

**STATUS AND MANAGEMENT OF POD BORER COMPLEX  
IN DOLICHOS BEAN *Lablab purpureus* (L.)**

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## CONTENTS

Chapter No.	Title
I	INTERDUCTION
II	REVIEW OF LITERATURE
III	MATERIALS AND METHODS
IV	EXPERIMENTAL RESULTS
V	DISSCUSSION
VI	SUMMARY
VII	REFERENCES
	APPENDICES

## LIST OF TABLES

Table No.	Title
1.	Occurrence of sucking pests on august sown crop
2.	Occurrence of sucking pests on September sown crop
3.	Pod damage due to individual species of pod borers (August sown crop)
4.	Pod damage due to individual species of pod borers (September sown crop)
5a.	Occurrence of predators on August sown crop
5b.	Occurrence of predators on September sown crop
6.	Pod borer population at varied level of plant protection (1 <sup>st</sup> spray)
7.	Pod borer population at varied level of plant protection (2nd spray)
8.	Pod borer population at varied level of plant protection (3rd spray)
9.	Pod borer population at varied level of plant protection (4th spray)
10.	Pod borer population at varied level of plant protection (5th spray)
11.	Influence of varied level of plant protection on pod damage
12.	Influence of varied level of plant protection on seed damage
13.	Reduction in pod and seed damage due to varied level of protection
14.	Influence in varied level of plant protection on pod yield
15.	Loss in yield due to varied level of plant protection
16.	Economics of insecticidal spray imposed for the control of pod borer in dolichos bean
17.	Determination of economic injury level for pod borers in dolichos bean
18..	Efficacy of indigenous material and new molecules against pod borers (First spray)
19.	Efficacy of indigenous material and new molecules against pod borers (Second spray)
20.	Efficacy of indigenous material and new molecules against pod borers (Third spray)
21.	Efficacy of indigenous material and new molecules against pod borers (Fourth spray)
22.	Influence of indigenous materials and new molecules on pod damage at different pickings
23.	Influence of indigenous materials and new molecules on seed damage at different pickings
24.	Influence of indigenous materials and new molecules on pod yield at different pickings
25.	Economics of pod borer management in field bean

## LIST OF FIGURES

Figure No.	Title
1.	Pod damage due to individual species of pod borers (August sown crop)
2.	Occurrence of predators on August sown crop
3.	Loss in yield due to varied level of plant protection
4.	Pod and seed damage due to varied level of plant protection
5.	Economics of various treatments
6.	Pod borer population and pod yield as influenced by varied level of plant protection
7.	Impact of indigenous material and new molecules against pod borers and on pod yield
8.	Efficacy of indigenous materials and new molecules against pod and seed damage
9.	Economics of various treatments used for the management of pod borers

## LIST OF PLATES

Plate No.	Title
1a.	Eggs of <i>R.pedestris</i>
1b.	Adults of <i>R.pedestris</i>
1c.	Pod damage due to <i>R.pedestris</i>
1d.	Seed damage due to <i>R.pedestris</i>
2.	Pod borer larvae feeding inside the pods
2a.	Larvae of <i>M.testulais</i> feeding inside the pod
2b.	Larvae of <i>H.armigera</i> feeding inside the pod
2c.	Larvae of <i>C.ptychora</i> feeding on the seed
2d.	Larvae of <i>L. boeticus</i> feeding inside the pod
3a.	Damage on pod due to <i>H.armigera</i>
3b.	Damage on pod due to <i>E. atomosa</i>

## LIST OF APPENDICES

Appendix No	Title
1.	Monthly meteorological data for experimental year 2004-05 and average of past 53 years (1950-2002) of Main Agricultural Research Station. University of Agricultural Science, Dharwad
2.	Details of material used to work out cost economics in different field experiemnts

# I. INTRODUCTION

The field bean, *Lablab purpureus* L. an important pulse-cum-vegetable crop in India is cultivated for its tender and mature pods, seeds and also for fodder. The fresh pods are acceptable and liked by all, especially during winter season under South Indian conditions and It is rich in nutritive value as it is a rich source of carbohydrate, minerals, vitamins, such as vitamin A, vitamin C, fat and fibre. The protein content of field bean is quite high varying from 20.00 to 28.00 per cent (Schaaffhausen, 1963).

The crop is cultivated in dry tropical parts of Asia, Africa, East and West Indies, South Central America and China. In India this crop is being grown mostly in Karnataka, Tamil Nadu, Andhra Pradesh, Kerala and Assam. In Karnataka, the total area under this crop was 0.81 lakh hectares with an annual production of 0.99 lakh tones at a productivity rate of 236 kg/ha (Anon., 2003). Though the crop is cultivated in almost all regions of Karnataka, it is largely grown as a mixed crop with finger millet and sorghum mainly in Kolar, Bangalore, Mandya, Mysore, Tumkur, Shimoga, Haveri, Belgaum and Hassan districts. However, it is also grown as pure crop under rainfed as well as irrigated conditions.

The primary cause attributed for lower yields of field bean has been due to the damage caused by the insect pests. Govindan (1974) recorded as many as 55 species of insects and a species of mite feeding on the crop from seedling stage to the harvest of the crop in Karnataka. Among them the pod borers are considered to be most important and they appeared regularly causing crop loss to the tune of 80-100 per cent (Katagihallimath and Siddappaji, 1962).

Among the sucking pests, lablab bug, *Coptosoma cribraria* (Fabricius) and *Riptortus pedestris* (Fabricius) occurred commonly and found in large numbers throughout the cropping period (Govindan, 1974). The bugs were found congregating on tender vines and sucking sap resulting in fading of vines and shoots (Ayyar, 1963). Whereas, the aphid, *Aphis craccivora* Koch. a serious pests of leguminous crop, suck the sap from tender shoots, inflorescence and pods resulting in drying up of tender shoot and premature fall of flower buds, flowers and tender pods.

The pod borers complex include *Maruca testulalis* (Geyer), *Helicoverpa armigera* (Hubner), *Adisura atkinsoni* (Moore), *Etiella zinckenella* (Treitschke), *Cydia ptychora* (Meyrick), *Exelastis atomosa* (Walshingham) and *Lampides boeticus* (Linnaeus). The spotted pod borer is an important pest of grain legumes appear on the crop from vegetative to reproductive stage and cause substantial damage to flowers, by webbing and also boring into the pods. The damage inflicted by *H. armigera* is generally confined to flower heads, seeds and pods. The young larvae of *L. boeticus* damage flowers and pods.

The plume moth affected pods exhibit small and round holes. The young caterpillar of *C. ptychora* remain inside the pods, while the grown up larvae cut an exist hole on the pod. The larvae of *E. zinckenella* bores the pods and feed on the seeds. The damage done by these pod borers drastically reduce the marketable yield of pods.

Though the crop is economically important, the information on the pest status, natural enemies, crop loss estimation are very much lacking particularly in Karnataka. As the pods are consumed as vegetables, the pest management and especially the pod borer control has to be on organic basis. Unfortunately, so far no efforts have been made in the crop to utilize ecofriendly approaches for the pest management. Hence, the investigations in the present studies are aimed with the following objectives.

1. Studies on pest complex of field bean with special reference to pod borers
2. To study the natural enemy complex of major pod borers
3. To study the extent of loss caused by pod borers
4. Evaluation of indigenous materials and new molecules against pod borers

## II. REVIEW OF LITERATURE

The available literature on pest complex, natural enemy complex, evaluation of indigenous materials and new molecules for pod borer management pertaining to the objectives envisaged has been reviewed and described below in the following subheadings.

### 2.1 STUDIES ON PEST COMPLEX OF DOLICHOS BEAN WITH SPECIAL REFERENCE TO POD BORERS

#### 2.1.1 Defoliators

The grass hopper, *Attractomorpha crenulata* (Fabricus) and *Catantops annexur* B. and surface grass hopper *Chrotogonus* sp. has been noted to be common and known to feed on field bean crops (Govindan and Thontadarya, 1982).

*Cyrtacanthacris ranacea* Linnaeus (Orthoptera : Acrididae) has been observed to feed on cotton, castor, groundnut and various other leguminaceous crops (Fletcher, 1914 and Ayyar, 1963) and on Lablab bean (Govindan and Thontadarya, 1982).

Usman (1953) reported that the red blister beetles, *Mylabris orientalis* Mars, *M. pustulata*, *M. thembergi* Billb, have been reported to feed on flowers of red gram and lablab.

#### 2.1.2 Sucking pests

The Eurybrachid bug was known to suck the sap from twigs and pods and coried bugs, *Anoplocnemis phasiana* suck the sap from tender twigs, whereas, *Clavigrella gibbosa* *C. horrens* and *Riptorus pedestirs* were known to suck the sap from pods (Govindan and Thontadarya, 1982).

The lablab stink bug, *Coptosoma cribraria* Fabricius was recorded on lablab, balckgram, cluster bean and *Sesbania grandiflora*. (Ayyar, 1913 and Fletcher, 1914).

The bug, *Dolicoris indicus* Stal (Hemiptera : Pentatomidae) is known to suck the sap from all aerial parts of the crop (Govindan and Thontadarya, 1982). Zucher (1920) recorded the mite, *Tetranychus ludeni* Zacher (Acarina : Tetranychidae) feeding on *Abatilon* spp., *Acalypha* spp., *Hibiscus rosasinensis*, *Lablab purpureus* (L.), *Physalis peruviana*, *Salvia splendens* and *Solanum melongena* in France and Germany.

Ayyar (1922) reported that *Alcidodes pictus* Boheman (Coleoptera : Curculionidae) bred on the main stems of *D. lablab* and the grubs bored into the stem forming a gall. The thrips, *Heliothrips indicus* Begnall (Thysanoptera : Thripidae) had a succession of hosts including lablab from July to October and in October and November it migrated to cotton (Cameron, 1930).

Puttarudhraiah and Maheswaraiiah (1956) studied the biology of *Anoplocnemis phasiana* (Fabricius) (Hemiptera : Coreidae). The pest was noted on grapes, brinjal, lablab, redgram, greengram, groundnut, glyricidia, pongemia, jowar and ridgegourd.

Kanakaraj David (1957) observed *Aphis craccivora* Koch. (Homoptera : Aphididae) on 27 host plants including *D. lablab* in South India. The leaf hopper, *Amrasca* sp. (Homoptera : Cicadellidae) was found feeding on cluster beans, lablab, cowpea and *Trifolium alexandrinum*. The biology of tur pod bug, *Clavigrella gibbosa* Spinola (Hemiptera : Coreidae) has been studied by many authors (Gangrade, 1961; Singh and Patel, 1968).

In East Indies, the fly, *Melanagromyza phaseoli* Coq. (Diptera : Agromyzidae) attacked chiefly the members of *Phaseolus pisum* and *Vigna* groups and to a lesser extent it damaged the seedlings of soybean, sunhemp, lablab and redgram (Agarwal and Pandey, 1960). The extent of damage due to *Melanagromyza obtusa* Malloch (Diptera : Agromyzidae) to the redgram pods of different varieties ranged from 27 to 100 per cent (Gangrade, 1962).

The green bug, *Nezara viridula* Linn. (Hemiptera : Pentatomidae) was found feeding on cabbage, rice, maize, bhendi, citrus, tobacco, jute and cowpea. In the laboratory it was successfully reared on sweet potato castor, tomato, brinjal and lablab (Corpuz, 1969). Lefroy (1909) mentioned that *Clavigrella horrens* Dohrn. (Hemiptera : Coreidae) suck the sap from leguminous crops but was not so injurious, though some times abundant on tur.

Rachappa (2003) reported the incidence of the gall weevil, *Alcidodes collaris* on pigeonpea which started around 10-15 days after germination of the crop.

### 2.1.3 Pod borers

According to Aoki (1927) the larvae of *L. boeticus* occurred in large number on beans (*Rivya faba*) in December, causing serious damage. They fed chiefly on the pods and flowers, but also on the stalks. From Punjab, Singh and Dhooria (1972) reported an average of 5.7 per cent pea pod infestation by the caterpillars of *L. boeticus*.

Bruner (1931) reported the occurrence of *M. testulalis* on limabean in Cuba. The infestation began in September and attained peak during November-December and then decreased owing to the action of natural enemies. The damage and loss due to *M. testulalis* in Nigeria was generally higher (20-40%) on the late crop of cowpea than on the early crop (Taylor, 1967). In Uganda, however, the pest was responsible for causing 60 per cent damage to the green pods of cowpea (Nyiira, 1971).

Krishnamurthi and Appanna (1951) reported the occurrence of *Sphenarches caffer* Zeller (Lepidoptera : Pterophoridae) from October to January. Abdul and Awadalla (1959) recorded about 70 per cent damage due to *E. zinkenella* on lablab. The adults of the overwintered generation emerged in late February or early March and infested the crop.

According to Adimani (1976), percentage of damage due to *C. ptychora* to soybean pods just before harvest ranged from 10.5 to 91.29 on the crop sown during October and July, respectively. Similarly, the percentage of damage to seeds just before harvest was 20.20 to 36.32, respectively when the crop was sown during the above months. In Northern-Nigeria, Akinfenwa (1975) recorded peak larval and pupal populations in August and peak adult catches from light trap in November.

In Northern Nigeria, a detailed study was conducted by Raheja (1976) on per cent potential yield loss due to damage by *M. testulalis*, thrips, aphids and other insects together. The per cent loss during flowering period was 16, 52 and 48 during 1971, 1972 and 1973, respectively. While at pod formation stage, the potential per cent yield loss was 25.0, 25.0 and 21.0 during the respective years.

According to Kumar (1978) the pod borer damage on different pulses varied from crop to crop. In cowpea, the damage was as high as 94.67 and 78.93 per cent on pods and seeds, respectively.

The Lycaenid caterpillar, *L. boeticus* was active in all the crop growth stages of pea and arhar crops from last week of November to 1<sup>st</sup> week of March, (Pandey *et al.*, 1978). Govindan and Thontadarya (1982) reported that the lycaenid pod borer was found abundantly on field bean varieties which have thin pod coat. The per cent incidence varied from 2.0 to 15.5 during April to February, 1972-1973.

*Cydia ptychora* caused 20 to 30 per cent yield loss in cowpea in Nigeria (Perrin and Ezueh, 1979). Olaifa and Akingbhongbe (1982) observed the seasonal population fluctuation of *C. ptychora* on cowpea in Nigeria. The population increased from May to September and declined from November to April. Increasing temperature and decreasing relative humidity appeared to be associated with population decline, while the reverse favoured the population increase.

The seasonal abundance of *H. armigera* was studied for three seasons on many economic plants at Anand (Gujarat) from 1972-1975. Its activity commenced with the onset of monsoon on lucerne and then moved on to tomato, chickpea and then back to lucerne by April. The peak period of infestation was observed from December to February. The activity declined as the summer advanced and the pest become almost inactive during May, when high temperature prevailed. Potato was the most preferred host for *H. armigera* than chickpea, tomato and lucerne (Yadav *et al.*, 1986).

Lalasanghi (1984) studied the seasonal incidence of *M. testulalis* which peaked during the month of July, August and October. Karel (1985) reported from Tanzania that *M. testulalis* was more abundant and injurious (31% damage) to pods than *H. armigera* (13% damage). Seed damage by both species averaged at 16.0 per cent on beans. Jakhmola and Singh (1985) reported that *C. ptychora* caused 8.6 and 2.9 per cent damage to pod and grain, respectively, in greengram and 15.0 and 1.5 per cent damage to pod and grain, respectively, in blackgram. Mallikarjunappa (1989) recorded ten pod borers throughout cropping season viz., *A. atkinsoni*, *H. armigera*, *Sphaenarches caffer*, *E. zinkenella*, *M. testulalis*, *L. boeticus*, *C. ptychora*, *M. obtusa* and *Callosobruchus theobromae*.

Bhojar *et al.* (2004) recorded the seasonal incidence of pigeonpea pod borer complex. The pod borer, *H. armigera* incidence increased from the second week of October (42<sup>nd</sup> meteorological week) to first fortnight of February (7<sup>th</sup> meteorological week) with highest peak during the second fortnight of November (48<sup>th</sup> meteorological week). Whereas, the tur plume moth, *E. atomosa* was quite active from second week of November (46<sup>th</sup> meteorological week) to second week of February, (7<sup>th</sup> meteorological week) with its peak observed during last week of December (52<sup>nd</sup> meteorological week).

## 2.2 THE NATURAL ENEMY COMPLEX OF MAJOR POD BORERS

Natural enemies recorded on the larvae of *M. testulalis* included *Microbracon thurnesphaque* Mues and *Apanteles* sp. from Cuba (Bruner, 1931 and Leonard and Mills, 1931); a chalcid, *Brachymeria ovala* Say, a tachinid, *Nemorilla floralis* Fall (Bruner, 1935); a braconid parasite, *Phanerotoma philippinensis* Ashm. (Tjoa, 1937), *Bracon* (*Microbracon*) *hebetor* Say (Moutia, 1937); a scelionid, *Telenomus* sp., a chalcid, *Antrocephalus* sp., braconids, *Microdus* sp. and *Phanerotoma hendecasisella* (Cam.) (Subasingh and Fellows, 1978); The braconid parasitoids viz., *Tetrastichus* sp., *Phanerotoma* sp. and *Braunsia* sp., the tachinids, *Thelairosoma palposum* Villen and *Pseudoperichaetulaeris villen*, the predatory spider, *Sclenops radiatus* H. S. Gahan, predatory ant, *Componotus sericeus* (F.) the mantids, *Polyspilata aeraginola* (Goeze) and *Sphodromantis lineola* (Burm) have been reported by Usua and Singh (1980) while, *Agathis* sp. and *Phanesotoma* sp. have been reported from Bangalore (Vishakantaiah and Jagadeesh Babu, 1980).

High percentage of parasitisation of the caterpillar, *Sphenarches caffer* Zeller by *Apanteles paludicola* was observed by Pruthi (1937). Kumar (1978) reported a *Trichogramma* sp. as the egg parasitoid of the pod borer. According to him, the larval parasitoid of the pod borer, *C. ptychora* were *Diadegma* sp. and *Phanerotoma hendecasisella* Cameron, parasitized the larvae to the extent of five and three per cent, respectively.

Perrin and Ezueh (1979) reported several natural enemies of pod borer, *C. ptychora* which included *Apanteles* spp. *Braunsia* sp. *Opinis* sp. and *Phanerotoma* sp. belonging to family Braconidae as larval parasitoids. Olaifa and Akingbhongbe (1982) recorded *Bracon hancocki* as a major parasitoid of *C. ptychora* and also recorded 13 other hymenopterous parasitoids. An egg parasitoid, *Trichogramma* sp and a larval parasitoid *Phanerotoma hendecasisella* were recorded by Katti (1984).

Ramadas Rai (1983) reported that *Bracon greeni* (Ashmed), *Apanteles targame*, *Mosochorus* sp., as larval parasitoid of *M. testulalis*. Among them, *Bracon* sp. nr. *greeni* was the most abundant parasitoid. The total parasitisation ranged from 7.14 to 20.0 per cent and the maximum parasitisation occurred during November.

## 2.3 EXTENT OF LOSS CAUSED BY POD BORERS

### 2.3.1 Assessment of crop loss due to insect pests

A reliable information on crop loss due to insects and other pests to establish the increased yield, is obtainable when these agents are controlled at acceptable economic cost. Crop loss estimates are thus regarded as the best way to indicate to both the farmer and the consumer that the opportunities are gained when sound plant protection measures are applied (Chiarappa *et al.*, 1970).

Pradhan (1964) reported that a basic point which needs to be properly appreciated is the insect's capacity to increase its number, rather than the nature of its damage that makes all the difference between a major and a minor pest. Any insect pest which causes some kind of damage to the crop can become serious pest once its population reaches a critical level. This critical level depends on the nature of damage caused by the insect pest involved. Losses caused vary in time and space from 0 to 100 per cent and estimation is fairly easy at these two extremes but there are a large number of factors which tend to invalidate any estimation in between these extreme limits.

### 2.3.2 Techniques adopted in estimating losses due to insect pests

By counting the number of pods and seeds affected from various samples in pigeonpea fields, Ahmad (1938) worked out the percentage of seeds damaged by tur-pod fly.

The loss in yield due to pod borers has been assessed by several workers by following different techniques in case of redgram. Prasad (1961) carried out experiments for quantitative estimation of loss of cabbage due to natural population and by releasing known number of larvae, *Peris rapae* (Linnaeus) into the cages.

Gangrade (1962) reported a technique of assessing the loss in weight of the seeds by the attack of different pod borers. The weight of sound and damaged seeds were taken separately from the number and weight of sound seeds and the probable weight of total number of seeds was calculated.

An increased yield in mung (*Phaseolus aureus* Roxb.) over the check plots was obtained by treating with aldicarb against the pest complex (Bindra and Jakhmola, 1967, Regupathy *et al.*, 1970 and Saxena *et al.*, 1972).

### 2.3.3 Damage and losses due to pod borers

The damage due to pod borers was to the tune of 80.00 per cent in Lablab (Katagihallimath and Siddappaji, 1962). Taylor (1964) studied the extent of damage caused by pod borer, *M. testulalis* on cowpea in Nigeria. He considered it as a serious pest as it damaged about 35.0 to 20.00 per cent loss to cowpea pods in the early and late sown crops, respectively, with the corresponding infestation of 34.8 and 20.4 per cent on seeds. Nyiira (1971) recorded a damage of 18 to 20 per cent for the ripe and dry cowpea pods in Uganda.

Gubbaiah *et al.* (1975) observed 42 to 56 per cent damage to cowpea pods around Dharwad and they also observed the infestation on greengram, lima and soybean. Just before harvest of soybean crop, Adimani (1976) recorded 10.5 to 91.39 per cent pod damage due to pod borers with a seed damage ranging from 20.20 to 36.32 per cent.

The percentage of damage to pods and seeds varied from 52.92 to 46.69 on soybean, 36.71 and 11.90 on cowpea, 94.67 to 78.93 on greengram and 69.04 to 58.22 on blackgram, respectively. Whereas, the pulses, blackgram, avare, horsegram and redgram remained free from infestation (Kumar, 1978). Perrin and Ezueh (1979) reported 26 to 30 per cent yield loss in cowpea due to pod borer in Nigeria.

Lalasingi (1984) made an effort to estimate the loss caused by *M. testulalis* on cowpea. He noticed 37.08 per cent loss in yield in cowpea protected at its different growth stages. The pod borer, *C. ptychora* caused 8.6 and 2.9 per cent damage to pod and grain in greengram and 15 per cent pod damage and 1.5 per cent grain damage in black gram (Jakhmola and Singh, 1985).

Karel (1985) recorded 33 to 53 per cent seed yield loss in cowpea due to pod borers, *M. testulalis* and *H. armigera*. The crop loss due to the pod borer, *Adisura atkinsoni* in field bean was to the extent of 11.82 quintals per hectare (Mallikarjun and Rajgopal, 1991).

A study was conducted to estimate the loss in pigeonpea due to gram caterpillar following different schedules of insecticides. Highest grain yield (869 kg/ha) was obtained in completely protected plot as compared to untreated control (357 kg/ha). The yield loss was minimum (9.43 kg/ha) in the plot where protection with insecticide (endosulfan 0.07%) was imposed at 50 per cent flowering stage while, the maximum loss was noticed in untreated control (58.91 kg/ha) (Kanakaraju, 1991).

Supriyatin (1992) reported the yield loss by pod damaging pests of soybean. Among the different pests, *Etiella* sp. caused 26 per cent pod damage and 23 per cent seed damage.

Extensive field surveys were carried out in 44 districts of Uttar Pradesh during 1978-84 to assess the damage caused by insect pests to seeds of pigeonpea. The borers recorded were *H. armigera*, *E. atomosa*, *L. boeticus* and *M. obtusa* and the bruchids, *Callosobruchus* spp. The major loss was due to *H. armigera* and *M. obtusa*. (Lal *et al.*, 1981).

## 2.4 EVALUATION OF INDIGENOUS MATERIALS AND NEW MOLECULES AGAINST POD BORERS

### 2.4.1 Field evaluation of indigenous materials for the management of pod borers

Abdul (1980) evaluated various neem products against gram pod borer and found that neem seed kernel extract (5%) registered lowest infestation and recorded highest yield. There was no significant difference in pod borer damage as well as yield in all the treatments of NSKE 5 per cent and neem leaf extract 5 per cent including insecticides used for comparison, in chickpea ecosystem (Anon., 1984).

