranging 1.02 to 6.35 and 2.49 to 5.92 per cent released, respectively, at 30 and 50 DAE. The present investigation is in confirmity with 3.0 to 4.5 per cent reductioin in weight of seeds of soybean due to *S. obliqua* (Singh and Gangrade, 1974) (Fig.-3).

The slight difference may be attributed to change in crop and larval load per plant. However, the higher per cent reduction in grain weight of 77.08 in soybean may be attributed to the difference in crop and higher larval population per plant (Singh, 1991).

5.3.6 Whole plot yield:

The assessed loss in yield from whole plot was 0.84 to 6.57 and 2.48 to 5.54 per cent when the differential larval

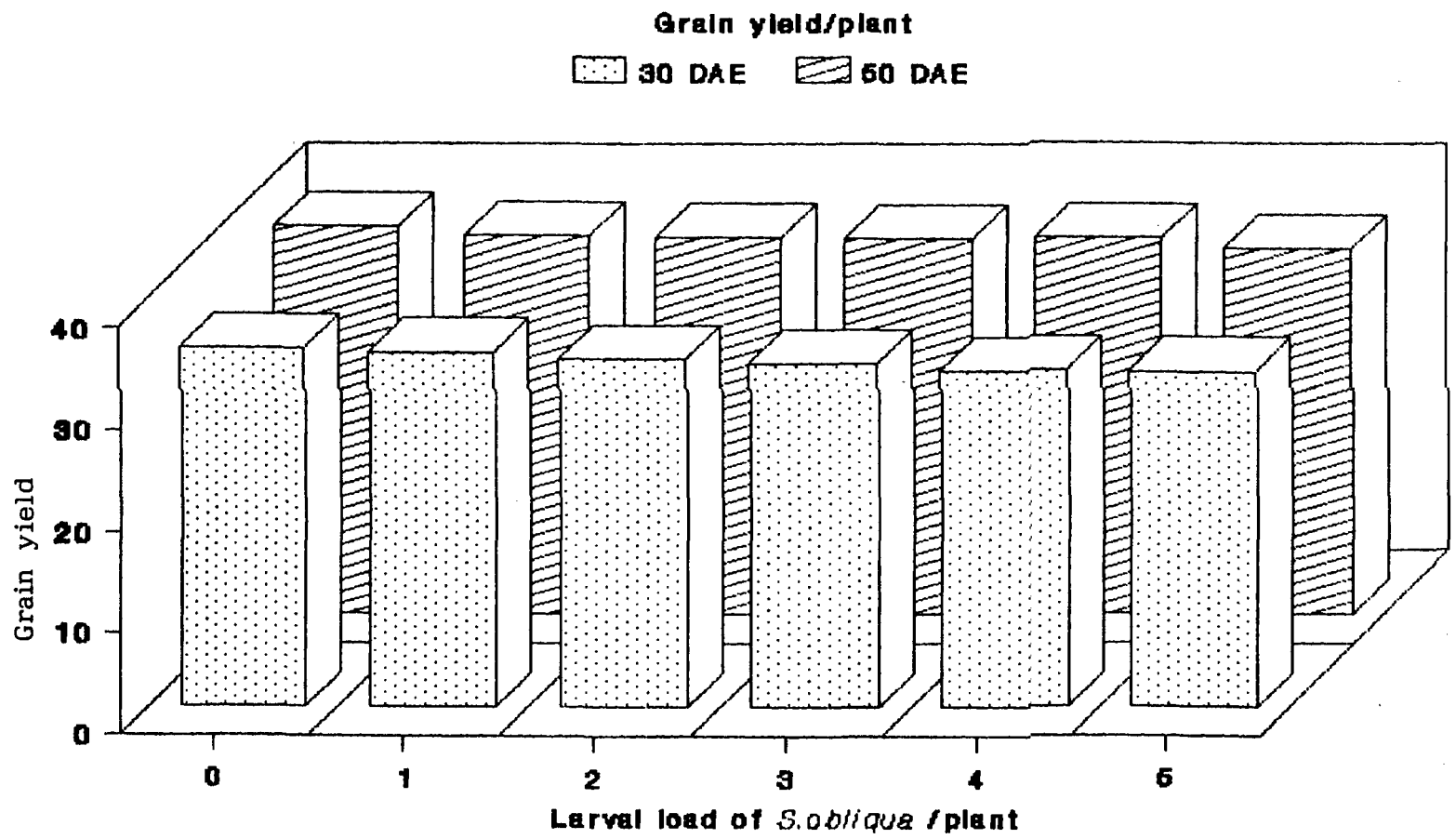


**Fig. 3. Effect of differential larval load of *S.obliqua* on grain yield (single plant)**

population was released at vegetative and flowering stage, respectively. Similar work of Panchori *et al.* (1980) revealed 27 per cent loss in yield of groundnut at greater than or equal to 15 larvae of BHHC per meter row.

5.4 Dispersal behaviour:

The dispersal of *S. obliqua* larvae in relation to the availability of food, studied under field conditions revealed the following facts.

5.4.1 Single egg mass per plant :

From the day of hatching till 2 days the larvae scrapped the chlorophyll content from the lower surface of the leaves. Their longitudinal movement increased gradually on every successive day of observation (Fig.-4). The increased distance in their movement was obviously to meet their food requirement at the site of their living. After the food was exhausted, they moved to the nearest plant for further feeding. They scattered in random fashion in all directions wherever the food was available to the nearest vicinity. Totally they had travelled a distance of 15.113 metre during their larval period when load was one egg mass per plant. Thus the shortage of leaf on the plant forced the larvae to

