Maharana Pratap University of Agriculture and Technology
Rajasthan College of Agriculture, Udaipur

CERTIFICATE - I

Dated : 19/06 / 2004

This is to certify that ***Mr. Nathu Lal Meena*** had successfully completed the comprehensive/ Preliminary examination held on 19-06-2004 as required under the regulations for the degree of **Doctor of Philosophy** in Agriculture.

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CERTIFICATE - II

Dated : 31/05/ 2005

This is to certify that this thesis entitled, **"Evaluation of IPM Components Against Major Insect Pests of Soybean [*Glycine max* (L.) Merrill] in South-Eastern Zone of Rajasthan"** submitted for the degree **Doctor of Philosophy in Agriculture** in the subject of **Entomology**, embodies bonafide research work carried out by ***Mr. Nathu Lal Meena*** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on date of 31-05-2005.

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Dated : / / 2005

This is to certify that this thesis entitled **"Evaluation of IPM Components Against Major Insect Pests of Soybean [*Glycine max* (L.) Merrill] in South-Eastern Zone of Rajasthan"** submitted by ***Mr. Nathu Lal Meena*** to Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Agriculture** in the subject of **Entomology** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory, we therefore recommended that the thesis be approved.

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CERTIFICATE - IV

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This is to certify that ***Mr. Nathu Lal Meena*** student Ph.D. **Department of Agricultural Zoology & Entomology**, Rajasthan College of Agriculture, Udaipur has made all corrections/ modifications in the thesis entitled, **"Evaluation of IPM Components Against Major Insect Pests of Soybean [*Glycine max* (L.) Merrill] in South-Eastern Zone of Rajasthan"** which were suggested by the external examiner and the advisory committee in the oral examination held on / /2005 The final copies of the thesis duly bound and corrected were submitted on / /2005 are enclosed herewith for approval.

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Evaluation of IPM Components Against Major Insect Pests of Soybean [*Glycine Max* (L.) Merrill] in South-Eastern Zone of Rajasthan

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ABSTRACT

The investigations were carried out on " "Evaluation of IPM Components Against Major Insect Pests of Soybean *Glycine max* (L.) Merrill in South-Eastern Zone of Rajasthan" during *Kharif*, 2002 and 2003.

The first appearance of stem fly was observed in 31st meteorological week, peaked in 32nd meteorological week during 2002, whereas in 2003 the first appearance was observed in 30th meteorological week, which peaked in 33rd meteorological week. The first appearance of girdle beetle was observed in 31st meteorological week, peaked in 35th meteorological week, during both the years. Semilooper was initially observed in 31st meteorological week during both years, peaked in 34th and 35th meteorological week.

The insect pest infestation significantly affect the yield attributing characters *viz.*, number of pod per plant, grain per plant, yield per plant, yield per plot which finally resulted into 30.62, 31.34, 31.94 and 35.76 per cent losses, respectively during 2002. Whereas in 2003 these losses were 33.32, 34.53, 36.70 and 38.43 per cent, respectively.

The early sown crop had lower infestation of stem fly and semilooper while mid and late sown crop had more infestation, whereas early sown crop had more infestation of girdle beetle, mid and late sown crop had les infestation. Further, the maximum infestation of major insect pests was observed in plots having 22.5 cm row to row spacing while the plots having 30 cm and 45 cm row spacing had less infestation.

Intercropping of maize and sorghum with soybean reduced the incidence of major insect pests while intercropping of pigeonpea and sesame accelerated the incidence of major insect pests.

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Variety JS80-21 was most preferred by stem fly and girdle beetle while NRC-12 was preferred by semilooper, contrary to this variety JS-335 had lowest infestation and least preferred by stem fly and semilooper, while Pratap Soya was least preferred by girdle beetle.

Treatment of crop with the carbosulfan (0.04%), triazophos (0.5%), endosulfan (0.07%) at 35 and 60 DAS and profenophos (0.125%) at 60 DAS found highly effective against stem fly and girdle beetle. All other treatment schedules were significantly less effective. Treatment schedule comprising spinosad (0.018%), propfenophos (0.125%), carbosulfan (0.04%), triazophos (0.05%) and endosulfan (0.07%) at 35 and 60 DAS proved highly effective against semilooper whereas, remaining treatments were less effective.

The maximum yield (24.17q/ha) was obtained by the treatment comprising triazophos (0.05%) at 35 and 60 DAS, followed by triazophos (0.05%) at 35 DAS and spinosad (0.018%) at 60 DAS (23.80 q/ha); Carbosulfan (0.04%) alone at 35 and 60 DAS (23.18 q/ha) and endosulfan (0.07%) at 35 and 60 DAS (22.57 q/ha). While, net profit and C : B ratio point view the maximum net profit and cost benefit ratio was obtained form triazophos (0.05%) at 35 and 60 DAS Rs. 13246/ha and 1: 12.63 followed by endosulfan (0.07%) at 35 and 60 DAS, i.e. Rs. 11094/ha and 1:11.56 and Carbosulfan (0.04%) at 35 and 60 DAS, i.e. Rs. 11188 and 1:6.50 respectively. Whereas, the minimum net profit and C : B ratio was obtained with spinosad (0.018%) i.e. Rs. 944 and 1:1.016.