Kumar and Sangappa (1984) compared the efficacy of plant products for the control of gram caterpillar in bengal gram. From the results it was evident that honge oil @ 5% concentration recorded least pod damage (1.05%), however, it was on par with NSKE 5%, neem oil 5%, honge oil 3% and endosulfan @ 0.07%. Ethanolic extracts of NSKE lowered the incidence of *H. armigera*, *M. testulalis* and *Melanagromyza obtusa* on pigeonpea. In general, the extracts offered less protection as compared to fenvalerate against lepidopterous borers (Singh and Rai, 1985). The ethanolic neem kernel extract reduced the incidence of *H. armigera*, *M. testulalis* and *M. obtusa* (Singh and Rai, 1985).

In another study, the cotton boll worm infestation was significantly influenced by plant extract. The lower boll worm incidence was recorded in NSKE (10.3%), datura and neem oil emulsion, whereas, the maximum yield was obtained with endosulfan (14.69 q/ha) which was statistically on par with NSKE, datura and garlic at 10 per cent concentration (Anon., 1987).

Bhat *et al.* (1988) reported that neem seed extract was the next best treatment to monocrotophos against the pod borers, *M. testulalis* and *C. ptychora* on cowpea. However, the neem seed kernel extract and neem leaf extract were highly effective in controlling *H. armigera* on chickpea than on pigeonpea (Sachan and Lal, 1993). Kareem *et al.* (1988) evaluated the efficacy of neem seed bitter (NSB) @ 5000 ppm and NSKE (3%) against pod borers (*Etiella* spp, *Maruca* sp. and *Heliothis* sp). The per cent pod damage was significantly reduced by NSB (22%), NSKE (20%) and monocrotophos (16%) as against untreated control (34%). However, the grain yield of mungbean was highest in the plots treated with insecticide followed by neem treated plots (Amarnath, 2000).

Thakur *et al.* (1988) reported higher efficacy of neem kernel and leaf extracts @ 5 per cent in reducing *H. armigera* larval population on chickpea after one week of spraying. Sinha (1993) revealed that neem seed kernel water extract at 5 per cent and neem wettable powder (NWP) at 0.25 per cent were found on par with endosulfan (0.07%) in reducing *H. armigera* infestation in chickpea. Sachan and Lal (1993) reported that NSKE and neem leaf extract were found more effective in controlling the podborer, *H. armigera* on chickpea as compared to pigeonpea. In the order of efficacy, neem seed kernel extract 5per cent, neem oil

(300 ppm) and endosulfan 0.07 per cent, were found to suppress *H. armigera* on chickpea (Ramteke *et al.*, 2002).

Panchabhavi *et al.* (1994) conducted a field experiment with insecticides and neem seed extract against *H. armigera* on pigeonpea. Lower pod damage and higher seed yield was recorded when fenvalerate was applied twice at 15 days interval. However, highest cost benefit ratio was obtained in NSKE sprayed at 15 days interval with a seed yield of 12.0 q/ha.

Sarode *et al.* (1994) recorded minimum grain damage (11.37%) in NSKE (6%) treatment which stood at par with NSKE (5%). Highest redgram yield (10.89 q/ha) was obtained in NSKE (6%) as compared to 10.54 q/ha in NSKE (5%).

Vijayalaxmi *et al.* (1996) reported the effectiveness of garlic extract in combination with other extracts like neem, chilli, ginger, tobacco and cow urine (with soap solution) against *H. armigera* and *S. litura* upto 13 days of spray. The ginger extract as natural pesticide, alone and in combination with other plant products like chilli, garlic and cow urine was found effective against *H. armigera* (Vijayalaxmi *et al.*, 1996).

Kasyappa (1998) reported from Medhak district of Andhra Pradesh that chilli + garlic extract, jaggery solution and NSKE spray were the common practices followed by local farmers for the pest management in different crops.

Mallapur (2002) evaluated indigenous materials like nimbecidine @ 5 ml/l, GCK (garlic chilli kerosene extract) @ 0.5 per cent + nimbecidine @ 2.5 ml/l, GCK alone (0.5 and 1%), turmeric + cow urine (25%) parthenium extract (17%) and cow urine (17%) for the management of chilli pests. Among the different treatments GCK at 0.5 per cent + nimbecidine @ 2.5 ml/l recorded least per cent fruit damage due to fruit borer, *H. armigera* and recorded highest yield (11.3 q/ha).

Ladaji (2004) reported that the treatment pongamia leaf extract (10%) + NSKE (10%) + aloe (5%) + cow urine (30%), GCA (2%) + GCK (0.5%) and vitex leaf extract (20%) + clerodendron extract (4%) + cow urine (17%) were efficient against *H. armigera* in chickpea by recording maximum reduction in larval population (56.11, 46.85 and 46.85% respectively) with higher pod yield (9.42, 8.62 and 8.45 q/ha, respectively).

Ravi Kumar (2004) reported that NSKE 5 per cent recorded lowest larval population (1.01/plant) as well as per cent fruit damage (7.57%), followed by garlic chilli kerosene extract at 10 per cent. The efficacy of NSKE 5 per cent (79.32 q/ha), NSKE 5 per cent + cow urine 10 per cent (78.00 q/ha), garlic chilli kerosene extract 3 per cent (76.23 q/ha), NSKE 5 per cent + garlic extract 3 per cent (83.67 q/ha) remained at par in recording higher yield of green chilli.

#### 2.4.2 Evaluation of new molecules for the management of pod borers

Balasubramanian *et al.* (1976) evaluated the effectiveness of various insecticides for the control of pod borer, *M. testulalis* on redgram. The incidence of the pest and mean grain yield data indicated that the application of two sprays of 0.07 per cent endosulfan 35 EC at 15 days interval starting from pod formation stage, gave good results. Whereas, Dina and Meddiyedu (1976) suggested the application of two sprays of endosulfan @ 0.6 kg per hectare at 2 weeks interval starting from 35 days after planting, gave best protection to flowers and pods of cowpea from *M. testulalis* and other borers, but did not enhance the grain yield significantly compared to monocrotophos, gamma-BHC and fenitrothion. Sangappa *et al.* (1977) reported that the application of endosulfan 0.07 per cent, carbaryl 0.1 per cent and chlordane 0.07 per cent, three times at an interval of 15 days, starting from the blossom stage proved very effective in controlling *M. testulalis* and other pod borers in redgram. In Uttar Pradesh, *M. testulalis* and other pod borers on redgram were reported to be effectively controlled with sprays of endosulfan (0.07%), monocrotophos (0.03%) and dimethoate (0.03%) @ 1000 litres per hectare (Srivastava, 1980).

Lal *et al.* (1981) suggested to use monocrotophos 0.04 per cent or endosulfan 0.07 per cent sprays @ 400-600 litre per hectare, or endosulfan 2 per cent or quinalphos 1.5 per cent dusts @ 20-25 kg/ha four to six weeks after sowing or at pod formation stage for the control of pod borer, *M. testulalis* and other pod borers of cowpea. The application of endosulfan @ 0.07 per cent, chlorpyrifos @ 0.04 per cent and fenvalerate @ 0.04

per cent gave better results against *H. armigera* on bengalgram (Yadav and Yadav, 1983). Ujagir and Khare (1987) indicated critical stage for application of insecticides as flowering, pod formation and maturation stage in chickpea and recommended two sprays of endosulfan (0.07%) at pod initiation and maturation stage to obtain higher yield.

Venkateswaralu *et al.* (1992) concluded that the application of 2 sprays of either monocrotophos or endosulfan at 15 days interval was most effective in reducing the infestation of pod borer complex in bengalgram. Srivastava *et al.* (1984) opined that two sprays consisting of endosulfan 35 EC (0.07%) and nimbecidine (0.2%) were quite effective in suppressing the pod borer menace in chickpea. Application of endosulfan 35 EC @ 0.07 per cent from flowering to pod maturation stage showed minimum pod damage thereby reducing the losses in early pigeonpea cultivars (Chaudhary and Sachan, 1997). Biradar *et al.* (1998) observed that spraying of insecticides 5 times at 15, 30, 45, 60 and 75 days after chickpea sowing recorded least pod borer incidence (18.71%) with higher seed yield of 11.5 q/ha, which resulted 25.5 per cent increased yield over untreated control.

Dandale *et al.* (2000) studied the efficacy of spinosad against cotton bollworm in comparison with some synthetic pyrethroids. The treatment spinosad 48 SC @ 50 and 75 g a.i./ha was equally effective as that of synthetic pyrethroids (Decis® Tablets and Bulldock®) in controlling the bollworms. The chemical retained its effectiveness against *H. armigera* even after 14 days of spraying. Walunj *et al.* (2001) proved the superiority of spinosad 48 SC @ 15 g a.i./ha against diamond back moth for a period of one week with better yield of marketable cabbage heads. None of the insecticidal treatments showed any phytotoxic effect on cabbage crop. Siddegowda *et al.* (2003) noticed that spinosad 45 SC at higher dosages recorded significantly lower pod damage and higher grain yield. However, the lower dosages of spinosad @ 50 g a.i./ha recorded pod damage and grain yield on par with endosulfan @ 700 g a.i./ha in pigeonpea.

Among the varying dosage of indoxacarb evaluated against American bollworm on cotton, the higher dosage (80 g a.i./ha) gave better control and resulted in higher seed cotton yield than chlorpyrifos and the treatment did not cause any resurgence of sucking pests as that of chlorpyrifos. Further, the new molecule was relatively safer to the beneficial arthropods (Dhawan and Simwat, 2000). Indoxacarb was effective at 60 g a.i./ha when sprayed thrice at 20 days interval against tomato fruit borer, *H. armigera* (Muthukrishna *et al.*, 2002).

Bhoyar *et al.* (2004) evaluated biointensive treatments for the management of pod borer complex in pigeonpea, which showed significant differences over untreated control. Treatment of spinosad 2.5 SC and endosulfan 35 EC, were the most promising treatments in terms of least mean pod damage (11.85 and 17.80 %) and grain damage (13.51 and 20.41 %) as against 28.65 and 41.17 per cent pod and grain damage in untreated control. The yield data also reflected the similar trend with grain yield of 14.43 and 12.88 q/ha in spinosad and endosulfan, respectively, compared to 7.76 q/ha in untreated control.

Ladaji (2004) reported that the new molecule, spinosad 48 SC (@ 0.2 ml/l) proved significantly superior over rest of the molecules by reducing the pod borer incidence in chickpea to the extent of 84.43 and 82.04 per cent after first and second spray and the treatment recorded highest pod yield of 14.53 q/ha. The other better treatments to follow included spinosad (@0.1 ml/l), indoxacarb (0.5 ml/l) and emamectin benzoate (0.4 g/l). However, the highest IBC ratio (11.26) was obtained with lambda cyhalothrin. Udikeri *et al.* (2004) reported that the damage due to bollworms was least in emamectin benzoate (4.19%) which resulted in significantly more number of good opened bolls as well as higher seed cotton yield (15.93 q/ha) as compared to untreated check (9.71 q/ha). Similar results were also obtained by Giraddi *et al.* (2004).

### III. MATERIAL AND METHODS

The materials used and methodology adopted for conducting various experiments to fulfil the objectives of the study are presented here under.

The studies were carried out at the Main Agricultural Research Station (MARS), University of Agricultural Sciences (UAS), Dharwad. Dharwad, a district head quarter in Northern Karnataka, is situated at 15° 26' North latitude, 70° 07' East latitude and at an altitude of 731.8 m above mean sea level (MSL). The place lying in Northern transitional zone (Zone-8) receives an annual rainfall of 751 mm distributed well over the season. The meteorological data collected from MARS, UAS, Dharwad during the period of study is furnished in Appendix-I.

#### 3.1 STUDIES ON PEST COMPLEX OF DOLICHOS BEAN WITH SPECIAL REFERENCE TO POD BORERS

The studies were carried out to know the pest scenario of dolichos bean during the year 2003-2004 at MARS, Dharwad. Konkanbushan, a popular dolichos bean variety was sown during third week of August and first week of September 2003-04 on an area of one gunta each to know the abundance of pest species at 2 different sowing dates.

After crop germination, the observations were made at 5 spots per plot on five randomly selected plants at each spot. The observations were made at weekly intervals.

The incidence of cutworms and ground beetles were estimated by making counts on number of insects per 5 plants and the sucking pest population was recorded by counting the number of leaf hoppers, thrips and aphids per 3 leaves on tagged plants. Similarly, the incidence of bug population was estimated by taking observation on number of bugs recorded on 5 plant per spot.

To assess the incidence of pod borers, viz., *Maruca testulalis*, *Helicoverpa armigera*, *Cydia ptychora*, *Lampides boeticus*, *Etiella zinckenella* and *Exelastis atomosa*, the observations were made at weekly interval on randomly selected five plants and the per cent damage was estimated by counting both damaged and total number of pods and also assessment was made on the damage due to individual species of pod borer complex by subjecting the damaged pods to cut open and observe for the species concerned.

The immature stages of different insect species occurred on the crop were collected and reared in the laboratory till adult emergence to confirm the species identity.

#### 3.2 TO STUDY THE NATURAL ENEMY COMPLEX OF MAJOR POD BORERS

During the course of study observations were also made on the natural enemies of dolichos bean pod borers. For the study, 100 damaged pods, each from three spots were collected from the field at an interval of 15 days. From these infested pods, larvae of individual species were reared separately upto adult stage to study the per cent parasitisation. The natural enemies collected got identified from Project Directorate of Biological Control, Bangalore. The number of predators on the tagged plants were also counted in the field on whole plant basis.

#### 3.3 TO STUDY THE EXTENT OF LOSS CAUSED BY POD BORERS

Assessment of loss in yield due to pod borer infestation in dolichos bean was studied by protecting the crop at different stages of growth. The crop was raised over a plot size of 1.5 m x 1.6 m with a spacing of 20 x 30 cm. The experiment included seven treatments, each replicated 3 times in randomized block design. All the recommended package of practices were followed for raising the crop except plant protection measures.

The following seven treatments were imposed after pod initiation stage (45 DAS) at an interval of 15 days.

Treatments

T<sub>1</sub> – No protection

T<sub>2</sub> – One spray with fenvalerate @ 0.5 ml/l at 45 DAS

T<sub>3</sub> – Two sprays with fenvalerate @ 0.5 ml/l at 45 and 60 DAS

T<sub>4</sub> – Three sprays with fenvalerate @ 0.5 ml/l at 45, 60 and 75 DAS

T<sub>5</sub> – Four spray with fenvalerate @ 0.5 ml/l at 45, 60, 75 and 90 DAS

T<sub>6</sub> – Five spray with fenvalerate @ 0.5 ml/l at 45, 60, 75, 90 and 105 DAS

T<sub>7</sub> – Supervisory control

In case of supervisory control, the spraying with fenvalerate @ 0.5 ml/l was done as and when the pest incidence was noticed.

When the crop matured, the pods were harvested plot wise and pod yield was recorded. The per cent pod damage was also noted based on the number of damaged pods out of 100 randomly selected pods per plot.

The probable loss due to pod borers was computed by comparing the yields obtained from different plots which were exposed to varied level of insecticide application against the treatment which was protected throughout the crop growth period by using the insecticide.

For economic injury level (EIL) determination, the parameters like pest density level, cost of plant protection, yield per plot and the average market price of the produce were taken into consideration. The EIL was computed by using the procedure given by Stone and Pedigo (1972) which was modified by Ogunlana and Pedigo (1974) as given below.

$$\text{Gain threshold} = \frac{\text{Management cost}}{\text{Market value of produce (green pods)}}$$

$$\text{EIL} = \frac{\text{Gain threshold}}{\text{Regression coefficient}}$$

The cost of pest control included the chemical cost (fenvalerate) as well as its application cost including labour charges. The cost of fenvalerate was taken at Rs.520/l and the market price of produce was taken at Rs. 800/q.

The regression coefficient 'b' between the two parameters namely population levels (x) and reduction in pod yield (y) and the regression model were calculated by using the following formula.

$$b = \frac{\sum xy - \sum x \sum y / N}{\sum x^2 - (\sum x)^2 / N}$$

where 'N' being the total number of observations, 'x' being the population levels of the pod borers per plant and 'y' being the pod yield.

## 3.4 EVALUATION OF INDIGENOUS MATERIALS AND NEW MOLECULES AGAINST POD BORERS

### 3.4.1 Preparation of indigenous products

The products required for the experimentation were prepared in the laboratory. The procedures adopted for the preparation of various indigenous products have been highlighted hereunder.

#### 3.4.1.1 Preparation of Neem Seed Kernel Extract (NSKE) 5 per cent

Fifty gram of neem seeds were shade dried, crushed and then soaked overnight in little quantity of water. Later the mixture was squeezed and filtered through the muslin cloth and the volume was made upto one litre so as to obtain 5 per cent NSKE.

#### 3.4.1.2 Preparation of Garlic Chilli Kerosene Extract (GCK) 0.5 per cent

5 g of each of dried garlic bulb and green chilli pods were thoroughly ground separately with the help of pestle and mortar. The crushed materials were soaked in kerosene (5 ml each) overnight, separately. Next day the extracts of garlic and chilli were mixed and filtered. Later, the volume was made upto 1000 ml to obtain 0.5 per cent garlic chilli kerosene extract.

#### 3.4.1.3 Preparation of aqueous extract of garlic (GE) 1 per cent

Dried 10 g garlic bulbs were crushed and soaked in 100 ml of water overnight. The contents were squeezed filtered through muslin cloth. The volume was then made upto one litre by adding water to obtain 1 per cent extract.

#### 3.4.1.4 Preparation of fermented cow urine 5 per cent

Fresh cow urine was collected in the morning on the day of spray. 5 ml of cow urine was mixed with 100 ml of water to get 5 per cent concentration. To get fermented cow urine, freshly collected cow urine was kept for 4 to 5 days in a bottle as such and then the required concentration was prepared.

### 3.4.2 Field evaluation of indigenous materials and new molecules for the management of pod borers

A field trail was conducted during 2003-04 at Main Agricultural Research Station, Dharwad. The experiment was laid out in randomized block design with 12 treatments replicated thrice in 1.5 x 1.6 m plot size. The dolichus bean (Konkanbushan variety) was raised as per the recommended package of practices except plant protection measures.

The treatments were imposed by using Knapsack sprayer @ 400-500 liters of spray solution/ha depending on stage of the crop. The crop received a total of 4 sprays, the first being given after pod initiation (45 DAS) while 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> sprays were imposed on need basis.

The number of pod borers were counted on 5 randomly selected plants in each plot. The pretreatment count was made a day before each spray while, the post treatment counts were made on 2<sup>nd</sup>, 5<sup>th</sup> and 10<sup>th</sup> day after each spray.

The observations were also made on the total number of pods and the affected ones on five randomly selected plants, at harvest in order to determine the per cent pod damage.

At each harvest, the number of healthy and damaged seeds per 10 pods were recorded in order to determine the per cent seed damage. The data obtained were subjected for arcsine transformation and then statistically analyzed. Finally the pod yield was recorded on the net plot area basis which was later converted to q/ha and subjected to statistically analysis. The treatment details are as follows.

Details of indigenous materials and new molecules used for field assessment against pod borers

Tr. No.	Treatment details
T <sub>1</sub>	NSKE (5%)
T <sub>2</sub>	NSKE (5%) + cow urine (5%)
T <sub>3</sub>	GCK (0.5%)
T <sub>4</sub>	GCK (0.5%) + cow urine (5%)
T <sub>5</sub>	GE (1%)
T <sub>6</sub>	GE (1%) + cow urine (5%)
T <sub>7</sub>	Spinosad 45 SC (@ 0.2 ml/l)
T <sub>8</sub>	Emamectin benzoate 5 SG (@ 0.2 g/l)
T <sub>9</sub>	Indoxacarb 14.5 SC (@ 0.1 g/l)
T <sub>10</sub>	Fenvalerate 20 EC (@ 0.5 ml/l)
T <sub>11</sub>	Endosulfan 35 EC (@ 2 ml/l)
T <sub>12</sub>	Untreated control

NSKE – Neem seed kernel extract  
GCK – Garlic chilli kerosene extract  
GE – Garlic extract

## IV. EXPERIMENTAL RESULTS

The results of investigations made to study the pest complex of field bean with special reference to pod borers, natural enemy complex of major pod borers, extent of loss caused by pod borers and evaluation of indigenous products against pod borers during 2004-05 under laboratory (Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad) as well as under field (Main Agricultural Research Station, Dharwad) conditions are presented in this chapter.

### 4.1 STUDIES ON PEST COMPLEX OF DOLICHOS BEAN WITH SPECIAL REFERENCE TO POD BORERS

Based on the observations made at various growth stages of field bean to know the occurrence of insect pests on the crop from seedling stage till harvest of the crop are reported below under the respective groups of insects. A total of 25 species of insect pests were found feeding or damaging on the crop during the experimental period. The list of insect pests observed on field bean under Dharwad condition is as follows.

Sl. No.	Insect pest	Scientific name	Systematic position (family and order)	Level of incidence
1.	Cutworms	Unidentified	Noctuidae : Lepidoptera	Low
2.	Ground beetles	Unidentified	Carabidae : Coleoptera	Low
3.	Grass hoppers	<i>Chrotogonus</i> sp. <i>C. ranacea</i>	Acrididae : Orthoptera	Low
4.	Hairy caterpillar	<i>Spilosoma obliqua</i>	Arctiidae : Lepidoptera	High
5.	Leaf miner	Unidentified	Gracillariidae: Lepidoptera	Low
6.	Gall weevil	<i>Alcidodes collaris</i>	Curculionidae : Coleoptera	Medium
7.	Semilooper	<i>Plusia signata</i>	Noctuidae : Lepidoptera	Low
8.	Blister beetle	Unidentified	Meloidae : Coleoptera	Low
9.	Leafhopper	Unidentified	Cicadellidae : Homoptera	Low
10.	Aphid	<i>Aphis craccivora</i>	Aphididae : Homoptera	High
11.	Thrips	Unidentified	Thripidae : Thysanoptera	Medium
12.	Eurybrachid bug	<i>Eurybrachys tomentosa</i>	Eurybrachidae : Homoptera	Low
13.	Coried bugs	<i>Riptortus pedestris</i> <i>Anoplocnemis phasiana</i> <i>Clavigrella gibbosa</i> <i>C. horrens</i>	Coreidae : Hemiptera	High
14.	Pentatomid bugs	<i>Nezara viridula</i> <i>Dolicoris indicus</i>	Pentatomidae : Hemiptera	High
15.	Spotted pod borer	<i>Maruca testulalis</i>	Pyralidae : Lepidoptera	High

16.	Gram pod borer	<i>Helcoverpa armigera</i>	Noctuidae : Lepidoptera	High
17.	Blue butterfly	<i>Lampides boeticus</i>	Lycaenidae : Lepidoptera	High
18.	African pea moth	<i>Cydia ptychora</i>	Tortricidae : Lepidoptera	Medium
19.	Plume moth	<i>Exelastis atomosa</i>	Pterophoridae : Lepidoptera	High
20.	Pea pod borer	<i>Etiella zinckenella</i>	Phycitidae : Lepidoptera	Medium

#### 4.1.1 Soil borne pests

Cut worms and ground beetles were found at the seedling stage to a negligible extent (2 cut worms/10 plant and 3 ground beetle/10 plant).

#### 4.1.2 Defoliators

The grass hoppers were found mostly in the vegetative stage of the crop feeding on the leaves making irregular holes. The surface grass hopper, *Chrotogonus* sp. was observed feeding on young plants during September and *C. ranacea* were found feeding on the crop during September and October. However, these grasshoppers were not noticed as regular and serious pests.

The hairy caterpillar, *Spilosoma obliqua* (Walker) (Lepidoptera : Arctiidae) appeared in large number on the crop. The early instars fed gregariously on the under surface of the leaves by scraping the leaves. The early infestation was seen on isolated plants. Grown up caterpillars consumed the leaves, scraped the pod coat and fed on the seeds. The percentage of infestation was quite high from October to February (3 to 4/plant).

The leaf miner infestation was noticed on the crop during September month. The extensive mining resulted in big blotches on the leaves.

*Alcidodes collaris* Bascoe (Coleoptera : Curculionidae) incidence was observed from September to November. The grub bored into the stem and made a gall was the common symptom observed.

The semilooper, *Plusia signata* was noticed in early stage of the crop (*i.e.*, during September) to a negligible extent and found feeding on the leaves. The blister beetle incidence was also observed to a negligible extent which found feeding on the flowers.

#### 4.1.3 Sucking pests

*Aphis craccivora* Koch (Homoptera : Aphididae) harboured the crop from September to January. The aphid population was more on early (3<sup>rd</sup> week of August) sown crop (30.5 to 50.0 aphids/3 leaves) (Table 1) compared to late (1<sup>st</sup> week of September) sown crop (8.40 to 11.20) (Table 2). The aphid preferred to attack the inflorescence, tender pods and also the terminal twigs resulting in twisting of pods and stunted plant growth.