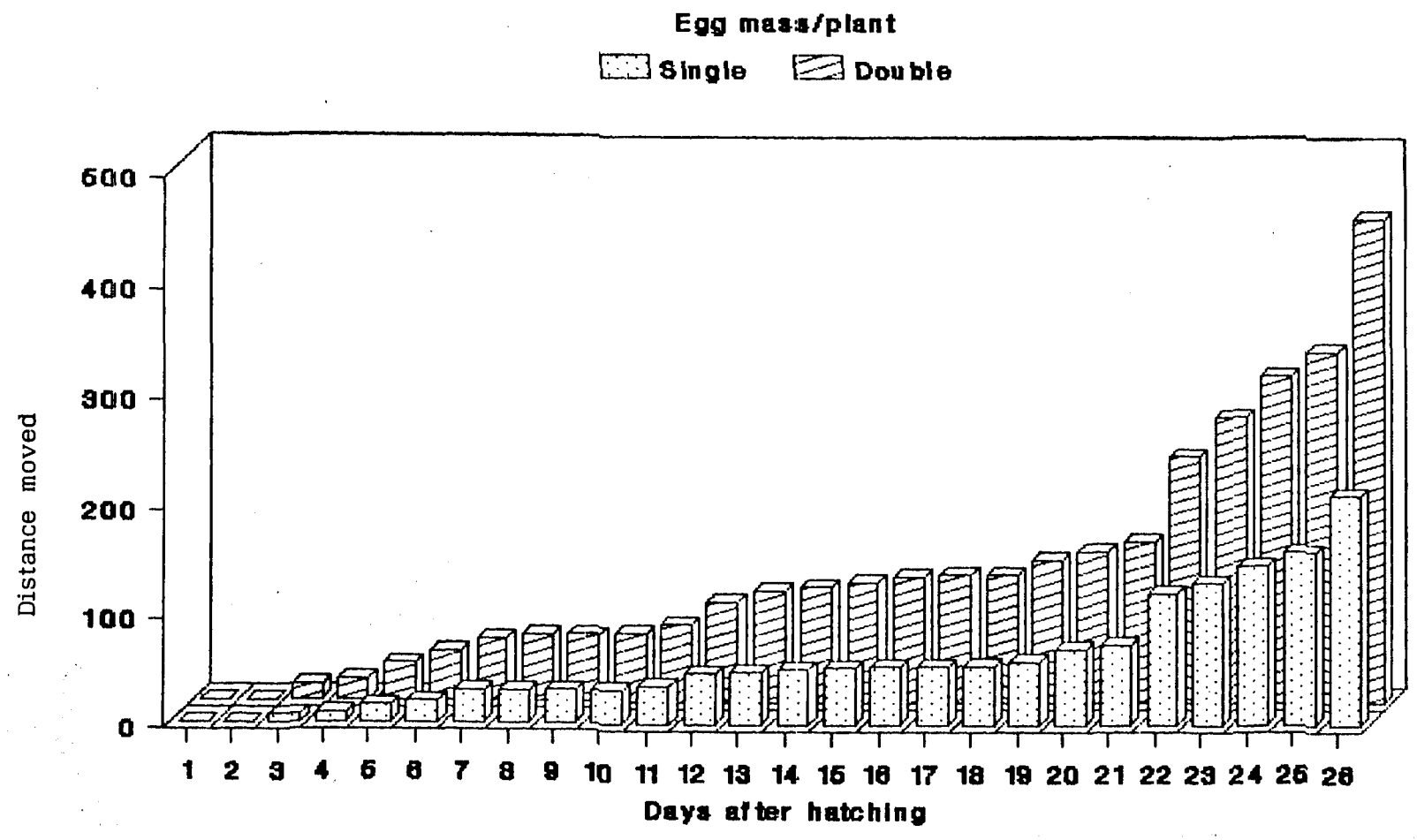


**Fig.4. Dispersal of *S.Obliqua* larvae under field conditions.**

move to the nearest plant. The present findings are in line with the observations of Sethi *et al.* (1976) who reported the larval descendence from the plants and crawling on the ground due to shortage of leaves as a food.

**5.4.2 Two egg masses per plant :**

The mode of dispersal and habit of feeding was same as above but, the larvae started moving from one plant to another at an earlier period since the food was exhausted at a faster rate due to heavy larval load per plant compared to the one egg mass per plant. The magnitude of their movement was also more in all respective days of observation compared to single egg mass per plant (Fig.-4). This may be attributed to sudden shortage of the food available to the existing population of larvae. With two egg masses per plant it was observed that totally the larvae dispressed to a distance of 31.384 meters from the day of hatching till pupation. Therefore, it may be said that the distance moved is a function of pest population per unit area. It is in accordance with the report of Sethi *et al.* (1976).

5.5 Management of *S. obliqua* :

Nine insecticides, two poison baits (of monocrotophos and endosulfan) and one plant extract were

tested for their efficacy under laboratory conditions by employing topical spray and leaf dip method of application against second and fourth instar larvae of BHHC on sunflower. The efficacy of each treatment in response to the method of application in the background of earlier work is discussed as under.

5.5.1 Under laboratory conditions : Topical spray

5.5.1.1 On second instar :