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1. INTRODUCTION

Soybean, *Glycine max* (L.) Merril is a major oil seed crop of the world. In the new millennium, the world is seeking a greater demand of agricultural output especially oils and protein. Soybean (wonder crop) has emerged as a potential source of protein, 40-42 per cent and oil, 18-22 per cent. It is a rich source of amino acids like Arginine and lysine, Vitamin, B complex, thiamine 11mg, Riboflavin 34 mg per 1 gm. Germinated soybean contains Vitamin-C, Vitamin-A (Beta-karotine) and Vitamin E Tokoferol (a natural antioxidant). Soya milk contains 20 fold more iron as compare to cow milk (1.3 mg/ 100 ml), which is an important element for haemoglobin production. The use of soybean is also beneficial to diabetic and heart patent.

Initially it was recognized as low cost source of high quality protein, now ranks at the top in the world for production of edible oil. Its wider adaptability makes soybean cultivation possible all over the world from temperate to tropical climatic conditions. India is among the top three countries in respect of growth rate in area expansion under soybean, the other two being Argentina and Brazil (Anonymous,1995). In India, there has been a phenomenal expansion in acreages during the last two decades, soybean is now estimated to occupies about 6.5 million ha area with the production of 7.61 million tones and the productivity is 11.71 q/ha.

Table 1 : Area, production and productivity of soybean in India during 2000-2003

State	Area (Million ha.)				Production (MT.)				Productivity q/ha.			
	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003
M.P.	4.24	4.32	3.84	4.10	3.25	3.62	2.85	4.17	7.67	8.38	7.42	10.17
Maharashtra	1.14	1.10	1.22	1.56	1.27	1.39	1.10	1.95	11.14	12.64	9.02	12.13
Rajasthan	0.62	0.66	0.42	0.56	0.47	0.72	0.21	0.60	7.58	10.91	5.04	10.57
Karnatka	0.07	0.06	0.08	0.06	0.06	0.05	0.05	0.05	8.57	8.33	6.25	9.00
Andhra.P.	0.01	0.02	0.04	0.08	0.01	0.02	0.03	0.08	10.1	10.15	7.50	9.40
India	6.42	6.22	5.68	6.50	5.27	5.86	4.30	7.61	8.21	9.41	7.58	11.71

Source: Oilseed Situation, a Statistical Compendium 2003 DOR, Hyderabad

Soybean was introduced in 1980 in Rajasthan as new crop in *Kharif* season and now stands third in the country occupying an area of 5.6 lakh hectares and production of 6.0 lakh tones with hovering productivity of 10.57 q/ha. Which is relatively very low as compared to the other states of India and national average 11.71 q/ha. and the world average 18 q/ha. In the state the crop is mostly grown in Kota division, in the districts of Kota, Bundi, Jhalawar, Baran and part of Chittorgarh, Banswara and Swai Madhopur.

The production of soybean crop is affected by variety of limiting factors. Introduction of new and high yielding varieties and their vulnerability to insect pests and diseases are one of the major constraints in achieving higher productivity. Soybean being a luxuriant crop having lush green, soft, succulent and nutritive dense foliage is attacked by more than 273 types of insects. Fortunately, out of these only about two dozen insects are of economic significance. On the basis of feeding habit, soybean insects can be categorized into six groups i.e. seed and seedling feeder, stem borers, foliage feeder, sap suckers, flower and pod feeder and storage insects (Anonymous, 1995).

Among the major insects causing significant reduction in seed yield in India are girdle beetle, *Obereopsis brevis* (Swed.), semilooper, *Chrysodeixis acuta* (Wlk.) *Diachrysia orichalcea* (Fab.), stem fly, *Melanagromyza sojae* (Zehnt.), gram pod borer, *Helicoverpa armigera* (Hub.) blue beetle, *Cneorane spp.* white fly, *Bemisia tabaci* (Germ.), tobacco caterpillar, *Spodoptera litura* (Fab.) and stink bug, *Nezara viridula* (L.) (Sharma, 1999). The increasing population of insect pest complex may cause severe yield losses. As per coordinated studies conducted at different locations across the country revealed that yield loss could be over 50%. In some endemic areas individual insect species can incur substantial yield losses. For example 80% reduction in yield is caused by whitefly in north-India; 58% by girdle beetle in north and central parts, 40-66% by leaf minor in south and south-western parts, 15-30% by stem fly and 21 to 35% by jasid in Madhya Pradesh (Sharma 1999). Practically almost no work on avoidable losses due to total pest complex in JS-335 variety of soybean has been carried out in India and particularly in the state of Rajasthan.

Since introduction of soybean crop in the zone/state, farmers used various methods of pest control especially and preferably insecticidal control, because of quick response and its easy use. But, over dependence and indiscriminate use of insecticides has resulted into manifold problems like application hazard, health hazard, development of resistance in insect to insecticides, destruction of natural enemies, insecticidal residue and environmental pollution. The out-break of *Spodoptera litura* in Kota division during *Kharif* 2000 in soybean ecosystem is an important examples where all insecticides failed to control insect population.

Recently, botanical insecticides and insect growth inhibitors have attracted the interest of entomologists all over the world. Quite a few plant species inherently exhibit feeding deterrence to insect of economic importance to several crops, including soybean. Out of all these plants, Neem has been phenomenal in its wide range utility in insect management.

Cultural control is the easiest and most economical method of managing the pest population without or with nominal use of chemical insecticides. Cultural control methods may involve adjustment of planting time, plant population, row spacing, inter cultural (tillage) operations, inter cropping with other crops, trap cropping and crop rotation. Inter cropping and mixed cropping offer and excellent opportunity of ecological maneuvering by bringing about changes in crop geometry and cropping system, which may have economically relevant impact on pest damage.