The leaf hopper population commonly appeared in the vegetative phases of the crop with the population ranging from 2.20 to 5.20 hopper/3 leaves. Both nymphs and adults suck the sap from ventral surface of the leaves and the affected leaves curled down wards and became inverted cup shaped.

The thrips incidence was found during September to October on the leaves as well as inside the flowers. The population ranged from 4.7 to 7.6 thrips per 3 leaves on early sown crop as compared to 1.20 to 3.36 thrips/3 leaves in late sown crop.

**Table 1 : Occurrence of sucking pests on August sown crop**

<b>Pests</b>	<b>15 DAS</b>	<b>30 DAS</b>	<b>45 DAS</b>	<b>60 DAS</b>	<b>75 DAS</b>	<b>90 DAS</b>	<b>105 DAS</b>	<b>120 DAS</b>	<b>135 DAS</b>
Leaf hopper/3 leaves	3.20	4.60	5.20	2.20	0.00	0.00	0.00	0.00	0.00
Thrips/ 3 leaves	6.50	6.90	7.60	4.70	0.00	0.00	0.00	0.00	0.00
Aphids/3 leaves	30.5	35.5	40.00	50.0	42.0	38.0	37.0	36.5	30.00
Coreid bugs / 5 plant	0.2	0.41	1.02	9.20	10.8	7.8	6.0	3.4	0.80
Pentatomid bugs/5 plant	0.1	0.2	0.86	4.30	3.80	2.0	1.6	0.41	0.20

Coreid bugs : (*Riptortus pedestris*, *Anoplocnemis phasiana*, *Clavigrella gibbosa*, *C. horrens*)

Pentatomid bugs : (*Nezara viridula*, *Dollicoris indicus*)

**Table 2 : Occurrence of sucking pests on September sown crop**

<b>Pests</b>	<b>30 DAS</b>	<b>45 DAS</b>	<b>60 DAS</b>	<b>75 DAS</b>	<b>90 DAS</b>	<b>105 DAS</b>
Thrips /3 leaves	2.70	3.36	1.20	1.24	0.00	0.00
Aphids/ 3 leaves	11.00	11.20	9.40	9.60	8.40	9.00
Eurybrachid bug/5 pl	0.00	0.40	2.00	3.00	0.80	0.41



**Plate 1a: Eggs of *R. Pedestris***

Plate 1a : Eggs of *R.Pedestris*



**Plate 1b: Adult of *R. Pedestris***

Plate 1b : Adults of *Riptortus pedestris*



**Plate 1c: Pod damage due to *R. Pedestris***

**Plate 1c : Pod damage due to *R.pedestris***



**Plate 1d: Seed damage due to *R. Pedestris***

**Plate 1d : Seed damage due to *R.Pedestris***

The bug, *Eurybrachys tomentosa* Fabricius (Hemiptera : Eurybrachidae) was found sucking the sap from the twigs on September sown crop to a limited extent (0.4 to 3.0/5 plant). In rare cases the bugs were seen sucking on the pods. The adults of *Anoplocnemis phasiana* F. were found sucking sap from tender twigs during September to December. Whereas, the nymphs and adults of *Clavigrella gibbosa* and *C. horrens* were seen sucking sap from the pods from October to January. *Riptortos pedestris* was found in severe form at later stages. Both nymphs and adults were found sucking the sap from pods (Plate 1a, 1b, 1c and 1d). The population ranged from 0.02 to 10.80 per 5 plants on August sown crop. While, the incidence was negligible on September sown crop.

The incidence of *Dollicoris indicus* and *N. viridula* (Hemiptera : Pentatomidae) was noticed throughout the crop season with a mean population range of 0.2 to 4.3 bugs per 5 plants (Table 1 and 2) and compared *D. indicus* the incidence *N. viridula* was more.

#### 4.1.4 Pod borer complex

The pod borer species encountered during the study included spotted pod borer, *M. testulalis*, gram pod borer, *H. armigera*, blue butterfly, *L. boeticus* L., African pea moth, *C. ptychora*, plume moth, *E. atomosa* and pea pod borer, *E. zinckenella*.

In August sown crop, among the various pod borer species, *M. testulalis* was found quite predominant at all the stage of crop growth with 9.14 per cent pod damage on 45 days crop to 34.95 per cent pod damage on 108 days old crop. Thereafter, the per cent pod damage declined and reached to 14.00 per cent at 136 days.

Similar was the case with other pod borers, viz., *H. armigera*, *C. ptychora*, *L. boeticus*, *E. atomosa* and *E. zinckenella*, in which the damage was initiated on 45 to 52 days old crop and peaked (20.05, 9.10, 13.80, 15.10 and 10.90%) at 73, 59, 122, 115 and 108 days of sowing, respectively.

The total per cent pod damage which was 30.12 per cent initially (45 DAS) increased gradually and reached peak (82.07 %) at 108 days of sowing. Afterwards, it started declining, reaching 35.50 per cent at 136 days (Table 3).

In September sown crop, among the various pod borer species, *M. testulalis* was found quite predominant at all the stages of crop growth with 5.3 per cent pod damage on 52 days crop to 12.16 per cent damage on 66 days old crop. Thereafter, the per cent pod damage declined and reached 4.07 per cent at 87 days. The other pod borers viz., *H. armigera*, *C. ptychora*, *L. boeticus*, *E. atomosa* and *E. zinckenella* damaged 45 to 52 days old crop and peaked (5.22, 1.5, 3.3, 8.9 and 6.6%) after 66, 66, 80, 73 and 66 days of sowing, respectively. The total pod damage ranged from 19.96 per cent initially (52 days) to 35.01 per cent at 73 days of sowing (Table 4).

Comparatively more green pod yield (3.69 q/ha) was obtained in early sown crop. The late sown crop with less crop duration (87 days) resulted in poor yield (2.3 q pod /ha) as compared to 136 days in the August sown crop.

**Table 3 : Pod damage due to individual species of pod borers (August sown crop)**

Crop age (days)	Per cent pod damage due to						Total
	<i>M. testulalis</i>	<i>H. armigera</i>	<i>C. ptychora</i>	<i>L. boeticus</i>	<i>E. atomosa</i>	<i>E. zinckenella</i>	
45	9.14 <sup>j</sup>	8.20 <sup>fg</sup>	6.58 <sup>cd</sup>	0.00 <sup>j</sup>	6.20 <sup>h</sup>	0.00 <sup>h</sup>	30.12
52	7.40 <sup>k</sup>	8.10 <sup>fg</sup>	7.20 <sup>bcd</sup>	6.50 <sup>fg</sup>	5.50 <sup>hi</sup>	3.75 <sup>g</sup>	38.45
59	12.32 <sup>i</sup>	12.51 <sup>d</sup>	9.10 <sup>a</sup>	4.00 <sup>i</sup>	9.75 <sup>de</sup>	3.00 <sup>g</sup>	50.68
66	17.60 <sup>g</sup>	15.50 <sup>c</sup>	7.90 <sup>b</sup>	5.60 <sup>gh</sup>	10.01 <sup>de</sup>	3.60 <sup>g</sup>	60.21
73	21.76 <sup>f</sup>	20.05 <sup>a</sup>	7.80 <sup>b</sup>	5.37 <sup>h</sup>	4.50 <sup>ig</sup>	5.40 <sup>f</sup>	64.88
80	23.50 <sup>e</sup>	18.50 <sup>b</sup>	8.05 <sup>b</sup>	6.90 <sup>f</sup>	11.15 <sup>c</sup>	6.58 <sup>e</sup>	74.68
87	25.53 <sup>d</sup>	17.94 <sup>b</sup>	7.85 <sup>b</sup>	7.80 <sup>e</sup>	9.44 <sup>d</sup>	7.70 <sup>d</sup>	76.26
94	32.95 <sup>b</sup>	10.55 <sup>e</sup>	7.75 <sup>b</sup>	10.37 <sup>d</sup>	9.00 <sup>ef</sup>	7.50 <sup>d</sup>	78.12
101	32.00 <sup>b</sup>	9.20 <sup>ef</sup>	7.50 <sup>bc</sup>	11.40 <sup>c</sup>	8.32 <sup>fg</sup>	9.95 <sup>b</sup>	78.37
108	34.95 <sup>a</sup>	8.52 <sup>ef</sup>	6.80 <sup>cd</sup>	12.60 <sup>b</sup>	8.30 <sup>fg</sup>	10.90 <sup>a</sup>	82.07
115	31.20 <sup>b</sup>	6.10 <sup>gh</sup>	5.40 <sup>e</sup>	12.20 <sup>bc</sup>	15.10 <sup>a</sup>	10.30 <sup>a</sup>	80.30
122	29.50 <sup>c</sup>	6.00 <sup>gh</sup>	4.25 <sup>f</sup>	13.80 <sup>a</sup>	13.10 <sup>b</sup>	9.40 <sup>bc</sup>	76.05
129	15.20 <sup>h</sup>	4.30 <sup>h</sup>	3.05 <sup>g</sup>	12.30 <sup>bc</sup>	7.60 <sup>g</sup>	9.39 <sup>bc</sup>	51.84
136	14.00 <sup>h</sup>	1.30 <sup>i</sup>	1.20 <sup>h</sup>	6.50 <sup>fg</sup>	5.00 <sup>i</sup>	7.50 <sup>d</sup>	35.50

Yield obtained : 3.69 q/ha

Means followed by same letter in the column do not differ significantly by DMRT ( $\rho = 0.05$ )

Original values were transformed into arc sine transformation before analysis

#### 4.1.4.1 Nature of damage

In case of spotted pod borer, *M. testulalis*, the caterpillar was found boring into the half matured pods. The early instar larvae entered into the seeds and fed on the contents of pods remaining inside whereas, the grown up larvae caused damage by excavating the seeds. The infested pods when opened, revealed the presence of caterpillars and excretory pellets and few silken threads (Plate 2a).

The caterpillar of gram pod borer, *H. armigera* (Lepidoptera : Noctuidae) bored into the flower buds and tender pods in early stages and the later instars entered into developing pods with circular holes on individual seeds of the pod (Plate 2b and 3a). While feeding on pods, the posterior part of the caterpillar remained out side.

The African pea moth (*C. ptychora*) larvae are red in colour, caterpillars bored into the well developed pod and fed exclusively on seeds either by boring into seeds or by excavating the surface of the seed (Plate 2c). The caterpillar always remained inside the pod except for the initial period of boring into the pod. The grown up larvae cut an exist hole on the pod.

The caterpillars of blue butterfly, *Lampides boeticus*, bored into the flower buds and tender pods (Plate 2d), resulting in drying up of flowers and tender pods.

*E. atomosa* caterpillars bored into the flower buds, developing pods and also mature pods. The affected pods exhibited small, round holes (Plate 3b).

The pea pod borer (*E. zinckenella*) caterpillars in their early stages bored into the tender pods and later into the mature pods. A few silken threads and mass of excreta were found inside the bored pods.

## 4.2 STUDY ON THE NATURAL ENEMY COMPLEX OF MAJOR POD BORERS

### 4.2.1 Parasitoids

The parasitoid activities during the study period was negligible. Hence, the data could not be generated on their abundance. However, the different species were recorded on various pod borers.

*Bracon* sp. nr. *greeni* Ashmed was recorded on *H. armigera* and *M. testulalis* (parasitization ranged from 10 to 20%). The parasitoid was also recorded on *C. ptychora* and *E. atomosa*. An unidentified dipteran parasitoid was recorded on *L. boeticus* and *H. armigera*. The parasitoids were more active during rainy season and winter months and the activity of parasitoids was noticed in October, November and December months *i.e.*, in August (3<sup>rd</sup> week) sown crop activity of parasitoids was more compared to September sown crop (1<sup>st</sup> week).

### 4.2.2 Predators

During the study period, on August sown crop, lady bird beetle, green lacewing and robber fly population was observed. Lady bird activity was quite high (4.5 to 6.0 beetle/ 5 plant) from 30 to 60 days after germination. The activity of green lace wing (0.9 to 1.48/ 10 plant) and robber fly (0.7 to 1.24 fly/10 plant) was observed from 15 to 45 days and afterwards no population could be traced. On September sown crop only the activity of lady bird beetle was noticed with a population of 2.0 and 5.4 grubs/10 plants on 30 to 75 days after germination, respectively (Table 5).

**Table 4 : Pod damage due to individual species of pod borers (September sown crop)**

Crop age (days)	Per cent pod damage due to						
	<i>M. testulalis</i>	<i>H. armigera</i>	<i>C. ptychora</i>	<i>L. boeticus</i>	<i>E. atomosa</i>	<i>E. zinckenella</i>	Total
45	NP	NP	NP	NP	NP	NP	-
52	5.30 <sup>b</sup>	4.50 <sup>a</sup>	1.25 <sup>ab</sup>	2.16 <sup>d</sup>	3.00 <sup>c</sup>	3.75 <sup>d</sup>	19.96
59	9.70 <sup>a</sup>	5.05 <sup>ab</sup>	1.20 <sup>ab</sup>	1.58 <sup>a</sup>	2.30 <sup>d</sup>	5.14 <sup>c</sup>	24.93
66	12.16 <sup>a</sup>	5.22 <sup>a</sup>	1.50 <sup>a</sup>	2.60 <sup>bc</sup>	2.10 <sup>d</sup>	6.60 <sup>a</sup>	30.18
73	11.83 <sup>a</sup>	4.50 <sup>b</sup>	1.28 <sup>ab</sup>	2.50 <sup>cd</sup>	8.90 <sup>a</sup>	6.00 <sup>b</sup>	35.01
80	9.80 <sup>a</sup>	3.50 <sup>c</sup>	1.30 <sup>ab</sup>	3.30 <sup>a</sup>	6.30 <sup>b</sup>	5.80 <sup>b</sup>	30.00
87	4.07 <sup>b</sup>	1.12 <sup>d</sup>	1.00 <sup>b</sup>	2.90 <sup>b</sup>	2.30 <sup>d</sup>	3.60 <sup>d</sup>	14.99
94	-	-	-	-	-	-	-
101	-	-	-	-	-	-	-
108	-	-	-	-	-	-	-

Yield obtained : 2.3 q/ha

NP – No pod formation

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

Original values were transformed into arc sine transformation before analysis



**Plate 2a: Larva of *M. testulalis* feeding inside the pod**

**Plate 2a. Larva of *M.testulalis* inside the pod**



**Plate 2b: Larvae of *H. amigera* feeding inside the pods**

**Plate 2b. Larvae of *H. amigera* feeding inside the pods**



**Plate 2c: Larva of *C. ptychora* feeding on the seeds**

**Plate 2c. Larva of *C.ptychora* feeding on the seeds**



**Plate 2d: Larvae of *L. boeticus* feeding inside the pod**

**Plate 2d. Larvae of *L.boeticus* feeding inside the pod**

**Plate 2: Pod borer larvae feeding inside the pods**



Plate 3a: Damage on pods due to *H. Armigera*

Plate 3a. Damage on pods due to *H.Armigera*



Plate 3b: Damage on pods due to *E. atamosa*

Plate 3b. Damages on pod due to *E.atamosa*

**Table 5a: Occurrence of predators on August sown crop**

<b>Predators</b>	<b>15 DAG</b>	<b>30 DAG</b>	<b>45 DAG</b>	<b>60 DAG</b>	<b>75 DAG</b>	<b>90 DAG</b>	<b>105 DAG</b>	<b>120 DAG</b>	<b>135 DAG</b>
Lady bird beetle grub/10 plant	4.40	10.00	12.00	9.00	4.20	-	-	-	-
Green lacewing /10 plant	1.20	1.48	0.90	0.00	0.00	-	-	-	-
Robber fly/10 plant	0.70	1.24	0.70	0.00	0.00	-	-	-	-

DAG – Days after germination

**Table 5b: Occurrence of predators on September sown crop**

<b>Predators</b>	<b>15 DAG</b>	<b>30 DAG</b>	<b>45 DAG</b>	<b>60 DAG</b>	<b>75 DAG</b>	<b>90 DAG</b>	<b>105 DAG</b>
Lady bird beetle grub/10 plant	-	9.00	10.80	8.00	4.00	-	-

**Table 6 : Pod borer population at varied level of plant protection (1<sup>st</sup> spray)**

Treatments	Number of pod borer larvae/plant				Mean
	1 DBS	2 DAS	5 DAS	10 DAS	
T <sub>1</sub> - No protection	4.50 <sup>a</sup>	4.50 <sup>b</sup>	4.50 <sup>b</sup>	4.52 <sup>b</sup>	4.51
T <sub>2</sub> – Fenvalerate: 1 spray	4.33 <sup>a</sup>	2.25 <sup>a</sup>	1.16 <sup>a</sup>	1.36 <sup>a</sup>	1.59
T <sub>3</sub> – Fenvalerate: 2 sprays	4.36 <sup>a</sup>	2.28 <sup>a</sup>	1.18 <sup>a</sup>	1.35 <sup>a</sup>	1.60
T <sub>4</sub> – Fenvalerate: 3 sprays	4.37 <sup>a</sup>	2.48 <sup>a</sup>	1.15 <sup>a</sup>	1.38 <sup>a</sup>	1.67
T <sub>5</sub> – Fenvalerate: 4 sprays	4.39 <sup>a</sup>	2.28 <sup>a</sup>	1.17 <sup>a</sup>	1.39 <sup>a</sup>	1.61
T <sub>6</sub> – Fenvalerate: 5 sprays	4.38 <sup>a</sup>	2.28 <sup>a</sup>	1.16 <sup>a</sup>	1.39 <sup>a</sup>	1.61
T <sub>7</sub> – Supervisory control	4.38 <sup>a</sup>	2.29 <sup>a</sup>	1.14 <sup>a</sup>	1.37 <sup>a</sup>	1.60

Note - Mean = 2, 5 and 10 DAS; DBS – Day before spray DAS – Days after spray  
Means followed by same letter in the column do not differ significantly by DMRT (p = 0.05)  
Original values were transformed into  $\sqrt{x+0.5}$  before analysis

## 4.3 TO STUDY THE EXTENT OF CROP LOSS CAUSED BY POD BORERS

### 4.3.1 Larval population

Insecticidal sprays were imposed to estimate the probable loss caused by pod borers in field bean. The observations were made on pod borer population, pod and seed damage and green pod yield.

The larval population (1<sup>st</sup> spray) in all the treatments was uniform a days before imposition of treatments as indicated by the non-significant difference among the various treatments (Table 6). However, after 2 days of spraying, the least larval population (2.25 to 2.48 larvae/plant) was noticed in all the treatments except control. Similar trend was noticed after 5 days (1.14 to 1.18 larvae/plant) and 10 days (1.35 to 1.39 larvae/plant) after spraying. The pod borer population, however, continued to appear at the same level even after 10 days in untreated check (4.52 larvae/plant).

At 2<sup>nd</sup> spray also the larval population was uniform in all the treatments except untreated check before treatment imposition (Table 7). After 2 days of spraying, the lowest larval population was noticed in supervisory control (0.52 larvae/plant) followed by T<sub>6</sub>, T<sub>5</sub>, T<sub>4</sub> and T<sub>3</sub> (1.00 to 1.04 larvae/plant) which were on par among each other. Similar trend was noticed after 5 and 10 days of spraying. At 5 days of spraying, the larval population in T<sub>7</sub> decreased to 0.33 larvae/plant. Whereas, in treatment T<sub>3</sub> to T<sub>6</sub>, the larval population ranged from 0.90 to 0.92 larvae/plant. But however, after 10 days, there was slight increase in larval population in all the treatments.

A day prior to third spray, the larval population varied statistically among the various treatments. The least larval population was recorded in treatments T<sub>3</sub> to T<sub>7</sub> (2.09 to 2.12 larvae/plant). Whereas, in T<sub>2</sub> a larval population of 4.2 was recorded on each plant. After 2 days of spraying, the least larval population was recorded in treatments T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> (0.0 to 0.42 larvae/plant) followed by T<sub>3</sub> (2.13 larvae/plant). Similar trend was noticed after 5 days (0.0 to 0.28 larvae/plant) and 10 days (0.45 to 0.52 larvae/plant) of treatment imposition also in treatment T<sub>4</sub> to T<sub>7</sub> (Table 8).

After fourth spray. The supervisory control with least population (0.05 larvae/plant) stood statistically superior over all other treatments before spray. After 2 days of spray, however, the larvae could not be noticed in T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> treatments. The treatments, T<sub>3</sub> and T<sub>4</sub> spared minimum population (0.53 to 2.17 larvae/plant) as compared and 4.34 and 4.64 larvae/pl in T<sub>2</sub> and T<sub>1</sub>, respectively. Almost a similar population level was observed in various treatments after 5 days. However, at 10 days after application, a meagre larval population ranging from 0.3 to 0.55 larvae/plant was observed in T<sub>7</sub> to T<sub>4</sub>, as compared to 2.19 larvae/pl in T<sub>3</sub> and more than 4 larvae/plant in case of T<sub>1</sub> and T<sub>2</sub> treatments (Table 9).

During fifth spray also a similar pattern in population level and population reduction was observed before and after the spray. In the treatments, T<sub>1</sub> and T<sub>2</sub> however, the population continued to prevail at higher side (> 4 larvae/plant) (Table 10).

**Table 7 : Pod borer population at varied level of plant protection (2<sup>nd</sup> spray)**

Treatments	Number of pod borer larvae/plant				Mean
	1 DBS	2 DAS	5 DAS	10 DAS	
T <sub>1</sub> – No protection	4.53 <sup>b</sup>	4.54 <sup>d</sup>	4.54 <sup>d</sup>	4.55 <sup>d</sup>	4.54
T <sub>2</sub> – Fenvalerate: 1 spray	3.23 <sup>a</sup>	3.24 <sup>c</sup>	3.25 <sup>c</sup>	3.26 <sup>c</sup>	3.25
T <sub>3</sub> – Fenvalerate: 2 sprays	3.24 <sup>a</sup>	1.00 <sup>b</sup>	0.91 <sup>b</sup>	1.11 <sup>b</sup>	1.00
T <sub>4</sub> – Fenvalerate: 3 sprays	3.22 <sup>a</sup>	1.03 <sup>b</sup>	0.90 <sup>b</sup>	1.10 <sup>b</sup>	1.01
T <sub>5</sub> – Fenvalerate: 4 sprays	3.24 <sup>a</sup>	1.02 <sup>b</sup>	0.92 <sup>b</sup>	1.11 <sup>b</sup>	1.02
T <sub>6</sub> – Fenvalerate: 5 sprays	3.22 <sup>a</sup>	1.04 <sup>b</sup>	0.90 <sup>b</sup>	1.10 <sup>b</sup>	1.02
T <sub>7</sub> – Supervisory control	3.23 <sup>a</sup>	0.52 <sup>a</sup>	0.33 <sup>a</sup>	0.65 <sup>a</sup>	0.50

Note - Mean = 2, 5 and 10 DAS; DBS – Day before spray DAS – Days after spray  
Means followed by same letter in the column do not differ significantly by DMRT (p = 0.05)  
Original values were transformed into  $\sqrt{x+0.5}$  before analysis

**Table 8 : Pod borer population at varied level of plant protection (3<sup>rd</sup> spray)**

Treatments	Number of pod borer larvae/plant				Mean
	1 DBS	2 DAS	5 DAS	10 DAS	
T <sub>1</sub> - No protection	4.56 <sup>b</sup>	4.57 <sup>d</sup>	4.58 <sup>d</sup>	4.62 <sup>d</sup>	4.59
T <sub>2</sub> – Fenvalerate : 1 spray	4.20 <sup>b</sup>	4.21 <sup>c</sup>	4.22 <sup>c</sup>	4.32 <sup>c</sup>	4.25
T <sub>3</sub> – Fenvalerate : 2 sprays	2.12 <sup>a</sup>	2.13 <sup>b</sup>	2.14 <sup>b</sup>	2.15 <sup>b</sup>	1.14
T <sub>4</sub> – Fenvalerate : 3 sprays	2.13 <sup>a</sup>	0.40 <sup>a</sup>	0.27 <sup>a</sup>	0.51 <sup>a</sup>	0.39
T <sub>5</sub> – Fenvalerate : 4 sprays	2.12 <sup>a</sup>	0.41 <sup>a</sup>	0.28 <sup>a</sup>	0.52 <sup>a</sup>	0.40
T <sub>6</sub> – Fenvalerate : 5 sprays	2.13 <sup>a</sup>	0.42 <sup>a</sup>	0.26 <sup>a</sup>	0.51 <sup>a</sup>	0.40
T <sub>7</sub> – Supervisory control	2.09 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.45 <sup>a</sup>	0.15

Note - Mean = 2, 5 and 10 DAS; DBS – Day before spray DAS – Days after spray

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

Original values were transformed into  $\sqrt{x+0.5}$  before analysis

### 4.3.2 Pod and seed damage

A minimum pod and seed damage was recorded in treatments T<sub>2</sub> to T<sub>7</sub> which varied from 18.12 to 19.0 and 23.13 to 24.0 per cent, respectively, at 1<sup>st</sup> picking. During second picking least pod damage was recorded in T<sub>7</sub> (10.56%) followed by T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub> and T<sub>6</sub> (12.82 to 13.20%) while, the least seed damage was observed in T<sub>7</sub>, to T<sub>3</sub> treatments (15.55 to 18.20%).