Under laboratory conditions fenvalerate spray (0.01%) 86.66 per cent, fenvalrate dust (0.4 %) 83.33 per cent, endosulfan dust (4.0%) 75.00 per cent, and endosulfan spray (0.07%) 60.00 per cent recorded significantly higher larval mortality than rest of the treatments. Dichlorvos (56.66%) was the next best. Fenvalerate dust and spray and endosulfan dust and spray induced 100.00 per cent larval kill and dichlorvos 78.33 per cent larval kill at 48 and 72 hours after treatment. These were superior over methomyl, carbaryl and chlorpyriphos which were on par with each other. Baits (monocrotophos and endosulfan) and *Prosophis julifera* extract did not prove to be effective in causing larval mortality. The present findings are in confirmity with the observations of

Basavaraja (1976), Sidhu and Dhawan (1980) abd Nagia *et al.* (1990).

**5.5.1.2 On fourth instar :**

The fenvalerate dust (0.4%) with 68.33 per cent was on par with fenvalerate spray (0.01%) with 65.00 per cent larval mortality which differed significantly from endosulfan dust (58.33%), endosulfan spray (55.00%) and dichlorvos spray (43.33%) larval mortality at 24 hours after the treatment. At 48 and 72 hours after treatment endosulfan dust and spray and fenvalerate dust and spray were on par with each other in recording significantly higher larval mortality over rest of the treatments. Fenvalerate dust recorded the highest mortality 90.00 and 100.00 per cent at 48 and 72 hours after treatment, respectively. The present observations are in accordance with the findings of Basavaraja (1976), Sinha *et al.* (1984) and Singh (1991) who obtained perfect control of fourth instar larvae with endosulfan (0.07%), endosulfan (0.07%) and fenvalerate, respectively. The little variation may be attributed to the method used in the application and change in host plant.