With the understanding of insect pest's phenology, the damage caused by them can be avoided by adjusting the planting time. Plant population and row spacing are important cultural practices which influence the micro climate and insect abundance. Row spacing, particularly determines the canopy closure-index i.e. space left open between the rows. Row spacing is also reported to have influence over efficiency of insecticides applied for the control of insect pests. In India the recommended plant population and row spacing are 4 to 6 lakh plants/ha and 30-45 cm respectively depending upon the region and the season.

In order to develop a sound, ecologically viable and socially acceptable IPM strategy, it is imperative to make use of all possible methods to keep the insect population below the economic threshold level. Therefore, it was proposed to investigate the "Evaluation of IPM Components Against Major Insect Pests of Soybean *Glycine max* (L.) Merrill in South-Eastern Zone of Rajasthan" with following specific objectives:

1. To study the seasonal incidence of major insect pest of soybean in relation to the abiotic factors.
2. To assess the losses caused by the insect-pests complex infesting soybean.
3. To study the effects of cultural practices on incidence of major insect pests and their management in soybean ecosystem.
4. To assess the relative efficacy of bio-pesticides and newer insecticides against major insect pests of soybean.

2. REVIEW OF LITERATURE

A perusal of available literature revealed that a large number of arthropod pests attack the soybean crop at different stages of crop growth and cause severe damage resulting in loss of yield. Not much work has been done so far on integrated management of soybean pests. There are few reports on incidence and management of soybean pests. The available information is reviewed here:

2.1 Seasonal incidence of major insect pests of soybean in relation to abiotic factors

Behera *et al.* (1990) studied the incidence of *Bilobala subsevivella* on 13 soybean cultivars and observed that larval activity started from 3rd week of July and reached at peak in the 1st week of August with (mean number ranged from 1.0 to 12.3 larvae per 5 plants). Number of larvae declined from the 2nd week of August 0.8 / 5 plants. The larval population peaked again from the 4th week of September to the first week of October when the crop was 90-98 days old, and declined rapidly thereafter. The incidence of *Spodoptera exigua* (Fab.) was observed by Sekhar *et al.* (1994) from 3rd week after germination and continued throughout the vegetative growth.

Rai and Patel (1990) described the incidence of the cerambycid, *Obereopsis brevis* in plots sown with the soybean variety JS-77-44 on 15 July 1988 in India. The pest first appeared on 10th August 1988 where (maximum and minimum temperature was 29.60 and 24.70°C, respectively and relative humidity 84.50 per cent and its activity continued until 12th October 1988. He reported the low infestation level (9.86-12.09%) during the period of activity that may be due to the late planting of the soybean crop and low rainfall.

Singh and Singh (1991) studied the incidence of thrips, *Caliothrips indicus* in Madhya Pradesh in *Kharif* 1988 and 1989. They observed that the thrips were present on soybean from August to October and September to October with peak population, 15.1 thrips/leaf in the second week of September and 10.1 thrips/leaf in the first week of October during 1988 and 1989 respectively.

McPherson *et al.* (1993) reported that pentatomids, *Nezara viridula*, L. *Aerosternum hilare*, *Euschistus servus* and *Piezodorus guildinii* population densities began to increase steadily in mid of August as the pod began to fill with seed and peaked in mid Sepember to early October.

According to Berg-H-Van-Den *et al.* (1995) *M. sojae* generally infested soybean throughout the season the infestation was initially low but reaches its peak in 5th to 8th weeks after sowing and declined in the end of the season.

Bhalkar (1996) observed aphid infestation from 29th meteorological week (16-22 July, 1994) and their peak period of activity was observed in 33rd meteorological week (13-19 August 1994). The infestation of weevil was started from 29th meteorological week (16th -22 July, 1994) and their peak period of activity was observed in 34th meteorological week (20-26 August, 1994). The infestation of stem fly, *M. sojae* was noticed from 29th meteorological week (16th -22 July, 1994) and their peak period of activities was observed in 31st meteorological week (30 July to 5 August, 1994).

Deepesh *et al.* (1997) observed critical examination of meteorological parameters in relation to the pest incidence on soybean at Jabalpur, Madhya Pradesh, revealed that mean temperature around 26°C was most conducive for the population build-up of key pests. Aphid, *Aphis sp.* population has a significant positive correlation with temperature. The whitefly, *Bemisia tabaci* (Gennadius) population showed a significant positive association with temperature, sunshine and a negative correlation with rainfall. The blue beetle, *Cneorane sp*. population had a significant positive correlation with rainfall. Temperature and sunshine were significantly and positively correlated with stem fly, *Ophiomyia phaseoli* (Tryon) infestation, while rainfall was negatively correlated. The correlations of weather parameters with the population build-up of green semilooper, *Thysanoplusia orichalcea* (Fab.), Bihar hairy caterpillar, *Spilosoma obliqua* (Walker) [*Spilarctia obliqua*] and leaf miner, *Liriomyza trifolii* (Burgess) were non-significant.

El-Khouly *et al.* (1998) studied the population density of aphids *Aphis spp.*, whitefly *Bemisia tabaci*, thrips *Thrips tabaci* and jassids *Empoasca spp*. on soybean in relation to common associated predators and some prevailing climatic factors (temperature, relative humidity and wind speed) during 1992 and 1993, in Egypt. Results indicated that the populations of the considered insect pests and associated predators were higher in the second season than in the first one. Every insect pest had one abundance peak, which coincided with the others. The whitefly, thrips and jassids had one generation, while the aphids had two generations in a season.