At 3<sup>rd</sup> picking, the least pod and seed damage was again recorded T<sub>7</sub> (4.0 and 9.0 %, respectively) followed by T<sub>6</sub>, T<sub>5</sub> and T<sub>4</sub> (7.0 to 7.2% pod damage 12.0 to 12.2% seed damage).

During 4<sup>th</sup> picking, lower pod and seed damage was observed in T<sub>7</sub>, T<sub>6</sub> and T<sub>5</sub> (1.0 to 2.0 and 6.0 to 7.02%, respectively). T<sub>1</sub> and T<sub>2</sub> recorded a very high pod and seed damage of 20.5 to 30.0 and 25.5 to 35.12 per cent, respectively (Table 11 and 12).

The per cent reduction in pod damage over untreated check indicated highest reduction (68.57%) in pod damage in the plot which was protected on need basis (supervisory control) which received five sprays of fenvalerate. The next higher per cent reduction was observed in T<sub>6</sub>, T<sub>5</sub> and T<sub>4</sub> treatments (61.96, 61.92 and 59.76 %, respectively). The least reduction was noticed in T<sub>2</sub> (28.74%) followed by T<sub>3</sub> (46.13%) (Table 13).

Similarly, the per cent reduction in seed damage over untreated check showed that the highest reduction (57.86%) in seed damage was noticed in T<sub>7</sub> (supervisory control) treatment. The next to follow were T<sub>6</sub>, T<sub>5</sub> and T<sub>4</sub> treatments which recorded 52.30, 52.24, 50.42 per cent reduction in seed damage, respectively (Table 13).

### 4.3.3 Green pod yield

Highest green pod yield of 2.08 to 2.15 q/ha was recorded in treatments T<sub>7</sub> to T<sub>2</sub> during 1<sup>st</sup> picking. During 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> picking also a similar trend in green pod yield was noticed. During all the pickings the treatments T<sub>1</sub> and T<sub>2</sub> recorded very low yields (1.78 to 2.08, 1.59 to 1.8, 0.4 to 0.42 and 0.12 to 0.2 q/ha during 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup>, respectively).

As high as 13.0 q/ha cumulative green pod yield was obtained in T<sub>7</sub> compared to 3.89 q/ha in T<sub>1</sub>. The next best was T<sub>6</sub> (12.92 q/ha) followed by T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub> and T<sub>2</sub> (11.89, 10.92, 7.89 and 4.50 q/ha, respectively) (Table 14).

More than 70 per cent loss in green pod yield was observed in untreated check (T<sub>1</sub>) compared to supervisory control (Table 15). Two sprays of fenvalerate reduced the extent of yield loss to 39.3 per cent. Whereas, five sprays of the chemical was as good as T<sub>7</sub>. An additional green pod yield of 9.11 q/ha over unprotected plots was obtained in T<sub>7</sub> while in T<sub>6</sub>, T<sub>5</sub> and T<sub>4</sub>, more than 7 q/ha more yield was recorded owing to insecticidal intervention.

### 4.3.4 IBC ratio

Economics of the insecticidal sprays during the course of investigation to estimate the loss caused by pod borers is presented in Table 16. The data revealed that the net returns was maximum (Rs. 5888/ha) in case of treatment which received 5 sprays on need based *i.e.*, supervisory control. The next to follow were T<sub>6</sub>, T<sub>5</sub> and T<sub>4</sub> with a net realization of Rs. 5824, 5280 and 4784 per ha. However, looking to the incremental benefit cost ratio, the treatment which received 3 sprays of fenvalerate (T<sub>4</sub>) proved to be the best (6.69) followed T<sub>3</sub> and T<sub>5</sub> (5.71) (Table 16).

**Table 9 : Pod borer population at varied level of plant protection (4<sup>th</sup> spray)**

Treatments	Number of pod borer larvae/plant				Mean
	1 DBS	2 DAS	5 DAS	10 DAS	
T <sub>1</sub> - No protection	4.63 <sup>d</sup>	4.64 <sup>d</sup>	4.64 <sup>d</sup>	4.65 <sup>d</sup>	4.64
T <sub>2</sub> – Fenvalerate: 1 spray	4.33 <sup>d</sup>	4.34 <sup>d</sup>	4.35 <sup>d</sup>	4.36 <sup>c</sup>	4.35
T <sub>3</sub> – Fenvalerate: 2 sprays	2.16 <sup>c</sup>	2.17 <sup>c</sup>	2.18 <sup>c</sup>	2.19 <sup>b</sup>	2.17
T <sub>4</sub> – Fenvalerate: 3 sprays	0.52 <sup>b</sup>	0.53 <sup>b</sup>	0.54 <sup>b</sup>	0.55 <sup>b</sup>	0.54
T <sub>5</sub> – Fenvalerate: 4 sprays	0.54 <sup>b</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.45 <sup>a</sup>	0.15
T <sub>6</sub> – Fenvalerate: 5 sprays	0.53 <sup>b</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.46 <sup>a</sup>	0.15
T <sub>7</sub> - Supervisory control	0.05 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.30 <sup>a</sup>	0.10

Note - Mean = 2, 5 and 10 DAS; DBS – Day before spray DAS – Days after spray  
Means followed by same letter in the column do not differ significantly by DMRT (p = 0.05)  
Original values were transformed into  $\sqrt{x+0.5}$  before analysis

**Table 10 : Pod borer population at varied level of plant protection (5<sup>th</sup> spray)**

Treatments	Number of pod borer larvae/plant				Mean
	1 DBS	2 DAS	5 DAS	10 DAS	
T <sub>1</sub> - No protection	4.66 <sup>d</sup>	4.67 <sup>d</sup>	4.68 <sup>d</sup>	4.69 <sup>d</sup>	4.67
T <sub>2</sub> – Fenvalerate: 1 spray	4.37 <sup>d</sup>	4.38 <sup>d</sup>	4.39 <sup>d</sup>	4.40 <sup>d</sup>	4.44
T <sub>3</sub> – Fenvalerate: 2 sprays	2.20 <sup>c</sup>	2.21 <sup>c</sup>	2.22 <sup>c</sup>	2.24 <sup>c</sup>	2.42
T <sub>4</sub> – Fenvalerate: 3 sprays	0.56 <sup>b</sup>	0.57 <sup>b</sup>	0.58 <sup>b</sup>	0.59 <sup>b</sup>	0.53
T <sub>5</sub> – Fenvalerate: 4 sprays	0.46 <sup>b</sup>	0.47 <sup>b</sup>	0.48 <sup>b</sup>	0.49 <sup>b</sup>	0.13
T <sub>6</sub> – Fenvalerate: 5 sprays	0.47 <sup>b</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00
T <sub>7</sub> - Supervisory control	0.31 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00

Note - Mean = 2, 5 and 10 DAS; DBS – Day before spray DAS – Days after spray  
Means followed by same letter in the column do not differ significantly by DMRT (p = 0.05)  
Original values were transformed into  $\sqrt{x+0.5}$  before analysis

**Table 11 : Influence of varied level of plant protection on pod damage**

Treatments	Per cent pod damage				Mean
	I picking	II picking	III picking	IV picking	
T <sub>1</sub> - No protection	23.27 <sup>b</sup>	26.80 <sup>d</sup>	27.10 <sup>e</sup>	30.00 <sup>e</sup>	26.79
T <sub>2</sub> – Fenvalerate: 1 spray	18.22 <sup>a</sup>	18.43 <sup>c</sup>	19.22 <sup>d</sup>	20.50 <sup>d</sup>	19.09
T <sub>3</sub> – Fenvalerate: 2 sprays	19.00 <sup>a</sup>	13.20 <sup>b</sup>	12.52 <sup>c</sup>	13.00 <sup>c</sup>	14.43
T <sub>4</sub> – Fenvalerate: 3 sprays	18.32 <sup>a</sup>	12.82 <sup>b</sup>	7.00 <sup>b</sup>	5.00 <sup>b</sup>	10.78
T <sub>5</sub> – Fenvalerate: 4 sprays	18.64 <sup>a</sup>	12.99 <sup>b</sup>	7.18 <sup>b</sup>	2.00 <sup>a</sup>	10.20
T <sub>6</sub> – Fenvalerate: 5 sprays	18.89 <sup>a</sup>	13.19 <sup>b</sup>	7.20 <sup>b</sup>	1.50 <sup>a</sup>	10.19
T <sub>7</sub> – Supervisory control	18.12 <sup>a</sup>	10.56 <sup>a</sup>	4.00 <sup>a</sup>	1.00 <sup>a</sup>	8.42

Means followed by same letter in the column do not differ significantly by DMRT ( $p = 0.05$ )  
 Original values were transformed into arc sine transformation before analysis

**Table 12 : Influence of varied level of plant protection on seed damage**

Treatments	Per cent seed damage				Mean
	I picking	II picking	III picking	IV picking	
T <sub>1</sub> - No protection	28.28 <sup>b</sup>	31.82 <sup>c</sup>	32.20 <sup>e</sup>	35.12 <sup>e</sup>	31.85
T <sub>2</sub> – Fenvalerate: 1 spray	23.24 <sup>a</sup>	23.43 <sup>b</sup>	24.23 <sup>d</sup>	25.50 <sup>d</sup>	24.10
T <sub>3</sub> – Fenvalerate: 2 sprays	24.00 <sup>a</sup>	18.20 <sup>a</sup>	17.52 <sup>c</sup>	18.00 <sup>c</sup>	19.43
T <sub>4</sub> – Fenvalerate: 3 sprays	23.33 <sup>a</sup>	17.83 <sup>a</sup>	12.00 <sup>b</sup>	10.00 <sup>b</sup>	15.79
T <sub>5</sub> – Fenvalerate: 4 sprays	23.65 <sup>a</sup>	17.99 <sup>a</sup>	12.18 <sup>b</sup>	7.02 <sup>a</sup>	15.21
T <sub>6</sub> – Fenvalerate: 5 sprays	23.89 <sup>a</sup>	18.19 <sup>a</sup>	12.20 <sup>b</sup>	6.50 <sup>a</sup>	15.19
T <sub>7</sub> – Supervisory control	23.13 <sup>a</sup>	15.55 <sup>a</sup>	9.00 <sup>a</sup>	6.00 <sup>a</sup>	13.42

Means followed by same letter in the column do not differ significantly by DMRT ( $p = 0.05$ )  
 Original values were transformed into arc sine transformation before analysis

**Table 13 : Reduction in pod and seed damage due to varied level of plant protection**

Treatments	Spraying at DAS	Average per cent damage		Per cent reduction over control	
		Pod	Seed	Pod	Seed
T <sub>1</sub> No protection	-	26.79	31.85	-	-
T <sub>2</sub> Fenvalerate: 1 spray	45	19.09	24.1	28.74	24.33
T <sub>3</sub> Fenvalerate: 2 sprays	45 and 60	14.43	19.43	46.13	38.99
T <sub>4</sub> Fenvalerate: 3 sprays	45, 60 and 75	10.78	15.79	59.76	50.42
T <sub>5</sub> Fenvalerate: 4 sprays	45, 60, 75 and 90	10.20	15.21	61.92	52.24
T <sub>6</sub> Fenvalerate: 5 sprays	45, 60, 75, 90 and 105	10.19	15.19	61.96	52.30
T <sub>7</sub> Supervisory control	-	8.42	13.42	68.57	57.86

**Table 14 : Influence of varied level of plant protection on pod yield**

Treatments	Green pod yield (q/ha)				Total
	I picking	II picking	III picking	IV picking	
T <sub>1</sub> - No protection	1.78 <sup>b</sup>	1.59 <sup>d</sup>	0.40 <sup>c</sup>	0.12 <sup>c</sup>	3.89
T <sub>2</sub> – Fenvalerate: 1 spray	2.08 <sup>a</sup>	1.80 <sup>c</sup>	0.42 <sup>c</sup>	0.20 <sup>c</sup>	4.50
T <sub>3</sub> – Fenvalerate: 2 sprays	2.08 <sup>a</sup>	4.00 <sup>b</sup>	0.61 <sup>c</sup>	0.20 <sup>c</sup>	7.89
T <sub>4</sub> – Fenvalerate: 3 sprays	2.12 <sup>a</sup>	4.20 <sup>b</sup>	4.08 <sup>b</sup>	0.52 <sup>b</sup>	10.92
T <sub>5</sub> – Fenvalerate: 4 sprays	2.15 <sup>a</sup>	4.21 <sup>b</sup>	4.89 <sup>a</sup>	0.64 <sup>b</sup>	11.89
T <sub>6</sub> – Fenvalerate: 5 sprays	2.10 <sup>a</sup>	4.22 <sup>b</sup>	4.89 <sup>a</sup>	1.71 <sup>a</sup>	12.92
T <sub>7</sub> - Supervisory control	2.12 <sup>a</sup>	4.88 <sup>a</sup>	4.89 <sup>a</sup>	1.11 <sup>a</sup>	13.00

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

**Table 15 : Loss in yield due to varied level of plant protection**

Treatments	Spraying at DAS	Green pod yield (q/ha)	Per cent loss in yield over supervisory control (q/ha)	Additional yield over untreated control (q/ha)
T <sub>1</sub> No protection	-	3.89	70.07	-
T <sub>2</sub> Fenvalerate: 1 spray	45	4.50	65.38	0.61
T <sub>3</sub> Fenvalerate: 2 sprays	45 and 60	7.89	39.30	4.0
T <sub>4</sub> Fenvalerate: 3 sprays	45, 60 and 75	10.92	16.00	7.03
T <sub>5</sub> Fenvalerate: 4 sprays	45, 60, 75 and 90	11.89	8.53	8.0
T <sub>6</sub> Fenvalerate: 5 sprays	45, 60, 75, 90 and 105	12.92	0.61	9.03
T <sub>7</sub> Supervisory control	-	13.00	-	9.11

#### 4.3.5 Determination of economic injury level for pod borers

The economic injury level was computed by using the following formula.

$$\text{Economic injury} = \frac{\text{Gain threshold}}{\text{Regression coefficient}}$$

The regression coefficient between number of pod borers per plant and green pod yield (y) was computed for 'n' number of observations.

$$\text{Regression coefficient (b)} = \frac{\sum xy - \sum x \cdot \sum y / N}{\sum x^2 - (\sum x)^2 / N}$$

$$\begin{aligned} \text{Therefore } b &= \frac{80.45 - 12.66 \times 65.01/7}{39.01 - (12.66)^2/7} \\ &= \frac{80.45 - 117.61}{39.01 - 22.9} \\ &= -2.31 \end{aligned}$$

$$\begin{aligned} \text{Intercept on Y } &= a = \sum y/n - b \sum x/n \\ &= 65.01/7 - (-2.31) 12.66/7 \\ &= 13.46 \\ y &= a + bx \\ &= 13.45 - 2.31 x \end{aligned}$$

For calculating the cost of pest control, cost of insecticide and labour cost were considered. Totally 500 litres of spray solution was used for one hectare area of field bean crop.

The market price of the produce (green pod) was fixed at Rs. 800/q. Then,

$$\text{Gain threshold (GT)} = \frac{\text{Cost of plant protection measures (Rs./ha)}}{\text{Market price of the produce (Rs./q)}}$$

$$\text{Therefore gain threshold (GT)} = \frac{8400}{8000} = 1.05$$

$$\text{EIL} = \frac{\text{GT}}{\text{Regression coefficient}}$$

$$\text{EIL} = \frac{1.05}{2.31} = 0.45 \text{ larvae/plant.}$$

Therefore, the economic injury level for pod borer complex in of *Dolichos* bean was calculated as 0.40 larvae per plant (Table 17).

**Table 16 : Economics of insecticidal sprays imposed for the control of pod borers in field bean**

Treatments		Spraying at DAS	Green pod yield (q/ha)	Add. yield over control (q/ha)	Add. returns (Rs./ha)	Total cost of treatment application (Rs/ha)	Net returns (Rs./ ha)	IBC ratio
T <sub>1</sub>	No protection	-	3.89	-	-	-	-	-
T <sub>2</sub>	Fenvalerate: 1 spray	45	4.50	0.61	488	280	208	1.74
T <sub>3</sub>	Fenvalerate: 2 sprays	45 and 60	7.89	4.00	3200	560	2640	5.71
T <sub>4</sub>	Fenvalerate: 3 sprays	45, 60 and 75	10.92	7.03	5624	840	4784	6.69
T <sub>5</sub>	Fenvalerate: 4 sprays	45, 60, 75 and 90	11.89	8.00	6400	1120	5280	5.71
T <sub>6</sub>	Fenvalerate: 5 sprays	45, 60, 75, 90 and 105	12.92	9.03	7224	1400	5824	5.16
T <sub>7</sub>	Supervisory control s	-	13.00	9.11	7288	1400	5888	5.20

## 4.4 FIELD EVALUATION OF INDIGENOUS MATERIALS AND NEW MOLECULES FOR THE MANAGEMENT OF POD BORERS IN *DOLICHOS* BEAN

### 4.4.1 Larval population of pod borers (1<sup>st</sup> spray)

The larval population in all the treatments was uniform a day before imposition of treatments as indicated by the non-significant difference among the various treatments (Table 18). However, after two days of spraying, among the different indigenous materials, the least larval number was noticed in GCK + cow urine treatment (3.68 larvae/plant) which stood at par with GCK (3.69 larvae/plant) alone, NSKE + cow urine (3.73 larvae/plant), GE + cow urine (3.77 larvae/plant), NSKE (3.94 larvae/plant). Among the different new molecules, the least larval population was noticed in emamectin benzoate (3.17 larvae/plant) followed by spinosad (3.33 larvae/plant). Indoxacarb and fenvalerate were statistically on par with each other.

A similar trend was noticed after 5 days of first spray. Among the various botanical extracts the population ranged from 3.25 to 3.87 larvae/pl. Similarly, the new molecules also stood at par with each other by recording population of 2.87 to 3.74 larvae/pl.

After 10 days of spray, all the indigenous materials showed statistically on par larval population (3.66 to 4.14 larvae/plant). On the contrary, the newer molecules viz., emamectin benzoate, spinosad and indoxacarb retained their efficacy (2.12, 2.46 and 2.52 larvae/plant) as compared to fenvalerate (3.5 larvae/plant) and endosulfan (3.91 larvae/plant).

With regard to per cent reduction in larval population, the maximum reduction at 2 DAS was observed in emamectin benzoate (26.78%) followed by spinosad (23.44%) and indoxacarb (22.02%). However, in case of indigenous materials the per cent reduction varied from 10.24 to 15.78 per cent. The similar trend was continued after 5 and 10 days of spray. At 5 DAS, the maximum reduction (33.72%) was recorded in emamectin benzoate and among the indigenous materials the per cent reduction was to the tune of 25.62 per cent in case of GCK + cow urine. After 10 days of spray, emamectin benzoate till recorded more than 50 per cent mortality followed by, spinosad and indoxacarb. Whereas, in case of indigenous materials, the per cent reduction varied from 16.24 per cent in GCK + cow urine to 7.79 per cent in GE (Table 18).

### 4.4.2 Larval population of pod borers (2<sup>nd</sup> spray)

The non-significant difference among the various treatments prior to application indicated the uniform distribution of the pest in the experimental area (Table 19). However, after two days of spraying, among botanicals, the least larval number was noticed in GCK + cow urine treatment (2.17 larvae/plant) which stood at par with GCK alone followed by GE + cow urine (2.36 larvae/plant), NSKE + cow urine (2.38 larvae/plant) and NSKE (2.64 larvae/plant).

Among the different new molecules, the least larval population was noticed in emamectin benzoate (1.45 larvae/plant) which stood on par with spinosad (1.5 larvae/plant) and Indoxacarb (1.60 larvae/plant) which was followed by fenvalerate (1.8 larvae/plant) and endosulfan.

After 5 days of second spray, among botanicals, GCK + cow urine and GCK treatments were found significantly superior over rest of the botanicals with the population ranging from 2.5 to 2.19 larvae/pl. Emamectin benzoate, among the new molecules ranked first with least pod borer population (1.05 larvae/plant) followed by spinosad, indoxacarb and fenvalerate in which the population varied from 1.26 to 1.46 larvae/pl. However, the untreated control plots recorded as high as 4.52 larvae per plant.

At 10 days of spraying also, a similar trend on the efficacy of both indigenous materials and new molecules was continued. The larval population ranged from 2.19 to 2.71 in botanicals compared to 0.31 to 2.64 in case of new molecules.