**5.5.2 Leaf dip method :**

5.5.2.1 On second instar larva :

At 24 hours after treatment fenvalerate spray recorded 71.66 per cent larval mortality and was superior to fenvalerate dust (61.66%), endosulfan spray (55.00%) and endosulfan dust (53.33% larval mortality).

At 48 hours after treatment, fenvalerate spray recorded highest larval mortality of 100.00 per cent and was superior to the remaining treatments. Fenvalerate dust (90.00%), endosulfan spray (90.00%) and endosulfan dust (88.33%) were next best. At 72 hours after treatment both formulations of fenvalerate and endosulfan recorded cent per cent larval mortality and were on par with each other. These present findings are in confirmity with observations of Basavaraja (1976) and Gudip and Grewal (1982) who got good control of second instar larvae under laboratory conditions. Observable differences may be attributed to method of application.

The per cent larval mortality in leaf dip method was less than in topical spray method. This may be attributed to the reason that in addition to the depositing pesticide on the food plant the larvae were also exposed to the treatment in spray method.

5.5.2.2 On fourth instar :

Fenvalerate dust (63.33%) and fenvalerate spray (61.66% larval mortality) were significantly superior over rest of the treatments. Endosulfan spray and dust were best with 50.00 per cent larval mortality at 24 hours after the treatment. Other treatments recorded less than 33.33 per cent larval mortality but were superior two untreated check. At 48 hours after the treatment fenvalerate dust and spray and endosulfan dust maintained their superiority. At 72 hours after treatment fenvalerate dust recorded 98.33 per cent larval mortality and was on par with fenvalerate spray (96.55%), endosulfan dust (95.00 %) and endosulfan spray (88.33%). The results of the present findings are in confirmity with observations of Basavaraja (1976), Sinha *et al.* (1984) and Singh (1991).

The per cent larval mortality by both methods of application to fourth instar larva was less than second instar which is mainly due to more biomass, more protective coverage by hairs on the body and solitary nature of the fourth instar larvae. The plant extract (*Prosophis julifera)* and baits (monocrotophos and endosulfan) did prove their efficacy in bringing larval mortality in both methods of application at 24

hours after treatment, but failed to maintain their effectiveness at subsequent interval of observation. No reports are available to compare the efficacy of baits and bellary jali extract against larvae of BHHC in the present study. The variation in the effacacy in the present study from that of available report may be attributed to the larval stage, method of application, crop and place of application (labortory or field). However, results of Prasad *et al.* (1983), Tripathi *et al.* (1985 and 1987), Chowdhary and Tripathi (1989) and few more are not in accordance with the results of present study owing again to the above mentioned reasons.

5.5.3 Under field conditions :

5.5.3.1 On second instar larvae :

The treatment fenvalerate spray recorded higher larval mortality of 66.66 per cent over remaining treatment, at 24 hours after the treatment. However the treatment fenvalerate dust (64.00%) was on par with fenvalerate spray and both were significantly superior over rest of the treatments. Endosulfan dust (56.00% larval mortality) was the next best. At 48 hours after treatment, both formulations of

fenvalerate maintained their superiority by recording higher larval mortality of 50.00 per cent. At 72 hours after treatment, cent per cent mortality was observed in fenvalerate dust and spray followed by endosulfan dust (92.00%) and endosulfan spray (89.33%) larval mortality. These results are in confirmity with the observations of Gargav and Katiyar (1971), Saxena (1972), Basavaraj (1976), Grewal *et al.* (1978) and Adgule and Kadam (1979). Although the target insect and insecticidal treatment was same but varied with different workers, which has resulted in recording varied level of treatment efficacy. The present investigation results are also in confirmity with results of Sidhu and Dhawan (1980), Sagar and Ramzan (1981) who got 100 per cent larval kill of BHHC after 24 hours and 5 days of treatment under field conditions. Reports of Gudip and Grewal (1982) are also in support of the present results.