Vinod *et al.* (1998) estimated the population density of some insects associated with soybean in a field experiment in India during *Kharif* 1998 by following simple random sampling and two-stage sampling techniques at three stages of plant growth, 60-64, 86-89 and 98-99 days after sowing, using the ground cloth sampling method. Population densities of *Spilosoma obliqua* Walker and *Spodoptera litura* (Fab.) during the crop growth period were maximum around the second half of October. However, densities of *Plusia orichalcea* (Fab.), *Aphis sp.*, *Empoasca sp.* and thrips were higher during the later part of September or early October. Significant correlations were observed between population densities of some insect species.

Lin *et al.* (2002) investigated the population dynamics of *B. tabaci* on cotton, soybean, groundnuts and maize in China. The results indicated that during the growing stage of hosts, the population of *B. tabaci* increased and reached its peak in 22nd August, then gradually decreased.

Jayappa *et al.* (2002) conducted a survey of soybean insect pests in *Kharif,* 1997 and 1998 in India. Nine insect pests *Thysanoplusia orichalcea, Spodoptera litura, Helicoverpa armigera, Amsacta lactinea, Spilosoma obliqua [Spilarctia obliqua], Chrysodeixis sp., Achaea janata, Aproaerema modicella and Lamprosema indicata [Omiodes indicata]* were observed on the plants at different stages of growth.

2.2 Assessment of losses due to insect pest complex in soybean

Kundu and Mehra (1990) carried out a field study in Delhi, India, in 1987 to determine the economic threshold of *Melanagromyza sojae* on soybean, variety Harosoy-63. Percent stem tunnelling was the most suitable parameter for determining the economic threshold, and at >26% resulted in significant yield reductions in terms of pod number and weight, seed number and weight, and plant height.

Singh and Singh (1990) reported yield losses caused by *M.sojae* based on various parameters such as pods/plant (17.57%), pod weight/ plant in gm (28.71%) , seed / plant (30.37%) , seed weight / plant in gm (32.43%) and seed yield in q/ha (30.26%) . Similarly, Singh *et al.* (1991) reported a yield loss in treated plants by feeding of the cicadellid, *Aphelion maculosa* to the extent of 21.42 to 24.87 per cent in pod numbers, 18.80 per cent in grain weight, 23.90 to 24.90 per cent in grain number, 24.30 to 29.70 per cent in grain weight per plant and avoidable loss of 21.46 to 35.37 per cent in grain yield.

Supriyatin (1992) reported the yield losses due to *Etiella spp.* and bugs *Nezara viridula*, *Riptortus linearis* and *Piezodorus rubrofasciatus* on soybean in Indonesia during 1988. *Etiella spp* caused 26 and 23 per cent pod and seed damage, respectively. The highest numbers of bugs were 18 per 20 plants, causing 19 and 39 per cent pod and seed damage. The highest seed yield 2.79 tonnes/ha was recorded in plots treated 5 times with deltamethrin.

Singh and Singh (1991) reported that an increase of one larval of *C. acuta* per meter row length at 45 days after emergence, at the flower initiation stage and at 66 d.a.e. (at the pod filling stage) resulted in reductions of 593 and 662 kg/ha in grain yield, respectively. The yield loss caused by 3-18 larvae per meter row length at the flower initiation stage ranged from 7.29 to 45.51 per cent and at pod filling stage ranged from 9.43 to 46.49 per cent. It is concluded that control measures should be adopted at the economic threshold level of 3 larvae and 2 larvae per meter row length at the flower initiation and pod filling stages of the crop respectively.

Singh and Singh (1992) reported 93 per cent soybean crop was infested by *M.sojae* and grub of the insect had tunnelled from 2.6 to 90% of the stem length at harvest. Infested plants had fewer branches (13.6%), and a lower pod weight (26.6%) and grain weight (31.1%) in comparison to healthy plants. A stem tunnel length of 5.7, 25.5, 45.8, 66.7 and 86.1% reduced the grain yield by 16.4, 19.5, 24.6, 28.1 and 64.9 per cent, respectively. A mean stem tunnelling of 46.0 per cent reduced the grain yield by 5.5 q/ha (30.2%). Correlations of stem tunnel length with the number of branches, pods and grain weight were also significant.

Higuchi *et al.* (1994) found an inverse relationship between the spectral reflectivity ratio (R750 nm - R600 nm)/ (R750 nm + R600 nm) and the percentage of damaged leaf area caused by young larvae of *S. litura* in soybean fields at the pod development stage. Yield components and reduction are given for plots artificially infested with 1 or 2egg masses/plant. Total yield losses were 13.9 and 24.7 per cent for 1 and 2 egg masses/plant, respectively, compared with untreated control plots.

Venkatesan and Kundu (1994) reported that the larvae of *M. sojae* cause extensive tunnelling in the pith region of soybean causing seedlings to die, while growth and yield of mature plants was are significantly reduced. In order to quantify the loss in soybean yield and yield-contributing characters due to stem tunnelling and to determine economic threshold level, the data on stem tunnelling, pod number, pod weight and grain yield obtained from field studies in Delhi, India and were subjected to regression analysis. A significant negative correlation was obtained between agromyzid infestation and grain yield. The stem tunnelling ranged from 10 to 20% per plant caused a loss of 24.83 to 33.96 per cent per plant or a loss in pod weight of 5.16-7.09 g or a grain yield loss of 2.75-3.81 g per plant. The linear and quadratic equations calculated for the variety Pusa-16 showed that for every 10% increase in stem tunnelling, there was a 1.65-2.74 g reduction in grain yield per plant, respectively. The economic injury levels were determined to be 6.40 and 11.23% stem tunnelling with a quadratic and linear form of relationship, respectively.

Kundu *et al.* (1995) repoted yield loss, 18.6 to 40.1 per cent due to *M. sojae* in seven varieties of soybean.