**Table 17 : Determination of economic injury level for pod borers in field bean**

Treatments	Number of pod borers/p (x)	Pod yield (q/ha) (y)	XY	X <sup>2</sup>
T <sub>1</sub>	4.59	3.89	17.85	21.07
T <sub>2</sub>	3.57	4.50	16.04	12.74
T <sub>3</sub>	1.83	7.89	14.44	3.35
T <sub>4</sub>	0.84	10.92	9.17	0.70
T <sub>5</sub>	0.73	11.89	8.68	0.53
T <sub>6</sub>	0.63	12.92	8.14	0.40
T <sub>7</sub>	0.47	13.00	6.11	0.22
	$\Sigma x = 12.66$	$\Sigma y = 65.01$	$\Sigma xy = 80.45$	$\Sigma x^2 = 39.01$

EIL – 0.45

**Table 18 : Efficacy of indigenous materials and new molecules against pod borers (First spray)**

Treatments	Number of larvae per plant							Mean % reduction of larval population
	1 DBS	2 DAS	% reduction over pre-treatment	5 DAS	% reduction over pre-treatment	10 DAS	% reduction over pre-treatment	
T <sub>1</sub> – NSKE 5%	4.40 <sup>a</sup>	3.94 <sup>bc</sup>	11.26	3.78 <sup>c</sup>	14.86	3.98 <sup>cd</sup>	10.36	12.16
T <sub>2</sub> – NSKE 5% + cow urine 5%	4.39 <sup>a</sup>	3.73 <sup>bc</sup>	15.03	3.65 <sup>bc</sup>	16.85	3.85 <sup>cd</sup>	12.30	14.72
T <sub>3</sub> – GCK 0.5%	4.38 <sup>a</sup>	3.69 <sup>abc</sup>	15.75	3.27 <sup>abc</sup>	25.34	3.78 <sup>c</sup>	13.69	18.26
T <sub>4</sub> – GCK 0.5% + cow urine 5%	4.37 <sup>a</sup>	3.68 <sup>abc</sup>	15.78	3.25 <sup>abc</sup>	25.62	3.66 <sup>c</sup>	16.24	19.21
T <sub>5</sub> – GE 1%	4.49 <sup>a</sup>	4.03 <sup>c</sup>	10.24	3.87 <sup>cd</sup>	13.80	4.14 <sup>cd</sup>	7.79	10.61
T <sub>6</sub> – GE 1% + cow urine 5%	4.39 <sup>a</sup>	3.77 <sup>bc</sup>	14.12	3.69 <sup>bc</sup>	15.94	3.94 <sup>cd</sup>	10.25	13.43
T <sub>7</sub> – <b>Spinosad 45 SC</b> (0.2 ml/l)	4.35 <sup>a</sup>	3.33 <sup>ab</sup>	23.44	2.98 <sup>ab</sup>	31.49	2.46 <sup>b</sup>	43.45	32.79
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	4.33 <sup>a</sup>	3.17 <sup>a</sup>	26.78	2.87 <sup>a</sup>	33.72	2.12 <sup>a</sup>	51.03	37.17
T <sub>9</sub> – <b>Indoxacarb 14.5 SC</b> (0.1 g/l)	4.36 <sup>a</sup>	3.40 <sup>ab</sup>	22.02	2.99 <sup>ab</sup>	31.42	2.52 <sup>b</sup>	42.20	31.88
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	4.34 <sup>a</sup>	3.50 <sup>ab</sup>	19.54	3.25 <sup>abc</sup>	25.28	3.5 <sup>c</sup>	19.54	21.45
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	4.41 <sup>a</sup>	3.85 <sup>bc</sup>	12.69	3.74 <sup>c</sup>	15.19	3.91 <sup>cd</sup>	11.34	13.07
T <sub>12</sub> – Untreated control	4.38 <sup>a</sup>	4.40 <sup>d</sup>	-0.46	4.50 <sup>d</sup>	-2.73	4.5 <sup>d</sup>	-2.74	-1.97

DAS; DBS – Day before spray

DAS – Days after spray

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

Original values were transformed into  $\sqrt{x+0.5}$  before analysis

**Table 19 : Efficacy of indigenous materials and new molecules against pod borers (Second spray)**

Treatments	Number of larvae per plant							Mean
	1 DBS	2 DBS	% reduction over pre-treatment	5 DAS	% reduction over pre-treatment	10 DAS	% reduction over pre-treatment	
T <sub>1</sub> – NSKE 5%	4.05 <sup>a</sup>	2.64 <sup>cd</sup>	34.81	2.45 <sup>f</sup>	39.50	2.66 <sup>e</sup>	34.32	36.21
T <sub>2</sub> – NSKE 5% + cow urine 5%	3.93 <sup>a</sup>	2.38 <sup>cd</sup>	39.44	2.19 <sup>ef</sup>	44.27	2.39 <sup>de</sup>	39.18	40.96
T <sub>3</sub> – GCK 0.5%	3.92 <sup>a</sup>	2.18 <sup>bc</sup>	44.38	1.98 <sup>de</sup>	49.48	2.19 <sup>d</sup>	44.13	45.99
T <sub>4</sub> – GCK 0.5% + cow urine 5%	3.91 <sup>a</sup>	2.17 <sup>bc</sup>	44.50	1.66 <sup>de</sup>	57.54	2.18 <sup>d</sup>	44.24	48.76
T <sub>5</sub> – GE 1%	4.07 <sup>a</sup>	2.72 <sup>d</sup>	33.16	2.50 <sup>f</sup>	38.57	2.71 <sup>e</sup>	33.41	35.04
T <sub>6</sub> – GE 1% + cow urine 5%	3.94 <sup>a</sup>	2.36 <sup>cd</sup>	40.10	2.20 <sup>ef</sup>	44.16	2.40 <sup>de</sup>	39.08	41.11
T <sub>7</sub> – Spinosad 45 SC (0.2 ml/l)	3.90 <sup>a</sup>	1.50 <sup>a</sup>	61.53	1.26 <sup>ab</sup>	67.86	0.55 <sup>b</sup>	85.89	71.76
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	3.89 <sup>a</sup>	1.45 <sup>a</sup>	62.72	1.05 <sup>a</sup>	73.00	0.31 <sup>a</sup>	92.03	75.91
T <sub>9</sub> – Indoxacarb 14.5 SC (0.1 g/l)	3.91 <sup>a</sup>	1.60 <sup>a</sup>	59.07	1.31 <sup>ab</sup>	66.49	0.57 <sup>b</sup>	85.42	70.32
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	3.90 <sup>a</sup>	1.80 <sup>a</sup>	53.84	1.46 <sup>bc</sup>	62.56	1.98 <sup>c</sup>	49.23	55.21
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	4.02 <sup>a</sup>	2.53 <sup>cd</sup>	37.06	2.38 <sup>ef</sup>	0.79	2.64 <sup>e</sup>	34.32	37.39
T <sub>12</sub> – Untreated control	4.51 <sup>a</sup>	4.52 <sup>e</sup>	-0.22	4.53 <sup>g</sup>	-0.44	4.55 <sup>f</sup>	-0.45	-0.37

DAS; DBS – Day before spray

DAS – Days after spray

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

Original values were transformed into  $\sqrt{x+0.5}$  before analysis

With regard to per cent reduction in larval population, the maximum reduction at 2 DAS was observed in emamectin benzoate (62.72%) and spinosad (61.53%) followed by indoxacarb (59.07%). However, in case of indigenous materials the per cent reduction varied from 33.16 to 44.5 per cent. The similar trend was continued after 5 and 10 days of spray. At 5 DAS, the maximum reduction (73.0%) was recorded in emamectin benzoate and among the indigenous materials, the per cent reduction was to the tune of 57.54 per cent in case of GCK + cow urine. After 10 days of spray, emamectin benzoate still recorded more than 70 per cent mortality followed by spinosad and indoxacarb whereas, in case of indigenous materials, the per cent reduction varied from 44.24 per cent in GCK + cow urine to 33.41 per cent in GE (Table 19).

#### 4.4.3 Larval population of pod borers (3<sup>rd</sup> spray)

A day prior to third spray the larval population varied statistically among the various treatments. Among botanicals the least larval number was recorded in GCK + cow urine (3.91 larvae/plant) and GCK (3.92 larvae/plant) followed by NSKE + cow urine (4.12 larvae/plant) and NSKE (4.22 larvae/plant). Among new molecules least larval population was recorded in emamectin benzoate (2.04 larvae/plant) followed by spinosad (2.28 larvae/plant) and indoxacarb (2.3 larvae/plant) (Table 20). However, after two days of spraying, among the different indigenous materials, the least larval number was noticed in GCK + cow urine treatment (1.84 larvae/plant) which stood at par with GCK alone (1.85 larvae/plant), GE + cow urine (1.94 larvae/plant), NSKE + cow urine (1.95 larvae/plant) and NSKE (1.98 larvae/plant). Among the different new molecules the least larval population was noticed in emamectin benzoate (0.60 larvae/plant), spinosad (0.80 larvae/plant) and indoxacarb (0.85 larvae/plant) which were statistically on par with each other and next best treatment fenvalerate (1.55 larvae/plant). A similar trend was noticed after 5 days of 3<sup>rd</sup> spray. Among the various botanicals, with a population range of 1.52 to 1.92 larvae/pl. similarly, the new molecules also stood at par with each other by recording larval population of 0.40 to 1.52 larvae/pl.

After 10 days of spray, all the indigenous materials showed statistically on par larval population (1.78 to 2.18 larvae/plant). On the contrary, the newer molecules *viz.*, emamectin benzoate, spinosad and indoxacarb retained their efficacy (0.20, 0.40 and 1.66 larvae/plant) as compared to fenvalerate (1.37 larvae/plant) and endosulfan (1.71 larvae/plant).

With regard to per cent reduction in larval population, the maximum reduction at 2 DAS was observed in emamectin benzoate (70.58%) followed by spinosad (64.91%) and indoxacarb (63.04%). However, in case of indigenous materials the per cent reduction varied from 51.57 to 52.94 per cent. The similar trend was continued at 5 and 10 days of spray. At 5 DAS, the maximum reduction (80.39%) was recorded in emamectin benzoate. Among the indigenous materials the per cent reduction was to the tune of 61.13 per cent in case of GCK + cow urine. After 10 days of spray, emamectin benzoate showed more than 90 per cent mortality followed by spinosad. Whereas, in case of indigenous materials, the maximum per cent reduction was observed in GCK + cow urine (54.48%).

#### 4.4.4 Larval population of pod borers (4<sup>th</sup> spray)

A day before fourth spray the larval population varied statistically among the various treatments. Among botanicals the least larval population was recorded in GCK + cow urine (2.35 larvae/plant) and GCK (2.36 larvae/plant) followed by NSKE + cow urine (2.42 larvae/plant) and NSKE (2.29 larvae/plant). Among new molecules least larval population was noticed in emamectin benzoate (0.9 larvae/plant) and spinosad (1.0 larvae/plant) followed by indoxacarb (1.17 larvae/plant) (Table 21). However, after two days of spraying, among botanicals the least larval number was noticed in GCK+ cow urine (1.00 larvae/plant) which stood at par with GCK alone (1.02 larvae/plant) and GE + cow urine (1.16 larvae/plant), NSKE + cow urine (1.08 larvae/plant) and NSKE (1.09 larvae/plant). Among the new molecules, the least larval population was noticed in emamectin benzoate (0.2 larvae/plant), spinosad (0.25 larvae/plant) and indoxacarb (0.3 larvae/plant) were statistically on par with each other and next best treatment was fenvalerate (0.55 larvae/plant). Similar trend was noticed after 5 days of fourth spray. Among the various botanical extracts, the population ranged from 1.19 to 2.20 larvae/plant. Similarly, the new molecules also stood at par with each other by recording larval population of 0.20 to 0.78 larvae/pl.

**Table 20 : Efficacy of indigenous materials and new molecules against pod borers (third spray)**

Treatments	Number of larvae per plant							Mean % reduction of larval population
	1 DBS	2 DAS	% reduction over pre-treatment	5 DAS	% reduction over pre-treatment	10 DAS	% reduction over pre-treatment	
T <sub>1</sub> – NSKE 5%	4.22 <sup>e</sup>	1.98 <sup>cd</sup>	52.84	1.56 <sup>cd</sup>	63.03	1.79 <sup>d</sup>	58.58	58.15
T <sub>2</sub> – NSKE 5% + cow urine 5%	4.12 <sup>e</sup>	1.95 <sup>cd</sup>	52.67	1.66 <sup>d</sup>	59.71	1.92 <sup>d</sup>	53.39	55.26
T <sub>3</sub> – GCK 0.5%	3.92 <sup>d</sup>	1.85 <sup>c</sup>	52.80	1.55 <sup>cd</sup>	60.45	1.81 <sup>d</sup>	53.83	55.69
T <sub>4</sub> – GCK 0.5% + cow urine 5%	3.91 <sup>d</sup>	1.84 <sup>c</sup>	52.94	1.52 <sup>cd</sup>	61.13	1.78 <sup>d</sup>	54.48	56.18
T <sub>5</sub> – GE 1%	4.44 <sup>f</sup>	2.15 <sup>d</sup>	51.57	1.92 <sup>e</sup>	56.76	2.18 <sup>e</sup>	50.90	53.07
T <sub>6</sub> – GE 1% + cow urine 5%	4.13 <sup>e</sup>	1.94 <sup>cd</sup>	53.02	1.62 <sup>cd</sup>	60.77	1.88 <sup>d</sup>	54.48	56.09
T <sub>7</sub> – Spinosad 45 SC (0.2 ml/l)	2.28 <sup>b</sup>	0.80 <sup>a</sup>	64.91	0.60 <sup>ab</sup>	73.68	0.40 <sup>a</sup>	82.46	73.68
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	2.04 <sup>a</sup>	0.60 <sup>a</sup>	70.58	0.40 <sup>a</sup>	80.39	0.20 <sup>a</sup>	90.20	80.39
T <sub>9</sub> – Indoxacarb 14.5 SC (0.1 g/l)	2.30 <sup>b</sup>	0.85 <sup>a</sup>	63.04	0.69 <sup>b</sup>	70.43	0.66 <sup>b</sup>	71.30	68.27
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	3.71 <sup>c</sup>	1.55 <sup>b</sup>	58.22	1.39 <sup>c</sup>	62.53	1.37 <sup>c</sup>	63.07	61.27
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	4.26 <sup>e</sup>	1.98 <sup>cd</sup>	53.52	1.52 <sup>cd</sup>	64.31	1.71 <sup>d</sup>	60.09	59.30
T <sub>12</sub> – Untreated control	4.56 <sup>f</sup>	4.57 <sup>e</sup>	-0.22	4.58 <sup>f</sup>	-0.44	4.58 <sup>f</sup>	-0.43	-0.36

DAS; DBS – Day before spray

DAS – Days after spray

Means followed by same letter in the column do not differ significantly by DMRT ( $\rho = 0.05$ )

Original values were transformed into  $\sqrt{x+0.5}$  before analysis

After 10 days of spray, all the indigenous materials showed statistically on par larval population (0.81 to 1.40 larvae/plant). On the contrary, the larval population reduced to zero in the newer molecules viz., emamectin benzoate, spinosad and indoxacarb. Whereas, the population in fenvalerate 0.92 larvae per plant and endosulfan 2.17 larvae per plant, respectively.

With regard to per cent reduction in larval populations, the maximum reduction at 2 DAS was observed in emamectin benzoate (77.78%) followed by spinosad (75.00%) and indoxacarb (74.35%). However, in case of indigenous materials the per cent reduction varied from 57.45 to 51.49 per cent. The similar trend was continued at 5 and 10 days of spray. At 5 DAS, the maximum reduction (77.78, 77.00 and 74.35%) was recorded in emamectin benzoate, spinosad and indoxacarb, respectively. Among the indigenous materials, the per cent reduction was the tune of 65.95 per cent in case of GCK + cow urine. At 10 DAS, 100 per cent larval reduction was recorded in emamectin benzoate, spinosad and indoxacarb whereas, in case of indigenous materials, the per cent reduction varied from 65.53 per cent in GCK + cow urine to 47.76 per cent in GE (Table 21).

#### 4.4.5 Effect of indigenous materials and new molecules on pod damage at different pickings

In the 1<sup>st</sup> picking, among the indigenous materials, the least per cent pod damage was observed in GCK + cow urine (19.00%) followed by GCK (19.6%), NSKE + cow urine (20.52%), GE + cow urine (21.45%) and NSKE (21.66%) which were statistically at par with each other. Emamectin benzoate was significantly superior (15.27 % pod damage) over endosulfan but failed to differ statistically from spinosad (16.36%), indoxacarb (17.19%) and fenvalerate (18.12%) which in turn were statistically at par with each other (Table 22).

The trend continued during rest of the three pickings. During second picking, the per cent pod damage varied from 23.17 to 26.42 in indigenous materials as compared to 19.10 to 25.50 per cent damage observed in chemical treatments. During the subsequent pickings, the per cent pod damage was on declining trend (9.03 to 17.89% in III picking and 6.62 to 13.99% in IV picking). However, in the untreated plots the damage continued to increase from 30.23 per cent to 60.20 per cent damage during different pickings.

#### 4.4.6 Effect of indigenous materials and new molecules on seed damage at different pickings

In the 1<sup>st</sup> picking, among the indigenous materials, the least per cent seed damage was observed in GCK (23.99%), GCK + cow urine (24.59%), NSKE + cow urine (24.93%) and GE + cow urine (25.27%) which were statistically at par with each other, followed by NSKE (26.67%). The newer molecule, emamectin benzoate was significantly superior (20.26% seed damage) over endosulfan but failed to differ statistically from spinosad (21.36%), indoxacarb (22.19%) and fenvalerate (23.06%) (Table 23).

The trend continued during rest of the three pickings. During second picking, the per cent seed damage varied from 43.09 to 46.76 in indigenous materials as compared to 38.10 to 45.70 per cent damage observed in chemical treatments. During the subsequent pickings, the per cent seed damage was on declining trend (13.70 to 22.89% in III picking and 10.62 to 18.99% IV picking). However, in the untreated plots the damage continued to increase from 35.24 to 65.30 per cent during different pickings.

#### 4.4.7 Effect of indigenous materials and new molecules on green pod yield at different picking

The highest green pod yield (4.04 q/ha) was obtained from emamectin benzoate plots which was statistically superior over all other treatments except spinosad (3.72 q/ha). Among the indigenous materials, GCK + cow urine recorded significantly more yield (2.52 q/ha) compared to GE (1.92 q/ha), but was found at par with other treatments, during I picking (Table 24).

**Table 21 : Efficacy of indigenous materials and new molecules against pod borers (fourth spray)**

Treatments	Number of larvae per plant						Per cent reduction over pre treatment	Mean per cent reduction of larval population
	1 DAS	2 DAS	% reduction over pre-treatment	5 DAS	% reduction over pre-treatment	10 DAS		
T <sub>1</sub> – NSKE 5%	2.29 <sup>de</sup>	1.09 <sup>bc</sup>	52.41	0.86 <sup>c</sup>	62.45	0.88 <sup>b</sup>	61.57	58.81
T <sub>2</sub> – NSKE 5% + cow urine 5%	2.42 <sup>e</sup>	1.08 <sup>bc</sup>	55.37	0.85 <sup>c</sup>	65.46	0.88 <sup>b</sup>	63.63	61.15
T <sub>3</sub> – GCK 0.5%	2.36 <sup>de</sup>	1.02 <sup>bc</sup>	56.78	0.83 <sup>c</sup>	64.83	0.85 <sup>b</sup>	64.46	62.02
T <sub>4</sub> – GCK 0.5% + cow urine 5%	2.35 <sup>de</sup>	1.00 <sup>bc</sup>	57.45	0.80 <sup>c</sup>	65.95	0.81 <sup>b</sup>	65.53	62.98
T <sub>5</sub> – GE 1%	2.68 <sup>f</sup>	1.30 <sup>c</sup>	51.49	1.20 <sup>d</sup>	56.52	1.40 <sup>c</sup>	47.76	51.92
T <sub>6</sub> – GE 1% + cow urine 5%	2.38 <sup>de</sup>	1.16 <sup>bc</sup>	51.68	0.90 <sup>c</sup>	62.18	1.12 <sup>bc</sup>	49.57	54.47
T <sub>7</sub> – Spinosad 45 SC (0.2 ml/l)	1.00 <sup>a</sup>	0.25 <sup>a</sup>	75.00	0.23 <sup>a</sup>	77.00	0.00 <sup>a</sup>	100.0	84.00
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	0.90 <sup>a</sup>	0.20 <sup>a</sup>	77.78	0.20 <sup>a</sup>	77.78	0.00 <sup>a</sup>	100.0	85.19
T <sub>9</sub> – Indoxacarb 14.5 SC (0.1 g/l)	1.17 <sup>b</sup>	0.30 <sup>a</sup>	74.35	0.30 <sup>a</sup>	74.35	0.00 <sup>a</sup>	100.0	87.00
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	1.88 <sup>c</sup>	0.55 <sup>ab</sup>	70.75	0.60 <sup>b</sup>	68.08	0.20 <sup>a</sup>	89.36	76.06
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	2.23 <sup>d</sup>	0.95 <sup>bc</sup>	57.4	0.78 <sup>bc</sup>	65.02	0.77 <sup>b</sup>	65.47	62.63
T <sub>12</sub> – Untreated control	4.59 <sup>g</sup>	4.60 <sup>d</sup>	-0.22	4.61 <sup>e</sup>	-0.43	4.61 <sup>d</sup>	-0.43	-0.36

DAS; DBS – Day before spray

DAS – Days after spray

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

Original values were transformed into  $\sqrt{x+0.5}$  before analysis

**Table 22 : Influence of indigenous materials and new molecules on pod damage at different pickings**

Treatments	Per cent pod damage				Mean
	I Picking	II Picking	III Picking	IV Picking	
T <sub>1</sub> – NSKE 5%	21.66 <sup>bc</sup>	25.77 <sup>c</sup>	16.50 <sup>fg</sup>	12.52 <sup>de</sup>	19.11
T <sub>2</sub> – NSKE 5% + cow urine 5%	20.52 <sup>bc</sup>	23.50 <sup>bc</sup>	16.10 <sup>efg</sup>	12.41 <sup>de</sup>	18.13
T <sub>3</sub> – GCK 0.5%	19.60 <sup>bc</sup>	23.43 <sup>bc</sup>	15.23 <sup>defg</sup>	11.24 <sup>cd</sup>	17.37
T <sub>4</sub> – GCK 0.5% + cow urine 5%	19.00 <sup>abc</sup>	23.17 <sup>bc</sup>	14.75 <sup>defg</sup>	10.87 <sup>cd</sup>	17.01
T <sub>5</sub> – GE 1%	22.76 <sup>c</sup>	26.42 <sup>b</sup>	17.89 <sup>g</sup>	13.99 <sup>e</sup>	20.27
T <sub>6</sub> – GE 1% + cow urine 5%	21.45 <sup>bc</sup>	24.99 <sup>c</sup>	16.16 <sup>efg</sup>	12.45 <sup>ed</sup>	18.73
T <sub>7</sub> – Spinosad 45 SC (0.2 ml/l)	16.36 <sup>ab</sup>	20.09 <sup>ab</sup>	10.83 <sup>ab</sup>	7.42 <sup>ab</sup>	12.92
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	15.27 <sup>a</sup>	19.10 <sup>a</sup>	9.03 <sup>a</sup>	6.62 <sup>a</sup>	11.75
T <sub>9</sub> – Indoxacarb 14.5 SC (0.1 g/l)	17.19 <sup>abc</sup>	21.03 <sup>bc</sup>	11.93 <sup>bc</sup>	8.92 <sup>bc</sup>	14.01
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	18.12 <sup>abc</sup>	22.03 <sup>abc</sup>	12.56 <sup>cd</sup>	9.22 <sup>bc</sup>	14.73
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	20.66 <sup>bc</sup>	25.50 <sup>c</sup>	14.95 <sup>defg</sup>	12.50 <sup>de</sup>	18.40
T <sub>12</sub> – Untreated control	30.23 <sup>d</sup>	40.00 <sup>d</sup>	55.00 <sup>h</sup>	60.20 <sup>f</sup>	46.35

Means followed by same letter in the column do not differ significantly by DMRT ( $p = 0.05$ )  
Original values were transformed into arc sine transformation before analysis

**Table 23 : Influence of indigenous materials and new molecules on seed damage at different pickings**

Treatments	Per cent seed damage				Mean
	I Picking	II Picking	III Picking	IV Picking	
T <sub>1</sub> – NSKE 5%	26.67 <sup>bc</sup>	45.77 <sup>d</sup>	21.50 <sup>fg</sup>	17.52 <sup>de</sup>	27.86
T <sub>2</sub> – NSKE 5% + cow urine 5%	24.93 <sup>abc</sup>	43.49 <sup>bcd</sup>	21.09 <sup>fg</sup>	17.41 <sup>de</sup>	26.73
T <sub>3</sub> – GCK 0.5%	23.99 <sup>abc</sup>	43.43 <sup>bcd</sup>	20.90 <sup>g</sup>	16.37 <sup>cd</sup>	26.17
T <sub>4</sub> – GCK 0.5% + cow urine 5%	24.59 <sup>abc</sup>	43.09 <sup>bcd</sup>	20.40 <sup>g</sup>	15.87 <sup>cd</sup>	25.99
T <sub>5</sub> – GE 1%	27.26 <sup>c</sup>	46.76 <sup>d</sup>	22.89 <sup>gh</sup>	18.99 <sup>e</sup>	28.98
T <sub>6</sub> – GE 1% + cow urine 5%	25.27 <sup>abc</sup>	44.28 <sup>bcd</sup>	21.10 <sup>fg</sup>	17.45 <sup>de</sup>	27.03
T <sub>7</sub> – Spinosad 45 SC (0.2 ml/l)	21.36 <sup>ab</sup>	39.09 <sup>b</sup>	15.83 <sup>bc</sup>	11.42 <sup>a</sup>	21.92
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	20.26 <sup>a</sup>	38.10 <sup>a</sup>	13.70 <sup>a</sup>	10.62 <sup>a</sup>	20.67
T <sub>9</sub> – Indoxacarb 14.5 SC (0.1 g/l)	22.19 <sup>abc</sup>	40.03 <sup>bc</sup>	16.93 <sup>b</sup>	13.92 <sup>b</sup>	22.76
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	23.06 <sup>abc</sup>	41.03 <sup>bcd</sup>	18.83 <sup>de</sup>	13.22 <sup>b</sup>	23.28
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	25.60 <sup>bc</sup>	45.70 <sup>d</sup>	19.00 <sup>ef</sup>	17.50 <sup>de</sup>	26.95
T <sub>12</sub> – Untreated control	35.24 <sup>d</sup>	45.00 <sup>e</sup>	36.00 <sup>h</sup>	65.30 <sup>f</sup>	51.41

Means followed by same letter in the column do not differ significantly by DMRT ( $p = 0.05$ )  
Original values were transformed into arc sine transformation before analysis