5.5.3.2 On fourth instar larvae :

At 24 hours after treatment, highest larval mortality was observed in fenvalerate spray (58.66 %) followed by fenvalerate rate dust (57.33%) which differed significantly superior to rest of the treatments. Next best were endosulfan dust (50.66%) and endosulfan spray (41.33% larval

mortality). At 48 hours after treatment, both formulations of fenvaleraate were on par with each other and recorded higher larval mortality. At 72 hours of treatment same trend was seen as before but recorded higher level of larval mortality. Both the dust and spray of fenvalerate recorded 88.00 and 82.66 per cent larval mortality. Endosulfan dust was next best. At 5 days after treatment fenvalerate dust and spray maintained their superiority followed by endosulfan dust and spray. These present observations corroborate with the findings of Tripathi (1967), Singh (1968), Sidhu (1980) and Singh (1973) who got good control of fourth instar larvae under field conditions. The observable difference in the above reports from present observations is mainly attributed to stage of the larvae, method of application and concentration of insecticide used. The per cent larval mortality in fourth instar is less when compared to second instar which is mainly attributed to more biomass and or age factor, thick hairs and solitary nature of fourth instar larvae when compared with less biomass and or age factor, less and sparsely distributed hairs and gregarious nature of second instar larvae. The per cent larval mortality of both instars (second and fourth) under laboratory conditions is more than the field conditions. This is because

under confinement (laboratory), the treatment imposed over food and larvae was well distributed and there is no chance of improper coverage which is normally encountered under field conditions.

# SUMMARY

# VI SUMMARY

Investigations on the biology, food consumption, crop-loss, dispersal behaviour and management of *Spilosoma obliqua* Walker on sunflower (Mordendwarf) were undertaken during 1992-1993 and results are summarised below.

The biology of *S.obliqua* was studied on Mordendwarf variety of sunflower under field conditions. Egg laying capacity ranged from 386 to 527 with an average of 467.1 ± 55.21. While the incubation period was 5 to 7 days with an average being 6.0 ± .066 days, per cent hatching ranged from 54.78 to 82.12 with an average of 67.91 ± 8.21. Larvae completed their development in about 22 to 26 days with an average of 23.9 ± 1.44 days and pupae in 10 to 14 days with an average of 12.3 ± 1.41 days, with a per cent pupation ranging from 85 to 90 per cent (87.00 ± 2.58). Male longevity ranged from 3 to 4 days with an average of 3.9 ± 0.06. Adult emergence ranged from 88.88 to 94.11 per cent with an average of 90.31 ± 2.62. Thus a total life cycle was completed in 47.6 ± 2.6 days (42 to 53 days) during January to March, 1993.

The peak activity of moth was seen during the month of January, 1993 (79). From November, 1992 to March, 1993, the moth activity was moderately high which indicated high larval incidence on its host plants.

Food consumed by the caterpillar during the larval period was 12.201 g (329.256 Sq. cm) on sunflower, 10.87 g (320.245 Sq. cm) on groundnut, 9.657 g (311.561 Sq. cm) on red gram and 7.191 g (276.678 Sq. cm) on rabi sorghum. Fifth, sixth and seventh instars consumed significantly higher quantity of food. Sunflower was the most preferred host followed by groundnut, red gram and rabi sorghum.

The crop loss in sunflower was estimated by releasing differential level of larvae under field conditions. The results revealed highly significant and positive correlation between number of larvae per plant and loss in grain weight per head at vegetative stage. From the regression equation it was evident that per unit increase in the larval population caused 0.4902 g and 0.3451 g loss in grain weight per head at vegetative and flowering stage, respectively. There was also reduction in the plant height,

head weight, head width and plot yield when number of larvae per plant both at vegetative and flowering stages was increased. The magnitude of loss was less due to BHHC infestation when difoliation was caused at flowering stage (50 DAE) than at vegetative stage (30 DAE).

The dispersal of the larvae was random in all directions from the point of hatching. The distance of dispersal increased at increasing rate, in proportion to the larval age. Thus, the dispersal movement was associated with the availability of food. Under field conditions, the larvae on an average travelled a total distance of 15.113 m and 31.384 m when one and two egg masses were deposited on each plant, respectively.