Pan and Pan (1996) studied infestation of *M. sojae* and correlation with population density and yield loss of soybean in fields, by artificial inoculation on caged sown soybean plants, in China. They reported that *M. sojae* completed 5 generations per year, with the 3rd and 4th generations causing the heaviest yield loss (33.4 and 28.1%, respectively). The economic threshold for control was 4 to 10 insects per 100 plants for the 3rd generation, and 8-12 insects per 100 plants for the 4th generation.

Berg *et al.* (1998a) studied that damage to physiologically mature soybean by *Etiella spp.* and *Helicoverpa armigera* on 100 farmers field in East Java and Indonesia where *E.*

zinckenella and *H. armegera* caused 9 percent and 11 percent of pod damage, respectively. The seed loss was 12 per cent, which was mainly caused by *E.zinckenella*.

Berg *et al.* (1998b) studied the effect of *M.sojae*, on soybean under field conditions in East Java, Indonesia from 70 field sites in 1996. Plant parameters and exit holes in the stem created by *M.sojae* prior to pupation were recorded. *M.sojae* infested 84 per cent of plants examined. Exit holes in the hypocotyls are indicative of early attack and were associated with decreases in seed number per plant, stem diameter and plant height. Early attack adversely affects plant development. Exit holes above the hypocotyls are indicative of attack later in the season and were associated with an increase in plant parameters. Late attack occurred in response to plant size or vigour 87 per cent of all exit holes occurred above the hypocotyls. Applications of insecticides had no influence on *M.sojae* infestation level. Multiple regression was used to analyze infestation effects on seed production. Infestation had no effect on seed weight. Early attack caused 2% less yield loss on a per-plant basis. Later attack did not reduce yield.

According to Sharma (1999) uncontrolled insect pest complex may cause over 50 per cent yield losses. In some endemic areas an individual insect species can incur substantial yield losses e.g. 80 per cent reduction in yield was caused by white fly in northern India, 58 per cent by girdle beetle in north and central parts, 40.66 per cent by leaf minor in south and south– western part; 15 to 30 per cent by stem fly and 21 to 35 per cent by jassid in M.P.

Singh (2001) studied the distribution and infestation intensity of *Spodoptera litura* in soybean (cvJS-335) in 3 fields from each village in Kolaras block of Shivpuri district, Madhya Pradesh, India during the second week of September 2000. From each field, 10 randomly selected plants were observed for plant and leaf damage and larval population. There was very severe level of infestation in villages Gongari, Kharai, Tendua and Deharvara. The average plant and leaf damage and larval population ranged from 88-100%, 72-98% and 6.1-8.2 larvae per plant, respectively. The damaged plants were leaf less and had small shrivelled pods with very small grains. The farmers were expecting yield of about 1-2 q/ha in comparison to normal yield of 20-25 q/ha in the area.

2.3 Effect of cultural practices on incidence of major insect pests

2.3.1 Effect of sowing date and row spacing

Rizk *et al.* (1990) conducted a field experiments in Egypt in 1987-88; Soybean was planted on 1 April, 1 May and 1 June. The soybean that was planted earliest had the largest infestations of *Nezara viridula*, *Empoasca decipiens* and *Frankliniella schultzei*. Infestations of *Bemisia tabaci* increased with the later planting dates. The crop planted on 1 May supported a larger infestation of *Tetranychus urticae* than either of the others.

Kundu and Srivastava (1991) reported that sowing of the crop immediately after the mansoon break, attracted lower agromyzid *M.sojae* than in case of delayed sowing.

McPherson and Bondari (1991) studied the influence of planting date and row width on seasonal abundance of *Anticarsia gemmatalis* and *Nezara viridula* on soybean. The populations of *A. gemmatalis* were more abundant in 'Braxton' soybean planted in early June than in early May. They were also more numerous in narrow rows (45 cm) than in wide rows (90 cm), regardless of pest population density or sampling date. *N.viridula* was more numerous from July to mid-August in soybean planted in early May than in soybean planted in mid May or early June. In late September to mid October, when peak numbers were observed, there were more *N. viridula* in the narrow-row plantings than in the wide-row plantings.

Parsai and Shrivastava (1993) observed the maximum damage to soybean by the cerambycid, *Obereopsis brevis* in crop sown on 8 June and minimum damage in those sown on 1 July, and among various soybean varieties, JS 76-205 suffered the least damage. The highest yield in the 10 July sowing with variety Punjab-1, and the lowest in the 8 June sowing with JS 75-46.

Sontakke *et al.* (1994) report that *Kharif* crop of sorghum suffered greater damage by insect pests then the rabi crops. Lowest pest incidence and highest yields were recorded with early sowing (20 June to 5 July and 1 to 15 November) in both seasons.

Sharma (1994) stated that with the understanding of insect pest phenology, the damage caused by them can be avoided by adjusting the planting time. Soybean planted in last week of June has least stem fly, *M.sojae* infestation in the plains of northern India. But the soybean planted during this period in central India is proven to attack by girdle beetle, *O. brevi* and the semilooper, *Rivula spp.* Late planting however escapes infestation by girdle beetle.

Chandel and Gupta (1995) conducted field studies in Himachal Pradesh, India, during 1993 showed that delaying in sowing date of soybean resulted in a decrease in yields. The maximum yield (3.69 tonnes/ha) was obtained by sowing on 28 May and the lowest yield (1.45 tonnes/ha) was obtained by sowing on June 25. Insect pests were more abundant when soybean were sown earlier in the year.