**Table 24 : Influence of indigenous materials and new molecules on pod yield at different pickings**

Treatments	Green pod yield (q/ha)				Mean
	I Picking	II Picking	III Picking	IV Picking	
T <sub>1</sub> – NSKE 5%	2.21 <sup>cd</sup>	0.66 <sup>fg</sup>	3.55 <sup>de</sup>	0.53 <sup>ef</sup>	6.95 <sup>d</sup>
T <sub>2</sub> – NSKE 5% + cow urine 5%	2.51 <sup>c</sup>	0.90 <sup>e</sup>	3.70 <sup>d</sup>	0.67 <sup>e</sup>	7.78 <sup>d</sup>
T <sub>3</sub> – GCK 0.5%	2.42 <sup>c</sup>	1.04 <sup>e</sup>	3.77 <sup>d</sup>	0.68 <sup>e</sup>	7.91 <sup>d</sup>
T <sub>4</sub> – GCK 0.5% + cow urine 5%	2.52 <sup>c</sup>	1.06 <sup>e</sup>	3.73 <sup>d</sup>	0.77 <sup>e</sup>	8.01 <sup>d</sup>
T <sub>5</sub> – GE 1%	1.92 <sup>d</sup>	0.55 <sup>g</sup>	3.05 <sup>e</sup>	0.17 <sup>g</sup>	5.69 <sup>e</sup>
T <sub>6</sub> – GE 1% + cow urine 5%	2.40 <sup>c</sup>	0.81 <sup>ef</sup>	3.57 <sup>de</sup>	0.55 <sup>ef</sup>	7.33 <sup>d</sup>
T <sub>7</sub> – Spinosad 45 SC (0.2 ml/l)	3.72 <sup>ab</sup>	2.89 <sup>b</sup>	3.06 <sup>ab</sup>	2.44 <sup>b</sup>	14.11 <sup>b</sup>
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	4.04 <sup>a</sup>	3.19 <sup>a</sup>	5.19 <sup>a</sup>	2.72 <sup>a</sup>	15.14 <sup>a</sup>
T <sub>9</sub> – Indoxacarb 14.5 SC (0.1 g/l)	3.63 <sup>b</sup>	2.57 <sup>c</sup>	4.79 <sup>b</sup>	2.12 <sup>c</sup>	13.11 <sup>b</sup>
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	3.46 <sup>b</sup>	2.23 <sup>d</sup>	4.42 <sup>c</sup>	1.76 <sup>d</sup>	11.87 <sup>c</sup>
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	2.27 <sup>cd</sup>	0.65 <sup>fg</sup>	3.65 <sup>d</sup>	0.54 <sup>ef</sup>	7.11 <sup>d</sup>
T <sub>12</sub> – Untreated control	1.96 <sup>d</sup>	0.43 <sup>h</sup>	0.19 <sup>f</sup>	0.08 <sup>h</sup>	3.26 <sup>f</sup>

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

**Table 25 : Economics of pod borer management in field bean**

Treatments	Green pod yield (q/ha)	Add. Yield over control (q/ha)	Add. returns (Rs./ha)	Total cost of treatment application (Rs./ha)	Net returns (Rs/ha)	IBC ratio
T <sub>1</sub> – NSKE 5%	6.95	3.69	2952	1360	1592	2.17
T <sub>2</sub> – NSKE 5% + cow urine 5%	7.78	4.52	3616	1360	2256	2.65
T <sub>3</sub> – GCK 0.5%	7.91	4.65	3720	1260	2460	2.95
T <sub>4</sub> – GCK 0.5% + cow urine 5%	8.01	4.75	3800	1260	2540	3.01
T <sub>5</sub> – GE 1%	5.69	2.43	1944	1160	784	1.67
T <sub>6</sub> – GE 1% + cow urine 5%	7.33	4.07	3256	1160	2096	2.81
T <sub>7</sub> – Spinosad 45 SC (0.2 ml/l)	14.11	10.85	8680	4920	3760	1.76
T <sub>8</sub> – Emamectin benzoate 5 SG (0.2 g/l)	15.14	11.88	9504	4600	4904	2.07
T <sub>9</sub> – Indoxacarb 14.5 SC (0.1 g/l)	13.11	9.85	7880	1240	6640	6.35
T <sub>10</sub> – Fenvalerate 20EC (0.5 ml/l)	11.87	8.61	6888	1120	5768	6.15
T <sub>11</sub> – Endosulfan 35 EC (2 ml/l)	7.11	3.85	3080	1500	1580	2.05
T <sub>12</sub> – Untreated control	3.26	-	-	-	-	-

The emamectin benzoate continued to retain its supremacy over all other treatments in rest of the pickings (3.19, 5.19 and 2.72 q/ha in II, III and IV picking, respectively). The indigenous materials recorded lower yield in all the treatments (0.55 to 1.06, 3.05 to 3.73 and 0.17 to 0.77 in II, III and IV picking) in comparison to the chemical treatments. The least yield was obtained from non-protected plots (1.90, 0.21, 0.19 and 0.08 q/ha in the corresponding pickings).

The total green pod yield was maximum (15.14 q/ha) in emamectin benzoate followed by spinosad (14.11 q/ha), indoxacarb (13.11 q/ha), which were on par with each other which was followed by fenvalerate (11.87 q/ha). Except GE (1.90 q/ha) and untreated control (1.09 q/ha) the pod yield in remaining treatments were on par with each other which vary from 2.32 to 2.67 q/ha.

#### 4.4.8 Cost economics of various treatments

Considering the cost effectiveness of various treatments, GCK + cow urine registered higher net returns (Rs. 2540/ha) followed by GCK, NSKE + cow urine and GCK + cow urine recorded higher IBC ratio of 3.01 followed by GCK (2.95), GE + cow urine (2.81) and NSKE + cow urine (2.65) (Table 25).

Among new molecules, the highest net returns were observed in indoxacarb (Rs. 6640) followed by fenvalerate (Rs. 5768) and emamectin benzoate (4904). However, the IBC ratio was high in indoxacarb and fenvalerate treatments (6.35 and 6.15, respectively). Though the emamectin benzoate and spinosad treatments proved to be the best efficacy wise, they recorded lower IBC ratio (2.07 and 1.76, respectively).

## V. DISCUSSION

### 5.1 STUDIES ON PEST COMPLEX OF DOLICHOS BEAN WITH SPECIAL REFERENCE TO POD BORERS

Available literature revealed that more than 64 species of insects have been recorded on *Lablab purpureus* from different parts of the world of which 57 species of insect pests have been reported from India alone. The present investigation was carried out to know the pest complex of field bean with special reference to pod borers, natural enemy complex of major pod borers, extent of loss caused by pod borers and also to evaluate the indigenous materials and new molecules against pod borers.

During the study period the following species of insects pests were recorded on the crop. Among the grass hoppers, *Chrotogonus* sp. *Cyrtacanthcaris ranacea* L. (Orthoptera : Acrididae) were found mostly in the vegetative stage of the crop. *Chrotogonus* sp. was found during September. While, *C. ranacea* was noticed during September and October. These species fed on leaves and young plants. However, the grass hoppers were not observed as regular and serious pests. The findings are in agreement with the observation of Govindan (1974). According to Fletcher (1914) and Ayyar (1963), the grass hopper species viz., *C. ranacea* and *Chrotogonus* sp. are known to feed on jowar, groundnut, cotton, tobacco and various other crops.

The polyphagous hairy caterpillar, *Spilosoma obliqua* (Walker) was found feeding on the leaves by scraping and skeletonizing while, the grown up caterpillars fed by cutting the leaves. They also scraped the pod coat and fed on the seeds. The percentage of infestation by this caterpillar was quite high from October to February which is in accordance with the observations of Govindan (1974). The leaf miner incidence was noticed on the crop in September month. The caterpillars mined the leaves and as a result big blotches appeared on the leaves. These observations are confirmation to Govindan (1974) who made studies on insect pests of *Dolichos lablab* at Bangalore.

The grubs of *Alcidodes collaris*, bored into the stem resulting in the formation of a gall on red gram, black gram and other pulses (Ayyar, 1963) is in agreement with the present studies.

The cut worms damaged the seedlings of *Dolichos* bean to a negligible extent. The pest has been recorded on green gram (Katti, 1984) and on soybean (Adimani, 1976).

The aphid (*Aphis craccivora*) incidence was noticed in large number from September to first week of October, with a population range of 30.5 to 50.0 and 8.4 to 11.2 aphids per 3 leaves on crop sown during 3<sup>rd</sup> week of August and 1<sup>st</sup> week of September, respectively. They fed in colonies on tender twigs, inflorescence and pods. The results are in confirmative with the observations made by Hafez *et al.* (1996) who reported, three peaks of aphid abundance i.e., May, August and September in Fayoum (Egypt) in cotton eco system.

The leaf hopper appeared commonly in the vegetative phases of the crop. Both nymphs and adults stayed on the ventral surface of the leaf and sucked the sap. Whereas, the thrips was found in large numbers on the leaves during September to October with the average number varying from 4.7 to 7.6 thrips/3 leaves on the August sown crop. Whereas, the crop sown in September harboured 1.2 to 3.36 thrips /3 leaves during October-November months. The results are in confirmity with the observations made by Govindan (1974).

The bug, *Eurybrachys tomentosa* F. was found usually sucking the sap from twigs and rarely from the pods. Similar observations were made by Govindan (1974). Fletcher (1914) reported this species as a pest on calotropis, cotton and various malvaceous plants.

Coreid bug (*A. phasiana*) incidence was noticed from September to December, the adults of which were found feeding on the sap from tender twigs. *Clavigrella gibbosa* and *C. horrens* harboured the crop from October-January. Both the nymphs and adults of coreid bugs were seen sucking the sap from the pods. Due to sucking, brown spots were formed on the pods and also shriveling of seeds occurred. The nymphs and adults of *Riptortus pedestris*

were observed at later stages of crop growth and were found sucking the sap from the pods. On August sown crop, the bug population ranged from 0.2 to 10.8 per 5 plants. Govindan (1974) recorded the incidence of *R. pedestris* during September to January. Lefroy (1909), Gangrade (1961) and Singh and Patel (1968) reported that *C. gibbosa* and *C. horrens* as pest of red gram pods. *R. pedestris* has been observed sucking the pods of lablab, cowpea, blackgram, greengram, ridgegourd and wheat by Fletcher (1914). Whereas, *Anoplocnemis phasiana* (F.) has been reported to feed on grapes, brinjal, lablab, redgram, groundnut, glyricidia, pongamia and ridge gourd (Puttarudraiah and Maheswaraiah, 1956).

Both nymphs and adults of *Dollicoris indicus* and *N. viridula* (Hemiptera : Pentatomidae) were found throughout the main cropping season on August sown crop. The mean population ranged from 0.2 to 4.3 bugs per 5 plants. However, the number was negligible on September sown crop. The bugs sucked sap from all the aerial parts of the plant which agrees with earlier observations made by Govindan (1974). Fletcher (1914) and Corpuz (1969) mentioned these bugs as pest of jowar, maize, bhendi, citrus, tobacco, sunflower, cowpea, brinjal and lablab. Singh and Taylor (1978) recorded green stinkbug (*N. viridula*) as pest of greengram which attacks young leaves, shoots and pods.

The pod damage due to pod borers was relatively more on August sown crop than September sown crop (Fig. 1). These findings are in close association with Lalasangi (1984) who reported the peak infestation of the pod during July and August sown crop.

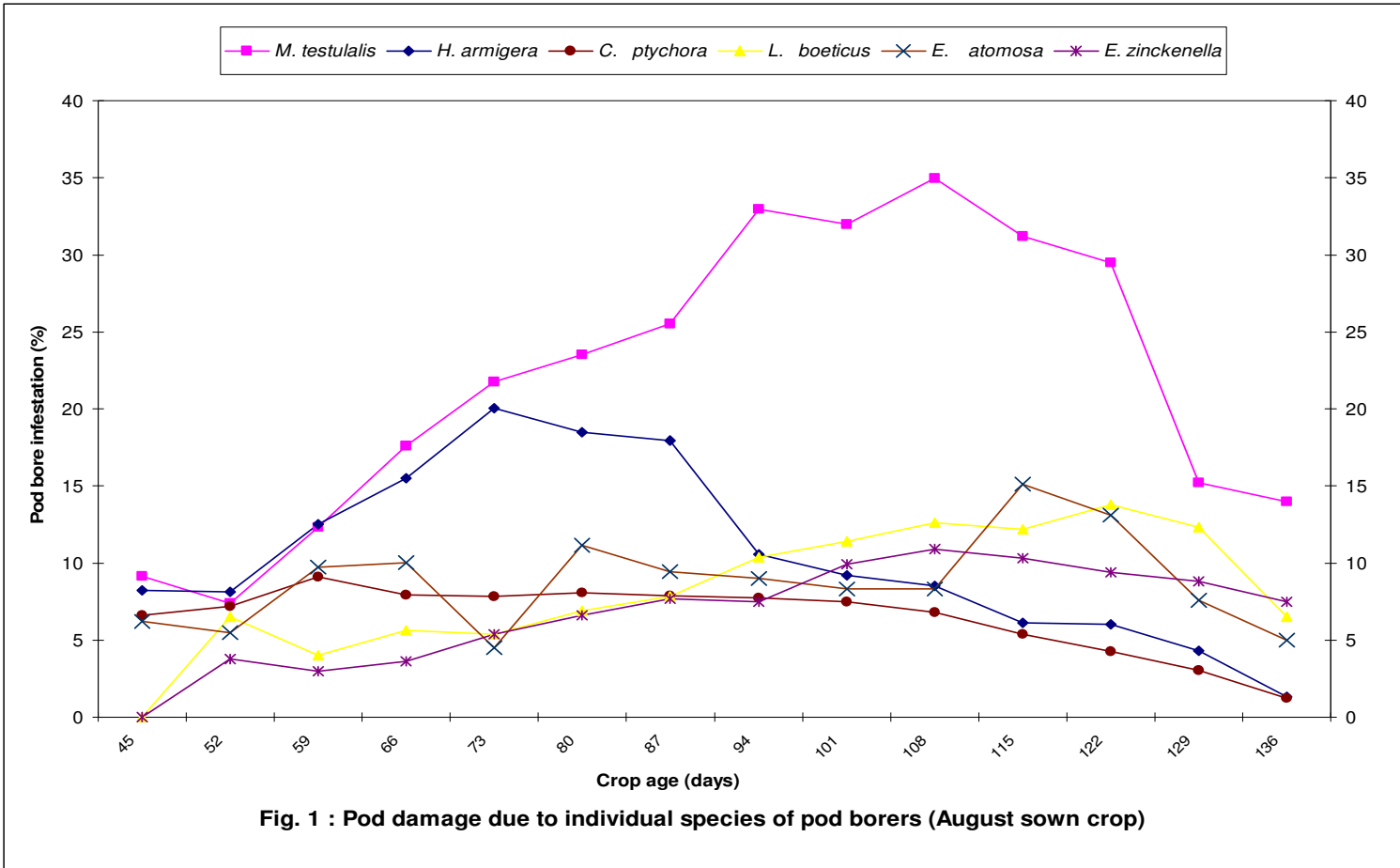
#### 5.1.1 Pod damage due to individual species of pod borers

*M. testulalis* appeared to be the predominant species causing 9.14 to 34.95 per cent pod damage. The peak infestation (31.20 to 34.95%) was observed on 94 to 115 days old crop which coincided with last week of November to December. These observations were in close agreement with Bruner (1931) who recorded the peak incidence of *M. testulalis* during November-December. The peak infestation (17.94 to 20.05%) of *H. armigera* was observed on 73 to 87 days old crop in November month. Bhoyar *et al.* (2004) also reported peak incidence of *H. armigera* on pigeonpea during November.

The pod damage due to *Cydia ptychora* ranged from 1.2 to 9.1 per cent. The peak infestation (7.75 to 9.1%) was noticed in October and November month on 59 to 94 days old crop. Similar observations were made by Katti (1984) who reported the pod borer attack on the crop sown during July.

In the order of infestation level, *L. boeticus* was next to *H. armigera* with a peak infestation of 12.20 to 13.8 per cent which was noticed on 108 to 129 days old crop during December to January. These observations are in close agreement with Aoki (1927) who recorded larvae of *L. boeticus* in large number on beans during December. The pod damage due to *E. atomosa* ranged from 5.0 to 15.1 per cent with the peak infestation (13 to 15%) observed on 112 to 115 days crop, which coincided with second fortnight of December. Bhoyar *et al.* (2004) also recorded the incidence of *E. atomosa* on pigeonpea in December. The incidence of *E. zinckenella* peaked (9.95 to 10.9%) at later stages of the crop (101 to 129 days old crop) i.e., December to first week of January. Similarly, Govindan (1974) also reported activity of *E. zinckenella* in field bean at later stages of the crop i.e., during last week of December to February. A similar trend in the incidence of various pests was observed on September sown crop as well but with lower level of infestation. Occurrence of pod borers throughout the cropping season has already been reported by Mallikarjunappa (1989).

More pod yield (3.69 q/ha) was obtained in early sown crop than September sown crop (2.30 q/ha), even though the pest incidence was more as compared to late sown crop (2.3 q/ha). The August sown crop duration was extended upto 136 days which allowed 5 pickings as compared to four pickings with 84 days duration in case of September sown crop. Added to this, the late sown crop suffered from moisture stress at later stages.



**Fig.1 : Pod damage due to individual species of pod borers (August sown crop)**

### 5.1.2 Nature of damage

During present investigation, the early instar larvae of spotted pod borer, *M. testulalis* bored into the seeds and fed on the contents of pods remaining inside whereas, the grownup larvae caused damage by excavating the seeds. The infested pods when opened revealed the presence of caterpillars and excretory pellets which is similar to the observation made by Jagginnavar (1988) in cowpea.

The early larval instars of gram pod borer, *H. armigera* bored into the flower buds and tender pods while, the later instars damaged mature and developing pods with circular holes on individual seeds of the pod. While feeding on pods usually the posterior parts of the caterpillar remained outside the pod. These observations are in agreement with Govindan (1974) and Mallikarjunappa (1989).

Damage symptom caused by the African moth, *C. ptychora* which bores into the seeds and makes an exist hole on the pod is similar to the observations made by Taylor (1964) and Jagginnavar (1988) on cowpea and Adimani (1976) on soybean.

The caterpillars of blue butterfly, *L. boeticus* bored into the flower buds and tender pods resulting in drying up of flowers and tender pods is in accordance with the earlier reports of Govindan (1974) and Mallikarjunappa (1989) on field bean.

The plume moth (*E. atomosa*) caterpillars bored into the flower buds, developing pods and also mature pods by making a small round hole on the pods. Similar observations were made by Govindan (1974) and Mallikarjunappa (1989).

The early instars of pea pod borer, *E. zinckenella* bored into the tender pods and later entered into the mature pods. The presence of silken threads and mass of excreta was observed inside the bored pods as reported by Govindan (1974) and Mallikarjunappa (1989).

## 5.2 STUDIES ON THE NATURAL ENEMY COMPLEX OF MAJOR POD BORERS

During the present investigations, the larval parasitoid, *Bracon* sp. nr. *greeni* caused 10 to 20 per cent parasitization of *M. testulalis*. Ramadas Rai (1983) and Lalasangi (1984) also recorded the parasitoid on *M. testulalis*.

Parasitization of *C. ptychora* by *Bracon* sp. was observed by Perrin and Ezueh (1979) and Olaiifa and Akingbhongbe (1982). The maximum parasitization which was noticed in October, November and December months is in accordance with the observations made by Ramadas Rai (1983).

On August sown crop, the predators including lady bird beetle (4.5 to 6 grub/10 plant), green lacewing (0.9 to 1.48 adult/plant) and Robber fly (0.7 to 1.24 fly/10 plant) were recorded at early stages of crop growth (Fig. 2). Whereas, on September sown crop, the activity of only lady bird beetle (2.0 to 5.4 grubs/10 plant) was noticed. There are no previous reports compare the present findings.

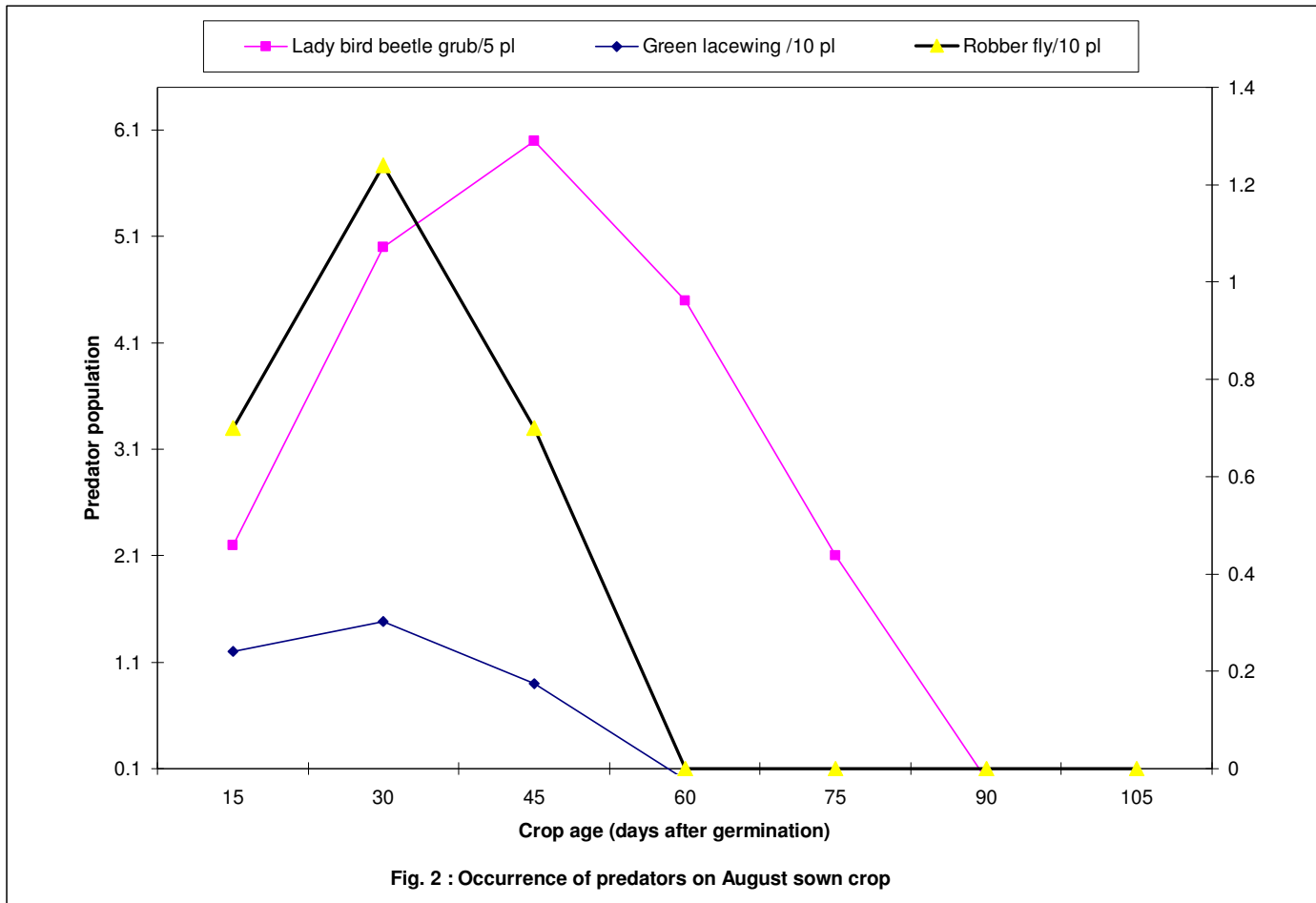
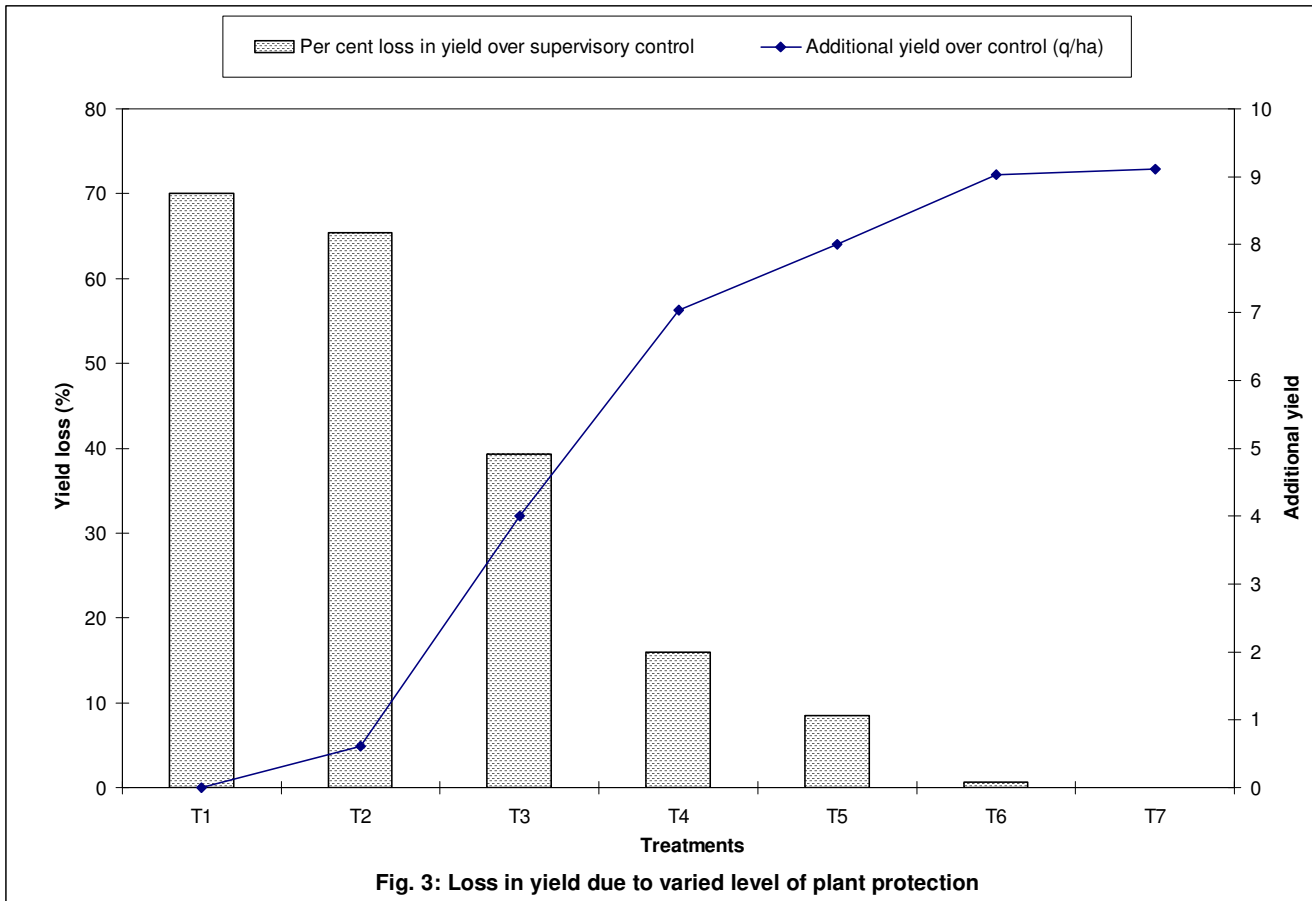


Fig. 2 : Occurrence of predators on August sown crop

## LEGEND

T1	No Protection
T2	Fenvalerate: 1 spray
T3	Fenvalerate: 2 spray
T4	Fenvalerate: 3 spray
T5	Fenvalerate: 4 spray
T6	Fenvalerate: 5 spray
T7	Supervisory control



**Fig.3 Loss in yield due to varied level of plant protection**

### 5.3 ESTIMATION OF CROP LOSS DUE TO POD BORERS IN DOLICHOS BEAN

The insect is considered as a pest only based on the extent of damage or loss it causes to the crop. Depending upon this, the plant protection measures have to be tailored for getting higher economic returns. The present work was carried out to estimate the loss caused in field bean by pod borers under field conditions. In all the five sprays, although the pod borer population remained more or less same in the untreated plots, the number was drastically reduced in the fenvalerate sprayed plots irrespective of number of sprays. However, after five days of spray, the pest population started building up in the latter treatments as indicated by 10 days of spray observation. Further, with the gap of five more days, the pod borer number in the fenvalerate treated plots increased by two to three fold. The distribution of natural enemies in the fenvalerate sprayed plots might be the reason for enhanced pest population in the treated plots as against untreated check where in the ecosystem was undisturbed. The experiment on yield loss due to pod borers was worked out by imposing differential level of insecticidal (fenvalerate) spray. The yield loss to the tune of 70.07 per cent was recorded in unprotected plots (Fig. 3). Chu (1943) reported as high as 90 per cent damage to soybean pods by *E. zinckenella* in China. Taylor (1967) reported 20-40 per cent loss in cowpea due to severe incidence of *M. testulalis* in Nigeria.