Dust, emulsifiable concentrate and bait formulation of 10 insecticides along with the one plant extract of *P. julifera* were evaluated for their efficacy against second (early instar) and fourth instar (late instar) larva of BHHC under laboratory and field conditions. Fenvalerate spray (0.01%) and dust (0.4%) and endosulfan spray (0.07%) and dust (4.0%) excelled over others followed by dichlorvos to both

stages of larvae at 24, 48, 72 hours and 5 days after treatment. On the basis of limited information generated over one season fenvalerate dust or spray and endosulfan spray or dust can be recommended for effective control of early and late instar larvae under field conditions. Among leaf dip and topical spray methods tested under laboratory conditions, topical spray application induced higher percentage of larval mortality of second and fourth instar compared to leaf dip method. Between the stages tested higher percentage of mortality was observed in the case of second instar (early stage) larvae compared to fourth instar (late stage) larvae. These results were confirmed in the field evaluation trials against BHHC.

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# VII REFERENCES


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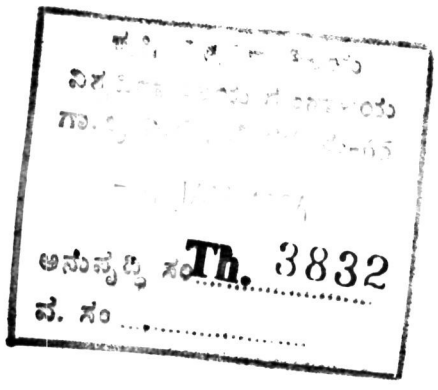
# APPENDICES

Appendix-I Meterological data for the period November, 1992 to October 1993 at Regional Research Station Raichur.

| Month | Temperature(°C) | | Relative humidity (%) | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | |
| 1992 | | | | | |
| November | 30.78 | 19.83 | 64.20 | 39.10 | 51.66 |
| December | 29.10 | 15.40 | 61.37 | 22.75 | 0.00 |
| 1993 | | | | | |
| January | 31.99 | 14.80 | 53.26 | 14.26 | 0.00 |
| February | 33.48 | 16.75 | 42.57 | 11.39 | 0.00 |
| March | 37.12 | 21.70 | 36.45 | 12.70 | 6.00 |
| April | 40.27 | 24.89 | 50.07 | 29.64 | 15.20 |
| May | 41.06 | 26.27 | 59.38 | 27.16 | 11.86 |
| June | 37.50 | 24.90 | 71.33 | 36.13 | 9.00 |
| July | 34.57 | 23.61 | 76.42 | 44.22 | 26.70 |
| August | 30.55 | 22.67 | 84.00 | 53.25 | 32.77 |
| September | 30.99 | 21.83 | 83.64 | 53.16 | 19.10 |
| October | 31.98 | 22.10 | 86.00 | 53.26 | 40.80 |

Appendix-II Meterological data of the year 1992, at Main Research Station Dharwad.

| Month | Temperature(°C) | | Relative humidity (%) | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | |
| January | 29.33 | 21.90 | 64.13 | 55.00 | 0.00 |
| February | 38.85 | 24.07 | 69.80 | 60.80 | 0.00 |
| March | 35.06 | 27.06 | 72.13 | 42.66 | 0.00 |
| April | 36.40 | 28.37 | 69.37 | 55.75 | 3.80 |
| May | 35.00 | 29.00 | 70.20 | 57.00 | 6.90 |
| June | 32.40 | 24.60 | 93.40 | 82.00 | 1.53 |
| July | 28.00 | 22.80 | 88.00 | 75.40 | 3.49 |
| August | 26.00 | 21.40 | 89.80 | 78.00 | 1.56 |
| September | 23.40 | 20.60 | 92.30 | 83.30 | 5.40 |
| October | 25.50 | 22.00 | 88.75 | 63.75 | 0.00 |
| November | 28.40 | 22.40 | 80.40 | 63.00 | 0.00 |
| December | 27.40 | 21.33 | 75.16 | 44.13 | 0.00 |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