Mandal *et al.* (1998) reported that delay in sowing decreased seed yield. Populations of *Biloba subsecivella* [*Bilobata subsecivella*], *Chrysodeixis acuta, S. litura* and *S.obliqua* [*Spilarctia obliqua*] were low in early-sown (22 June and 2 July) soybean. Incidence of these pests was high in crops sown between 12 July and 1 August. Infestation of *A. biguttula biguttula* was high in early- and late-sown crops and low in crops sown between 12 July and 1 August.

Sharma (1999) stated that plant population and row spacing are important cultural factors which influence the micro-climate and insect abundance. Fully closed canopy i.e. narrow row spacing in soybean deter the females of *H.zea* from ovipositing at bottom and is also not favourable for potato leaf hopper, *Empoasca fabae*. Contrary to this, narrow row spacing enhances the incidence of velvet bean caterpillar and southern green stink bug, green clover worm, *Planthypena scobra* loopers, *Pseudoplusia includens* and *Trichoplusia ni* Hub. More damage was observed by Bihar hairy caterpillar *S. oblique* and white fly, *B. tobaci* at the density of 0.6 and 0.8 million plant/ha.

Shepard *et al.*, (2001) reported that late planted soybean, suffered with more damage by *Etiella* and *Helicoverpa armigera* than the early planted ones.

2.3.2 Effect of intercropping on incidence of major insect pests of soybean

Singh *et al.* (1990) carried out a comprehensive study on the influence of inter-cropping of soybean varieties (JS72-44, JS-2 and JS 76-188) with sorghum (Cv CSH-5) on the incidence of major pests of soybean and reported that there was a significantly higher larval population 8.50 - 16.0 larvae/ 5 plants of *C.acuta* in comparison with pure crop (3.75 to 8.0 larvae/ 5 plants). While in variety JS-2 recorded less larvae of *C.acuta* in intercropped and in pure crop. The infestation of *O.brevis* was also more in intercropped soybean than pure stands and infestation by *M. sojae* did not differ significantly between intercropped and pure stands, but higher numbers of *B .tabaci* were found on pure stands.

Singh *et al.* (1991) reported that sowing of groundnut alongwith pigeonpea as an intercrop increased the incidence of *Empoasca kerri* and *Caliothrips indicus* and reduced the incidence of *Myllocerus dentife*r and *S. obliqua* [*Spilarctia obliqua*]. While intercropping with sorghum reduced the incidence of *E.kerri*, *C.indicus*, *S.obliqua* and *Spodoptera litura* and increased the incidence of *M. dentifer*. Intercropping with groundnut and sesame had little effect on pest incidence. The effects of intercropping on the timing of infestations are noted. It is concluded that intercropping with sorghum reduced the numbers of insect pests the most.

Natarajan *et al.* (1991) Studied the effect of inter-cropping of pulses with cereals on incidence of major insect pests. It was observed that population of *O. phaseoloi* on green gram and *B.tabaci* on cowpea were increased by inter-cropping with maize, whereas pod damage to *Vigna radiata* was lower in monoculture than in inter-crops. However, there was no significant difference in population of *A. soccata* and *C.partellus* in pure and inter-crops.

Yang *et al.* (1994) reported that incidence of stem miner, *M. sojae* and soybean pod borer, *Leguminivora glycinivorella* decreased if another crop was grown between soybean crop.

Gupta *et al*. (1997) estimated the yield losses in soybean due to the insect pest complex in Himachal Pradesh, India, They found 24 losses in mono crop and 18 per cent when intercropped with maize. The mono crop had a higher incidence of most of the insect pests as compared to the intercrop.

Wang *et al.* (1998) studied the effects of inter-planting and mixed-sowing of maize and soybean on the integrated management of insects and diseases in soybean during 1993-95 in Shantung, China. Insect infestation and disease incidence in soybean in inter-planted and mixed-sown fields were less than in mono planted soybean fields. The lower infestation (11.4-81.4%) and (20.9-76.0%) was observed in inter-planted and mixed-sown fields respectively, than in monoculture. In fields with inter-planting and mixed-sowing of maize and soybean, lady beetle [Coccinellidae] populations increased by 84.0 and 86.5%, lacewing [chrysopid] populations by 58.9 and 80.6%, and spider populations by 41.3 and 52.3%. compared with that in soybean monoculture.

2.3.3 Relative preference of soybean varieties against major insect pests.

Kundu and Srivastava (1991) tested 40 varieties and germplasm of soybean against stem fly *M.sojae* and found that the cultivar DS-22 and MACS-212, were relatively resistant to the agromyzid.

Sharma (1994) tested two sets of 16 soybean genotypes in June 1993, one was left untreated (T1) and the other was treated with insecticides (T2), *viz.* a pre-sowing soil application of phorate @ 1 kg a.i./ha, 800 ml/ha quinalphos 25EC before flowering and 800 ml/ha monocrotophos 36 S at pod setting. Average number of *O. brevis* infested plants/plot varied from 6.5 (T1) and 3.0 (T2) in line DS396 to 26.5 (T1) and 18.0 (T2) in Savana out the 4 control varieties, Gaurav had the greatest infestation, followed by NRC-2, Punjab-1 and JS-335. The use of insecticides reduced infestation by a maximum of 74.61% in GC600689 and a minimum of 32.28% in Savana. The results suggest that the level of infestation is not necessarily correlated to damage and female egg laying preference does not guarantee successful development of larvae.

Sharma *et al.* (1994a) evaluated 45 varieties of soybean for their tolerance to stem fly, *M.sojae* in field trials in Maharashtra, India, in 1991. Grain yield was negatively correlated with infestation and per cent stem tunnelling. The varieties PK262, PK 416, PK 564 and Shivalik gave good yields despite tunnelling in their stems and it is suggested that they may be tolerant to the pest.