The results of the present findings revealed the highest per cent pod damage (26.79) and seed damage (31.85) in the untreated check (Fig. 4). Similarly, Taylor (1964) observed 35.0 per cent pod damage and 31.85 per cent seed damage in cowpea crop. Relatively higher pod damage (42.0 to 56.0%) was recorded on cowpea (Gubbaiah *et al.*, 1975).

The results on the number of insecticidal application revealed that 2 to 3 sprays of fenvalerate gave effective protection to pod against pod borers by recording highest IBC ratio (Fig. 5). The crop loss estimation through differential level of spraying indicated that three sprays at an interval of 15 days resulted in effective management of pod borer complex in field bean.

The results on the number of applications are in conformity with Dina (1976) who concluded that six spray applications beginning from flowering to pod maturation stage provide the highest yield with minimum pod damage. However, three applications made during flowering to pod maturation phase gave effective protection to pod against pod borers of cowpea.

Similar results were also obtained by Kobayashi (1978) who opined that two or three effective applications of insecticides gave 50-70 per cent control of all soybean seed pests. Singh and Taylor (1978) suggested two applications of endosulfan or monocrotophos @ 500 g a.i./ha at 45 and 60 DAP for effective control of *Cydia* sp. in soybean.

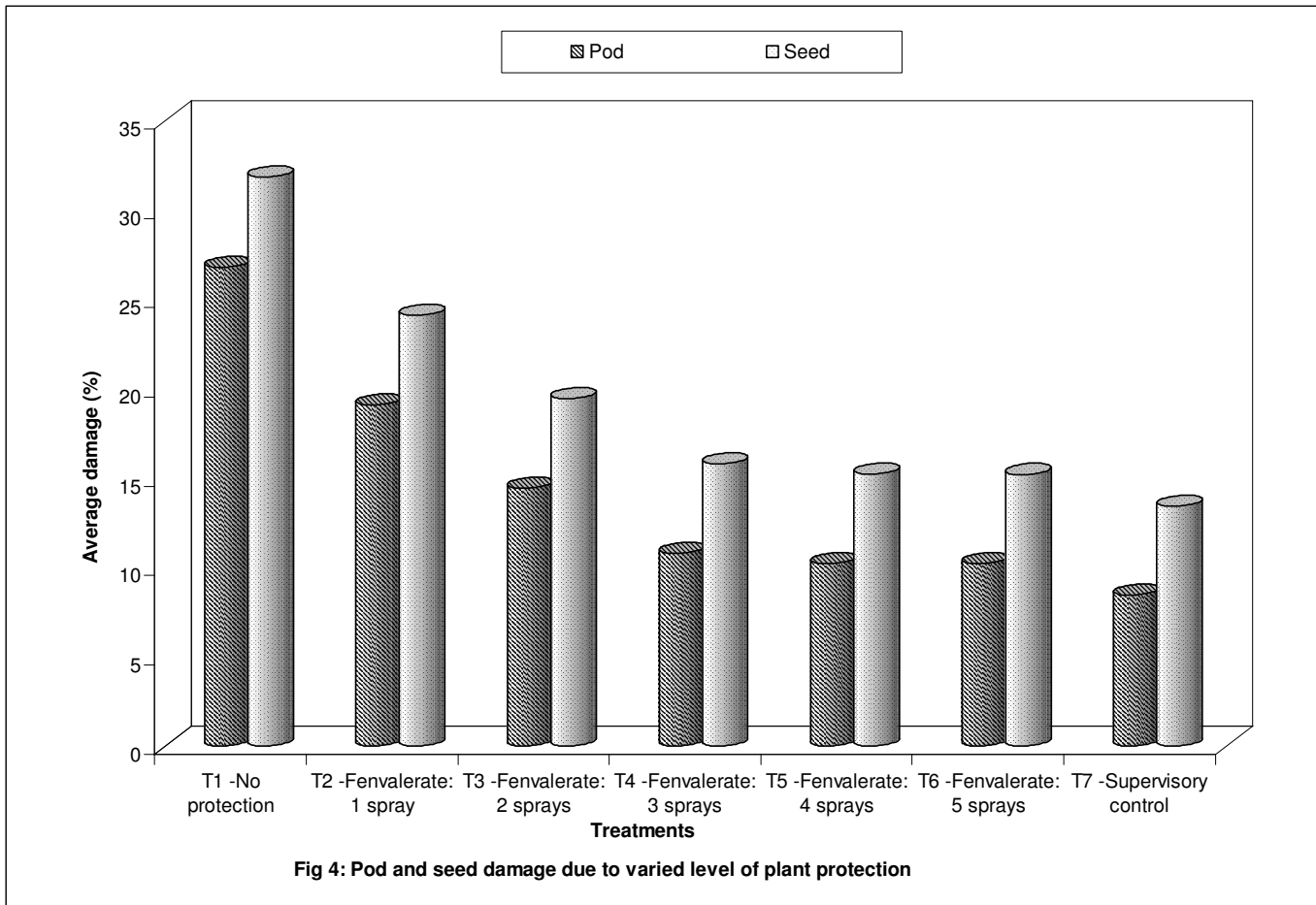
Three spray applications of quinalphos at fortnightly interval, starting from flowering stage was most effective in controlling the red gram pod fly as reported by Singh and Rai (1985) agrees with the present results. Alghali (1992) concluded that three sprays at flower-budding flowering and podding were profitable which increased the yield by 50-200 per cent in cowpea. These results are closely in line with the present findings.

Four to three application of monocrotophos at 10 days interval starting from flowering stage and pod formation stage were most effective in controlling soybean pod borer, *C. ptychora* as reported by Amaranath (2000).

Narendra Reddy *et al.* (2001) reported that 2 to 3 times spraying of fenvalerate @ 0.02 per cent was most effective against pod borer complex in pigeonpea. All the reports quoted above are in confirmation with the present findings.

## LEGEND

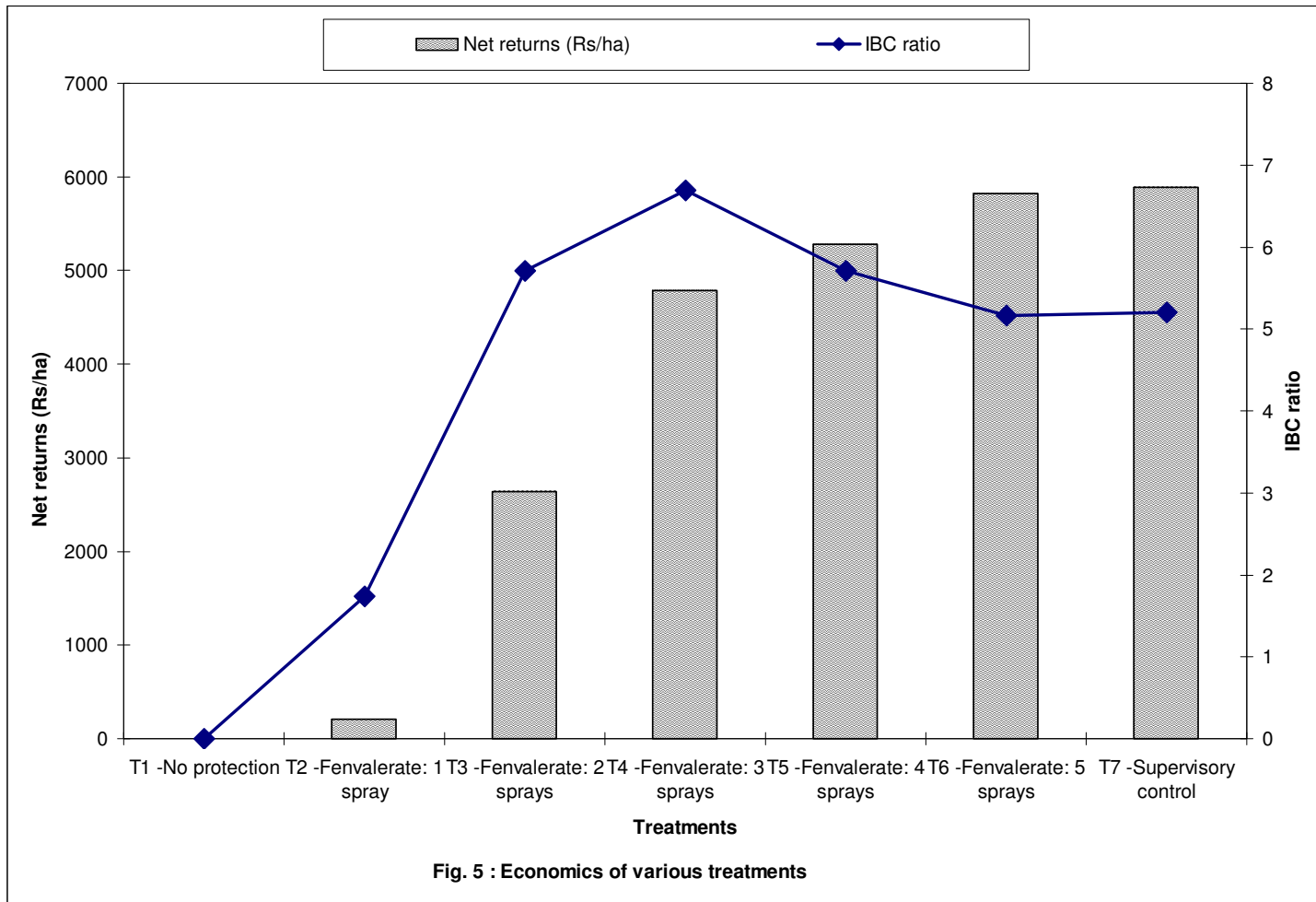
T1	No Protection
T2	Fenvalerate: 1 spray
T3	Fenvalerate: 2 spray
T4	Fenvalerate: 3 spray
T5	Fenvalerate: 4 spray
T6	Fenvalerate: 5 spray
T7	Supervisory control



**Fig.4: Pod and seed damage due to varied level of plant protection**

**LEGEND**

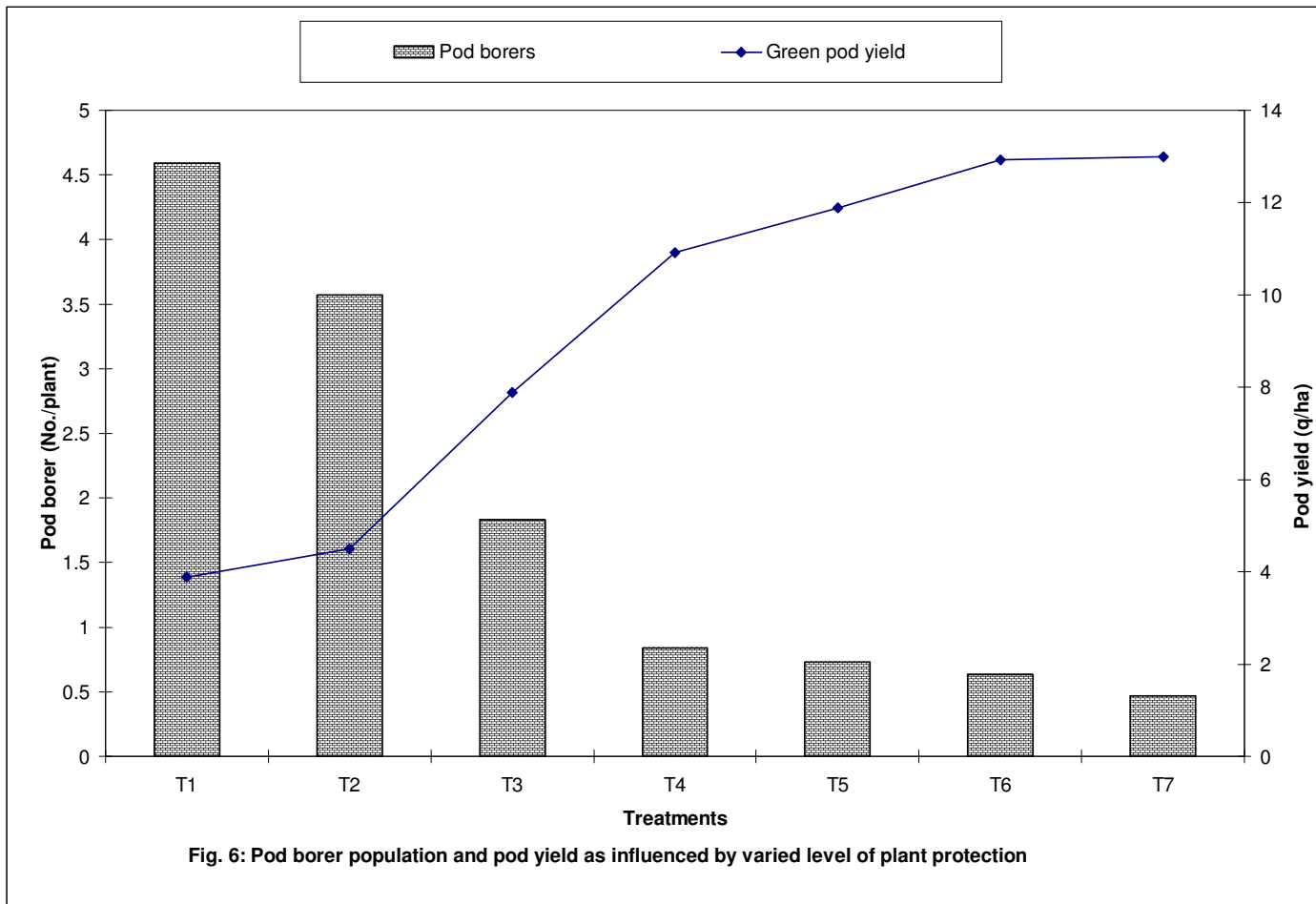
T1	No Protection
T2	Fenvalerate: 1 spray
T3	Fenvalerate: 2 spray
T4	Fenvalerate: 3 spray
T5	Fenvalerate: 4 spray
T6	Fenvalerate: 5 spray
T7	Supervisory control



**Fig.5: Economics of various treatments**

## LEGEND

T1	No Protection
T2	Fenvalerate: 1 spray
T3	Fenvalerate: 2 spray
T4	Fenvalerate: 3 spray
T5	Fenvalerate: 4 spray
T6	Fenvalerate: 5 spray
T7	Supervisory control



**Fig.6: Pod borer population and pod yield as influenced by varied level of plant protection**

### 5.3.1 Economic injury level

To calculate the EIL, the parameters considered were the economic losses in yield resulting from pod borers (Fig. 6) and the cost involved in the plant protection. To arrive at the EIL, it is necessary to derive the gain threshold. EIL is the amount of yield loss that constitutes minimum economic damage as per Stone and Pedigo (1972) and Ogunlana and Pedigo (1974). The gain threshold was worked out based on the ratio of cost of pest control and the market price of the produce. The economic injury level of pod borers was worked out to be 0.45 larvae/ plant for Konkanbushan variety of field bean. So it is evident from the present studies that the management strategies should be imposed in the initial buildup of pod borers. There is no literature on the estimation of economic injury level against pod borer complex in field bean. However, different authors have reported ETL on various other crops.

The threshold for the pod borer, *H. armigera* on soybean was 5 larvae per meter row length (Singh and Singh, 1990). Gaztoni *et al.* (1994) opined that action level for insect control on soybean pod borer was 10 larvae per meter row length.

EIL for *H. armigera* has been worked out in several crops like pigeonpea (0.60 larvae/plant) (Venkataiah *et al.*, 1994), safflower (0.67 larvae/plant) (Venkata Rajesh, 2004). While, the EIL for soybean pod borer, *C. ptychora* was determined 1.16 larvae/plant (Amarnath, 2000).

According to Smith and Reynolds (1972), the economic injury on threshold is flexible and may vary from areas, crop varieties and even between two adjoining fields depending upon specific agronomic practices. The method suggested for calculation of EIL by Stone and Pedigo (1972) and Ogunlana and Pedigo (1974) mainly depends on the market price of the produce and cost of plant protection as a result the EIL varies from time to time and crop to crop. The present findings differs from the earlier reports. Since, the crop as well as pest species differed.

## 5.4 FIELD EVALUATION OF INDIGENOUS MATERIALS AND NEW MOLECULES ON POD BORER COMPLEX

### 5.4.1 Larval population and per cent reduction

The present investigation clearly indicated that among the indigenous materials, GCK + cow urine and GCK alone treatments were found to be quite effective in reducing the mean larval population to the extent of 19.21 and 18.26, 48.76 and 45.99, 56.18 and 55.98 and 62.98 and 62.02 per cent with a larval population of 3.53 and 3.58, 2.00 and 2.12, 1.71 and 1.73, 0.87 and 0.90 larvae per plant after 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> spray respectively (Fig. 7). The next best treatments included NSKE + cow urine, GE + cow urine and NSKE. These results are in accordance with the findings of Mallapur (2002) and Ravi Kumar (2004) who reported higher effectiveness of GCK + cow urine and GCK against *H. armigera* in chilli.

The efficacy of NSKE + cow urine and NSKE treatments can be supported by the reports of Bhat *et al.* (1988) and Sachan and Lal (1990). The former author reported that NSKE was the best treatment against pod borers, *M. testulalis* and *C. ptychora* on cowpea. While, the latter author indicated the role of NSKE in controlling *H. armigera* on chickpea.

Ramteke *et al* (2002) revealed that neem seed kernel extract and neem wettable powder were found on par with endosulfan in reducing *H. armigera* infestation in chickpea. Whereas, the effectiveness of GE + cow urine is supported by Vijayalaxmi *et al.* (1996) who reported the higher effectiveness of GE in combination with other extracts like neem, chilli, ginger and cow urine along with soap solution against *H. armigera*.

Many of the authors opined that sole dependence on either indigenous materials/botanicals or conventional insecticides did not result in effective management of pests. They also opined that scientific and judicious use of new molecules is still the best method of plant protection from the yield and economic point of view. Added to this some of the new molecules being originated from microbial source are eco-friendly as well. In the light of the above, the results obtained from present investigation are discussed here under.

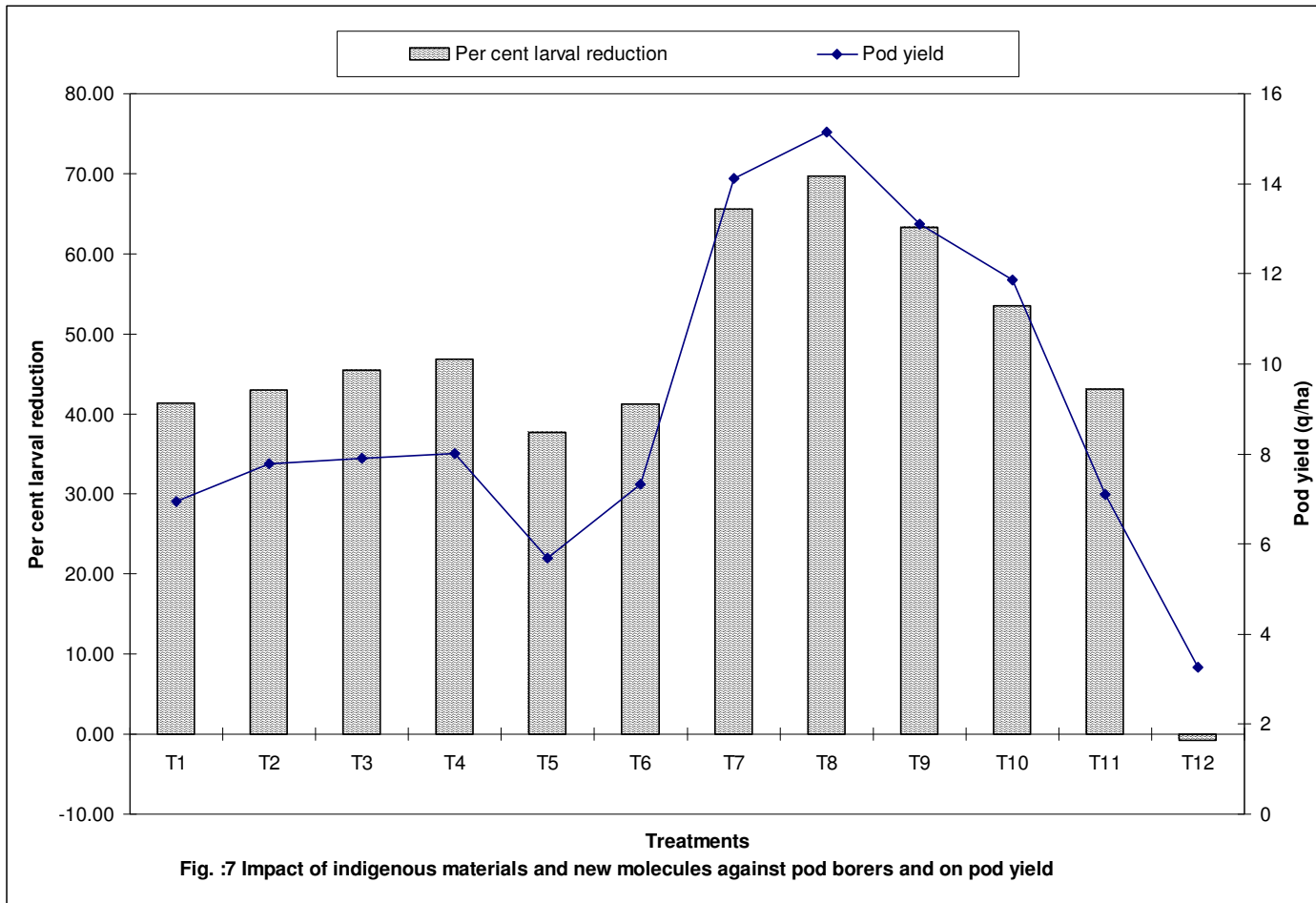
All the insecticides proved their superiority over untreated control but however, endosulfan was found less effective as compared to the new molecules. Emamectin benzoate (0.2 g/l) emerged as the best treatment which spared as low as 2.72, 0.74, 0.4 and 0.13 larvae per plant with 37.17, 75.91, 80.39 and 85.19 per cent reduction in pod borer populations after 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> spray, respectively (Fig. 7). However, it was comparable with spinosad (0.2 ml/ha) which allowed 2.92, 1.10, 0.6 and 0.16 larvae per plant to survive and (32.79, 71.76, 73.68 and 84.90 % mortality) as influenced by first, second, third and fourth spray, respectively.

No information is traceable on the efficacy of emamectin benzoate in field bean ecosystem. However, the reports of Udikeri *et al.* (2004) and Giraddi *et al.* (2004) in cotton against its efficacy on bollworm, *H. armigera*, confirm the high effectiveness of this new molecule.

The efficacy of spinosad is supported by many authors. Ladaji (2004) reported higher effectiveness of spinosad against *H. armigera* in chickpea ecosystem. Dandale *et al.* (2000) in cotton against bollworm, *H. armigera*, Siddegowda *et al.* (2003) in pigeonpea against pod borer, *H. armigera* and Bhoyar *et al.* (2004) against pod borer complex in pigeonpea ecosystem.

## LEGEND

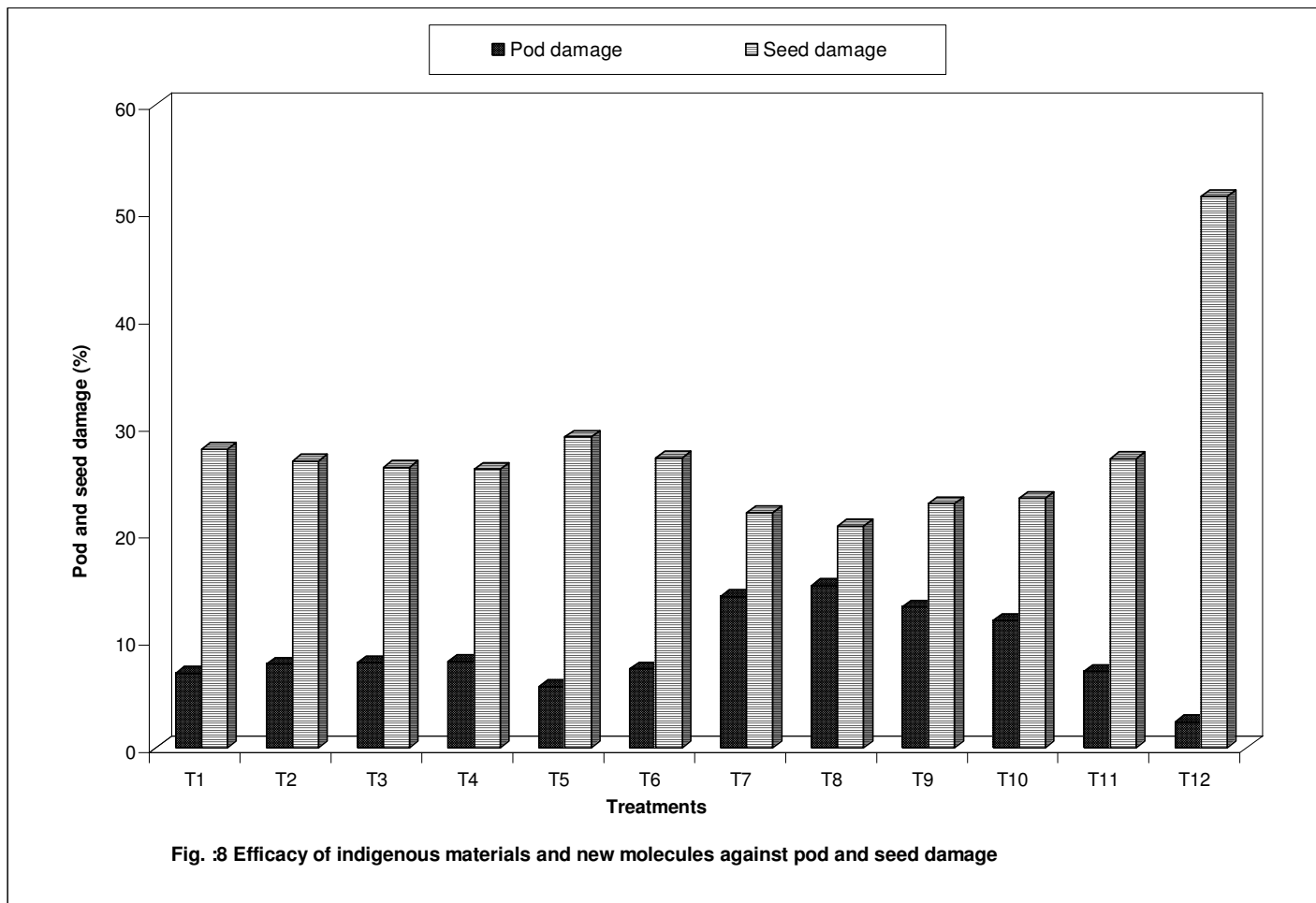
T1	NSKE (5%)
T2	NSKE (5%)+ cow urine (fermented) (5%)
T3	GCK (0.5%)
T4	GCK (0.5%) + cow urine (fermented) (5%)
T5	GE (1%)
T6	GE (1%) + cow urine (fermented)(5%)
T7	Spinosad 45SC (@ 0.2 ml/l)
T8	Emamectin benzoate 5Sg (@ 0.2 g/l)
T9	Indoxcarb 14.5 SC (@0.1 g/l)
T10	Fenvalerate 20EC (@0.5ml/l)
T11	Endosulfan 35 EC (@2 ml/l)
T12	Untreated control



**Fig.7: Impact of indigenous material and new molecules against pod borers and on pod yield**

## LEGEND

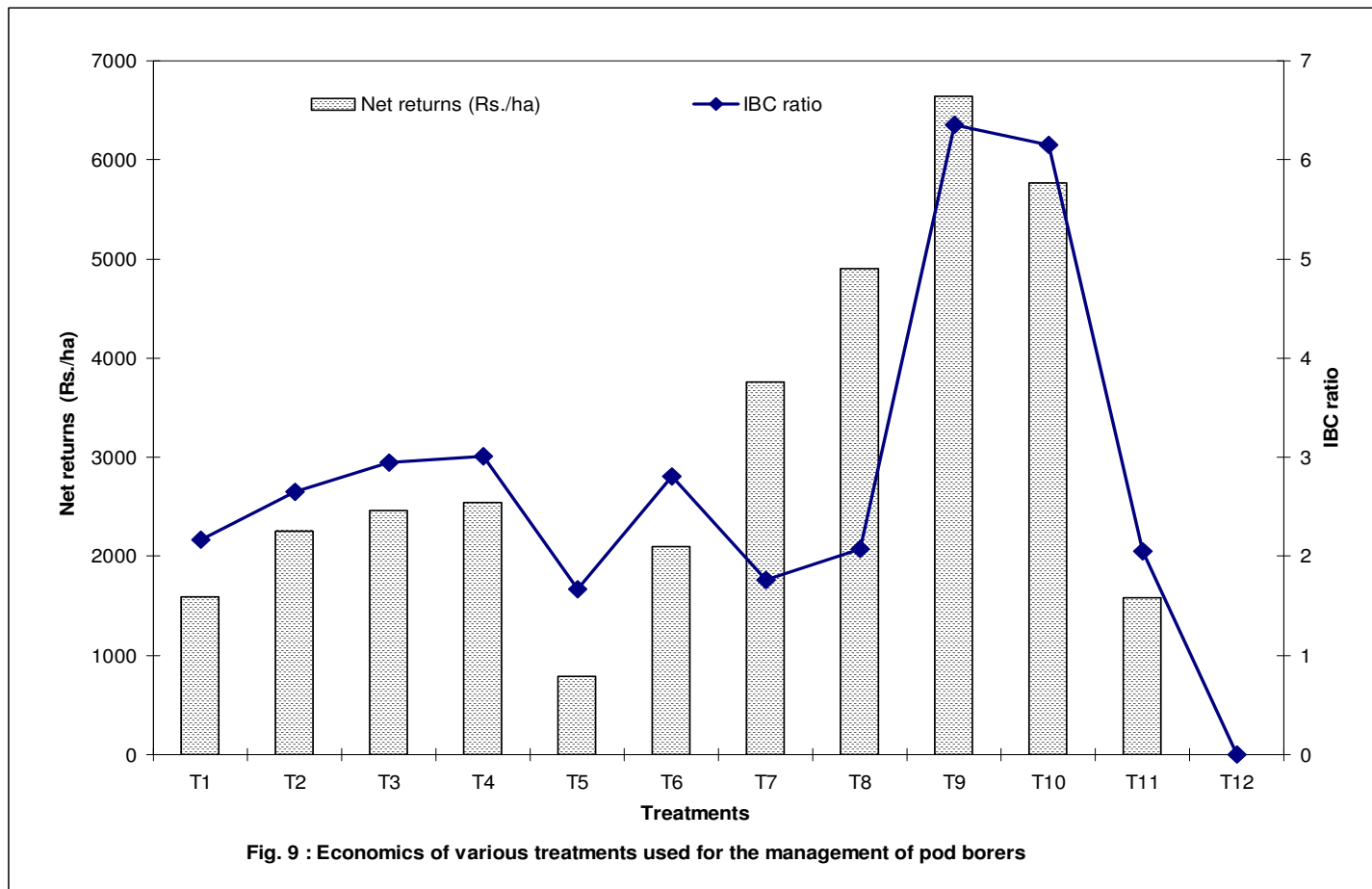
T1	NSKE (5%)
T2	NSKE (5%)+ cow urine (fermented) (5%)
T3	GCK (0.5%)
T4	GCK (0.5%) + cow urine (fermented) (5%)
T5	GE (1%)
T6	GE (1%) + cow urine (fermented)(5%)
T7	Spinosad 45SC (@ 0.2 ml/l)
T8	Emamectin benzoate 5Sg (@ 0.2 g/l)
T9	Indoxcarb 14.5 SC (@0.1 g/l)
T10	Fenvalerate 20EC (@0.5ml/l)
T11	Endosulfan 35 EC (@2 ml/l)
T12	Untreated control



**Fig.8: Efficacy of indigenous materials and new molecules against pod and seed damage**

## LEGEND

T1	NSKE (5%)
T2	NSKE (5%)+ cow urine (fermented) (5%)
T3	GCK (0.5%)
T4	GCK (0.5%) + cow urine (fermented) (5%)
T5	GE (1%)
T6	GE (1%) + cow urine (fermented)(5%)
T7	Spinosad 45SC (@ 0.2 ml/l)
T8	Emamectin benzoate 5Sg (@ 0.2 g/l)
T9	Indoxcarb 14.5 SC (@0.1 g/l)
T10	Fenvalerate 20EC (@0.5ml/l)
T11	Endosulfan 35 EC (@2 ml/l)
T12	Untreated control



**Fig.9: Economics of various treatments used for the management of pod borers**

In the present investigation, indoxacarb (0.1 g/l) was the next best to emamectin benzoate and spinosad. The treatment recorded an average larval population of 2.97, 1.16, 0.73 and 0.20 larvae per plant (31.88, 70.32, 68.27 and 82.90% mortality) after 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> spray, respectively. These findings are in line with Dhawan and Simwat (2000), who tested the insecticide against *S. litura*. Muthukrishna *et al.* (2002) also reported indoxacarb 60 g a.i./ha as quite effective treatment against tomato fruit borer, *H. armigera*. Ladaji (2004) also reported indoxacarb as an chemical against *H. armigera* in chickpea ecosystem. The lower efficacy of all the treatments after spray could be attributed to rain which commenced soon after 1<sup>st</sup> spray.

#### 5.4.2 Pod and seed damage and pod yield

The treatments GCK + cow urine and GCK recorded lower pod and seed damage and consequently resulted in higher yield (Fig. 8) which were followed by NSKE + cow urine, GE + cow urine and NSKE. These findings are in agreement with Mallapur (2002), Ravi Kumar (2004), Sachan and Lal (1990), Bhat *et al.* (1988), Vijayalaxmi *et al.* (1996) and Sarode *et al.* (1994).

Emamectin benzoate recorded lower pod and seed damage of 11.75 and 20.67 per cent (Fig. 8), respectively and consequently resulted in higher yield of 15.14 q/ha (Fig. 7). The next treatment to follow was spinosad (0.2 ml/ha) in which the pod and seed damage were recorded at 12.92 and 21.92 per cent, with a yield of 14.11 q/ha.

The next best treatments were Indoxacarb (0.1 g/l) and fenvalerate (0.5 ml/l) in which 14.01 and 14.73 per cent pod damage and 22.76 and 23.28 per cent seed damage, was recorded respectively. With a pod yield of 13.11 and 11.87 q/ha.

Udikeri *et al.* (2004) and Giraddi *et al.* (2004) obtained similar impact of emamectin benzoate on cotton yield. While Dandale *et al.* (2000) and Vadodaria *et al.* (2002) could get high cotton yields using spinosad. Similarly more chickpea yield was obtained using spinosad (Ladaji, 2004). Dhawan and Simwat (2000) could get the same impact using indoxacarb. Narendra Reddy (2001) recorded lower pod damage and high yield of pigeonpea using fenvalerate against pod borer complex.

#### 5.4.3 Economics of indigenous materials and new molecules

Some of the indigenous materials like GCK + cow urine, GCK, GE + cow urine and NSKE + cow urine registered a very high IBC ratio of 3.01, 2.95, 2.81 and 2.65, respectively (Fig. 9). Ravikumar (2004) also recorded similar result in chilli.

Although the emamectin benzoate and spinosad proved to be the most effective treatments, due to high cost of the chemicals, they could record lower IBC ratio of 2.07 and 1.76. However, the highest IBC ratio of 6.35 and 6.15 was recorded in indoxacarb and fenvalerate, respectively (Fig. 9). No previous reports are traceable on IBC ratio in Dolichos bean ecosystem to compare the present findings.

### FUTURE LINE OF WORK

1. Studies on biology, economic status and management of *R. pedestris*
2. Large scale evaluation of promising botanicals and safer new molecules
3. Integrated management of pod borer complex

## VI SUMMARY

Investigations on different aspects of pod borers in Dolichos bean were undertaken at the main agriculture institute, University of Agricultural Sciences, Dharwad during 2004. The studies inoculated the pest complex of field bean with special reference to pod borers, natural enemy complex, crop loss estimation and evaluation of indigenous materials and new molecules against pod borers under field conditions.

During the present investigation a study was made occurrence of insect pests in relation to the stage of the crop and season. As many 25 species of insect pests were recorded on the crop at Dharwad conditions. However the aphid *Aphis craccivora* the hairy caterpillar *Spilosoma obliqua* the gall weevil *Alcidodes collaris* thrips coried bugs such as *Clavigrella gibbosa* *Anoplocnemis phasiana* *C.horrens* *Riptortus pedestris* pentatomod bugs *Nezara viridula* and *Dollicoris indicus* were considered as serious sucking pests while the pod borer complex included *Maruca testulalis* *Helicoverpa armigera* *Cydia ptychora* *lampides boeticus* *Exelastis atomosa* and *Etiellea zincknella*. The pest population was more abundant on the crop sown during August than September sown crop.

*Aphis craccivora* was noticed from September to January (30.5 to 50 aphids/3 leaves), whereas the thrips were found in large numbers (4.7 to 7.6 thripos/3 leaves) during the September to October months. The coried bug incidence observed throughout the cropping season (0.8 to 10.8 bugs/ 5 plants) while the pentatomoid bugs activity was restricted only to early sown crop (0.2 to 4.3 bugs /5 plants).

The percentage of infestation by hairy caterpillar was quite high from October to February whereas *Alcidodes collaris* damaged the crop from September to November. The activity of pod borers occurred throughout cropping period after pod formation stage. The maximum pod damage due to borers mainly *M.testulalis* (34.95%) *H.armigera* (20.05%) *C.ptychora* (9.10%) *L.boeticus* (13.8%) *E.atomosa* (51.1%) and *E.zinckenellia* (10.9%) was recorded at 108, 73, 59, 122, 115 and 108 days respectively. Whereas on September sown crop the highest pod damage due to *M.testulalis* (12.60%) *H.armigera* (5.22%), *C.ptychora* (1.50%) *E.zinckenellia* (6.60%) and *E.atomosa* (8.90%) were observed at 80 to 73 days old crop.

Among the natural enemies of podborers the parasitoid activity was very much restricted. *Bracon* sp. Nr. *Greeni* (Ashmed) caused amongst 10 to 20 percent parasitization of *H.armigera* *C.ptychora*, *E.atomosa* and *M.testulalis* and unidentified dipteran parasitoid was recorded on *L.boeticus* and *H.arigera*.

The predator activity was mostly restricted to early stage of the crop. In August sown crop, the lady bird beetle green lace wing and robber fly were observed to the tune of 2.1 to 6.0 grub/10plant, 0.9 to 1.48 adults /10plant and 0.7 to 1.24 fly/10 plant respectively. However the September sown crop harboured only the lady bird beetle (2-5.4) grub/5plant) from 30 to 75 days after germination.

Varied population of pod borers had significant effect on percent pod damage, seed damage and pod yield. The economic injury level for pod borers was determined at 0.45 larva plant. The loss in yield due to pod borers was assessed by protecting the crop with varied number of sprays at 15 days interval after pod initiation. A maximum pod damages of 26.79 percent by pod borers was recorded when the crop was left for natural infestation. However, a maximum of 8.42 percent pod damages was recorded when the crop was protected on need basis i.e supervisor control. Similarly, the seed damage by pod borers was maximum (31.85%) in the untreated check and minimum (13.42%) in the supervisory control.

A maximum pod yield of 3.89 q/ha was recorded in untreated control where the crop was exposed to natural infestation while, as 13.0 q/ha pod yield could be obtained from completely protected plots followed by the treatments with Five, Four and Three sprays respectively, which were on par with fully protected treatments. However, on the basis of IBC ratio, the treatment with 3 sprays was the best (6.69) followed by the 2 and 4 sprays (5.71%).

Studies on the effect of indigenous materials and new molecules against the pod borers revealed that among the indigenous materials, GCK + cow urine recorded comparatively high larval reduction of 19.21, 48.76, 56.18 and 62.98 percent after I II III and IV sprays, respectively. The next best treatment were GCK (13.69, 45.59, 55.69 and 32.02%), NSKE + cow urine (12.30, 40.96, 55.26 and 61.65%), GE + cow urine (10.25, 41.11, 56.09 and 54.47%) after I II III and IV spray, respectively. The above mentioned treatments also recorded lower pod damages (17.01, 17.37, 18.13, 18.73 and 19.11%, respectively) and seed damages (25.99, 26.17, 26.73, 27.03 and 27.86%, respectively).

The application of GCK + cow urine resulted in maximum yield of 8.01 q/ha followed by GCK (7.91 q/ha) NSKE + cow urine (7.78 q/ha) GE + cow urine 7.33q/ha and NSKE (6.95q/ha). The highest IBC ratio of 3.01 observed in GCK + cow urine followed by GCK (2.95), GE + cow urine (2.81) and NSKE + cow urine (2.65).

The newer molecules were general superior over the conventional insecticides as well as the indigenous materials. Emamectin benzoate recorded very high larval reduction of 37.17, 75.91, 80.39 and 85.19 percent after first second third and fourth spray respectively. The next to follow were spinosad (32.79 71.76 73.66 and 84.00%, indoxacarb (31.88 70.32 68.27 and 82.90%) and fenvalerate (21.45 55.21 61.27 and 76.06%). The treatments recorded lower pod and seed damage (11.75 to 14.73 and 20.67 to 23.28, respectively).

The maximum pod yield (15.14 q/ha) could be obtained from the plots treated with emamectin benzoate followed by spinosad (14.11 q/ha), indoxacarb (13.11q/ha) and fenvalerate (11.87q/ha). However, the indoxacarb application resulted in highest IBC ratio (6.35) followed by fenvalerate (6.15)

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**Appendix I: Monthly meteorological data for experimental year (2004) and average of past 54 years (1950-2004) of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad**

Month	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
	2004	1950-2004	Maximum		Minimum		2004	1950-2004
			2004	1950-2004	2004	1950-2004		
January	Traces	0.086	29.6	29.15	14.7	19.23	54	63.37
February	Traces	1.161	32.5	34.52	16.4	16.02	53	51.18
March	Traces	0.147	36.5	35.73	19.6	18.81	49	56.47
April	24.4	48.45	37.4	37.00	19.8	21.32	51	76.98
May	61.1	81.40	33.6	36.52	21.4	21.48	66	66.71
June	43.8	109.14	28.8	29.50	21.5	21.21	80	81.69
July	24.8	15.77	29.2	22.06	21.0	20.95	79	87.46
August	160.7	95.30	27.0	22.01	20.3	20.62	83	86.51
September	222.1	100.54	28.6	28.75	19.9	20.16	77	82.40
October	64.6	130.99	30.1	30.12	18.4	19.30	65	76.44
November	0.6	32.04	30.2	29.46	15.9	15.50	52	68.13
December	0.0	54.50	29.4	29.18	12.5	13.44	45	63.81
<b>Total</b>	<b>602.10</b>	<b>615.52</b>						

**Appendix II: Details of materials used to work out cost economics in different field experiments**

Sl. No.	Inputs	Rate (Rs.)	Quantity require/ha
I	Plant protection materials		
1.	Neem seed kernel	6/kg	50 kg
2.	Garlic	20/kg	5 kg
3.	Chilli	8/kg	5 kg
4.	Kerosene	22/l	100 ml
5.	Spinosad	10800/l	100 ml
6.	Emamectin benzoate	10000/kg	100 ml
7.	Indoxacarb	3200/l	50 ml
8.	Fenvalerate	520/l	250 ml
9.	Endosulfan	225/l	1000 ml
II	Spray solution used	-	500 L
III	Services	-	-
1.	Plant extract preparation	50/spray	-
2.	Spraying	40/spray	2 labour
3.	Miscellaneous	10/spray	-
IV	Rate of produce (Rs./ha)		
	Dolichos bean	800	-

# Status and Management of Pod Borer Complex in *Dolichos Bean, Lablab Purpureus (L.)*

REKHA S.

2005

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## ABSTRACT

Investigations on the status and management of pod borer complex in Dolichos bean were carried out under field conditions during 2004-05 at MARS, UAS, Dharwad. During the present investigation, as many as 25 species of insect pests were been recorded on the crop at Dharwad condition. However, the aphid, *Aphis craccivora*, the hairy caterpillar and *Spilosoma abliqua*, the gall weevil, *Alcidodes collaris*, thrips, the coried bugs such as *Clavigrella gibbosa*, *Anoplocnemis phasiana*, *C. horrens*, *Riptortus pedestris*, pentatomid bugs, *Nezara viridula* and *Dollicoris indicus* were considered as serious sucking pests.

The activity of pod borers occurred throughout cropping period after pod formation stage. The maximum pod damage due to borers was highest in August sown crop than September sown crop. Among the natural enemies of pod borers, the parasitoid *Bracon* sp. nr. *greeni* (Ashmed) caused almost 10 to 20 per cent parasitization of *H. armigera*, *C. ptychora*, *E. atomosa* and *M. testulalis* and unidentified dipteran parasitoid was recorded on *L. boeticus* and *H. armigera*.

The predator, lady bird beetle, green lace wing and robber fly were observed in August sown crop where, September sown crop harboured only the lady bird beetle.

The economic injury level for pod borers was determined at 0.45 larva per plant. The loss in yield due to pod borers was assessed by protecting the crop with varied number of sprays at 15 days interval after pod initiation. A minimum pod yield of 3.89q/ha was recorded in untreated control where the crop was exposed to natural infestation while, as high as 13.0q/ha pod yield could be obtained from completely protected plots followed by the treatments with five, four and three sprays, respectively, which were on par with fully protected treatments. However, on the basis of IBC ratio, the treatment with 3 sprays was the best (6.69) followed by 2 and 4 sprays (5.71%).