Sharma *et al.* (1994b) screened 14 varieties of soybean for their resistance to stem fly, *M. sojae* during 1989, in the field in Chhindwara, Madhya Pradesh, India. None of the variety was free from attack by *M. sojae*, however varieties JS-87-36 was the least susceptible and had the greatest grain yield, followed by JS-87-39, JS-87-27 and JS-87-1.

Gupta *et al.* (1995) screened fifty soybean germplasm for resistance to *O.brevis* and *Ophiomyia phaseoli* in Jabalpur, Madhya Pradesh, India, during *Kharif,* 1994. Three germplasm namely, JS 80-21, P-1 (IS) and JS-335 exhibited the least susceptibility to both insects. These varieties were not only less preferred by the insects, but were also higher yielding.

Sharma (1995) evaluated 16 soybean genotypes on the basis of number of twigs/plant cut down by larvae of *O.brevis*, leaf area damaged by defoliators, stem tunnelling by larvae of *M. sojae*, and grain yield. He found that JS-335, NRC-2, Punjab-1 and genotypes DS-396, L-129 and Soja Savana were tolerant to overall insect damage. Genotype TGX 855-53D was less damaged by defoliators and TGX 342-536D and TGX 814-54D were less damaged by *M.sojae* and *O.brevis*.

Gaur and Deshpande (1998) evaluated relative susceptibility of promising soybean cultivars, NRC-12, JS 71-05, PK-564, NRC-7, JS-335, PUSA-16 and NRC-8 in a field experiment during *Kharif,* 1996-97 in Madhya Pradesh, India. NRC-12 was tolerant to the infestation of blue beetle, *Cneorane sp*.; gram caterpillar, *H. armigera*, leaf miner *Bilobata subsecivella;* whitefly, *Bemisia tabaci* and jassid, *Amrasca sp*. NRC-7 proved tolerate against grey weevil, *Myllocerus maculosus* [*Myllocerus undecimpustulatus*], green semilooper, *Plusia orichalcea* [*Thysanoplusia orichalcea*], girdle beetle, jassid, leaf miner and whitefly Whereas, JS 71-05 was tolerant to green semilooper, girdle beetle, jassid and stem fly. PUSA-16 was frond tolerant to jassid.

Dubey *et al*. (1998) screened forty-four genotypes of soybean against *Chrysodeixis acuta* and *M. sojae* during *Kharif,* 1996 at Sehore. Out of these, one genotype was highly resistant, two were resistant, 20 were moderately resistant, 19 were slightly resistant and two were susceptible to *C.acuta,* whereas, one genotype was highly resistant, two were resistant, 17 were moderately resistant, 19 were slightly resistant, three were susceptible and two were highly susceptible to *M.sojae*.

Upadhyay *et al.* (1999) tested nineteen promising soybean cultivars for resistance to girdle beetle infestation and protected environments during 1994-96 at Mandsaur. A protective environment was created by spraying endosulfan @ 0.07 per cent on the 30, 45 and 60 days old crop. Information on pods/plant, seeds/plant and yield/plant was recorded along with percentage incidence of pest damage. Infestation ranged from 11.40% in Bragg to 44.42% in MACS-58. The maximum reduction in seed yield (39.06%) was noted in JS-335 and was least in NRC-2 (15.78%). Although, Bragg recorded the least infestation it had a high reduction of yield components in the unprotected environment. NRC-2 recorded a higher plant infestation (32.71%) but had a minimum reduction in yield.

Sharma (1999) conducted large scale field screening against agromyzid stem fly *M.Sojae* and revealed that except few wild varieties, none of the cultivated varietie germplasm or breeding line was completely free from its infestation. Among the less susceptible sources the important ones are IC-18736, L-64, L-537, L-587, TGX568-12D, TGX 1096-19E, TGX802-150D. Some cultivated varieties *viz.* PK-262, PK416, PK-564 and Shivalik have been reported to give good seed yield even with higher stem tunneling. Development of resistant varieties to girdle beetle has not been possible for the want of broad genetic base but varieties Punjab-1, PK-262, Bragg and line JS-72-128 and PK-438 have been reported to be less susceptible.

Sekhar *et al.* (2000a) evaluated comparative susceptibility of seventy soybean genotypes against the stem fly, *M.sojae* in 1994, under natural infestation. Resistance was evaluated in terms of the percentage of stem tunnelled by stem fly larvae at harvest. None of the genotypes were highly resistant or resistant. Thirty-nine genotypes were moderately resistant with per cent tunnelling ranging from 28.90 to 41.70 per cent was recorded in DS93-P-40-3. The lowest per cent tunnelling (28.90%). Twenty-eight genotypes exhibited low resistance, with tunnelling ranged from 43.0 to 59.4 per cent. DSK 92-19 and DS93 MPT 16-1 were susceptible to stem fly with 60.5 and 60.7 per cent tunnelling, respectively. DS91-2-1 was highly susceptible to stem fly with 68.5 per cent tunnelling.

Sekhar *et al.* (2000b) evaluated 131 soybean lines in the field with heavy natural infestation of stem fly, *M.sojae* and found that G 12th/9A (ch) was highly resistant, whereas three lines, EC 113397 (ch), G 178 and G 2656 (BI) were resistant to stem fly damage.

Taware *et al.* (2001) screened forty-one soybean lines for resistance to leaf miner, *A. modicella* and stem fly *M.sojae* during the rainy season of 1998 in Maharasthra, India, with 5 control cultivars. Cultivar NRC 41 was highly resistant to leaf miner, while 11 lines were resistant to stem fly. Cultivars NRC 41, JS 92-22, JS (SH) 93-01 and the control cultivar MACS 124 showed resistance to both insects.

Salunke *et al.* (2002) screened 14 soybean cultivars against major insect pests in *Kharif*, 1998-99 at Parbhani. All the cultivars varied in leaf damage from (29.0 to 52.0%) and number of leaf miner, *Aproaerema modicella* from 3.18 to 5.13 larvae/plant. The highest incidence of leaf miner was recorded in MAUS-20 (5.13 larvae /plant) and the lowest leaf damage in NRC-37 (3.18 larvae/plant). Stem length tunneled due to stem fly, *M.sojae* varied from 5.87 to 14.07 per cent. The highest stem length tunneling was recorded in JS(SH)-9246 (14.07%) and the lowest in NRC-37 (5.86%). Girdle beetle, *O. brevis* infestation varied from 9.62 to 18.75 per cent. Infestation was maximum in RSC-3 (18.79%) and minimum in NRC-

37 (9.62%). Whitefly, *Bemisia tabaci* incidence varied from 0.50 to 1.48 whiteflies per three leaves. The maximum incidence was recorded in MAUS-201 (1.48 whiteflies per three leaves) and minimum in NRC-37 (0.50 whiteflies per three leaves). Incidence of jassids, *Empoasca kerri* varied from 0.90 to 1.74 jassids per three leaves, whereas maximum incidence was recorded in MAUS-52-3 (1.74 jassids per three leaves) and the least in MAUS-49-2 (0.90 Jassids per three leaves). Yield of soybean varied from 4.93 to 14.81 q/ha. Maximum yield of soybean was recorded in MAUS-49-2 (14.81 q/ha) and the lowest yield in cultivar MAUS-20 (4.93 q/ha). MAUS-20 was the most susceptible cultivar, whereas NRC-37 and MAUS-49-2 were more tolerant.

Shridhar *et al.* (2002) evaluated five soybean genotypes *viz.*, Pusa-16, PK-1062, DS-93 Br(OT)2, MACS-212 and JS-335 for their resistance to *M.sojae* and the morphological basis of resistance was determined. Pusa-16 and PK-1092 were susceptible, DS-93 Br (OT) 2 was tolerant, and MACS-212 and JS-335 were resistant to the pest at unifoliate, first, second, third and trifoliate leaf stage. Leaf petioles were gererally shorter and narrow with lower moisture content in resistant cultivars compared to susceptible cultivars. Inter nodal length, diameter, pith and moisture content were negatively associated with resistance, while inter nodal dry matter was positively associated.

Sharma *et al.* (2003) evaluated ten genotypes of soybean (early maturing, NRC-18, NRC-25, NRC-33, JS 71-05 and NRC-7; medium maturing JS-335, L-129 and MACS-450; late maturing Bragg and JS 80-21) in *Kharif,* 2000 in Madhya Pradesh, India for resistance to green semi-loopers, *C. acuta* and *D. orichalcea* [*T.orichalcea*], blue beetle, *Cneorane spp*., stem fly, *M. sojae*, jassids and caterpillar, *S. litura*. JS 71-05 was highly resistant and NRC-25 was resistant to green semiloopers. JS 71-05 and NRC-33 were highly resistant, and NRC-18 and NRC-7 were resistant to tobacco caterpillar. JS 335 and JS 80-21, and line 129 were highly resistant to stem fly. None of the genotypes were resistant to girdle beetle. NRC-18, JS 335, JS 71-05 and JS 80-21 were highly resistant to jassids.

Sridhar *et al.* (2003) tested 30 soybean lines to identify their resistance to, *M.sojae* and *B.tabaci* in a field trial in Delhi, under heavy natural infestation, based on the overall performance in two consecutive cropping seasons 1997-98. MACS-57 was found promising against stem fly attack whereas DS-1016 was consistently found a promising source of resistance to whitefly attack.

Gupta *et al.* (2004) evaluated resistance of 46 soybean genotypes against major insect pests, i.e. *M.sojae*, *O.brevis*, *Cydia ptychora* [*Leguminivora ptychora*], and *B.tabaci*, and nonfilling of pods in Tikamgarh, Madhya Pradesh, India, during the *Kharif* seasons of 1995-99. Based on mean pest incidence, MACS-13, JS84-200, JS86-24, JS81-1610 and JS78-41 (14.3 to 15.7% damaged stem length) were resistant to stem fly. Resistance to girdle beetle was observed in JS86-22, JS81-1564, JS81-303, JS81-1504, JS81-1619, JS86-23, JS84-1, JS81-1608, JS77-81, JS72-44, JS81-1625, JS80-21 and JS84-200 (1 to 5.7% stem tunnelling). JS77-81, PK472, JS86-24, JS81-335, JS87-59, JS76-205, JS86-26 and JS86-23 (3.5 to 4.9% pod damage) were resistant to pod borer. The genotypes which exhibited multiple resistance consisted of JS84-200 (against stem fly, girdle beetle and non-filling of pods), JS86-23 (against girdle beetle, pod borer and non-filling of pods), JS86-24 (against stem fly and pod borer), JS86-22 (against girdle beetle and non filling of pods), JS81-1504 (against girdle beetle and white fly), JS81-335 (against pod borer and non-filling of pods), and JS77-81 (against girdle beetle and pod borer).

2.4 Relative efficacy of bio-pesticides and newer insecticides against major insect pests of soybean

Bhattacherjee (1990) tested various insecticides for the control of *B. tabaci* to prevent the spread of soybean yellow mosaic virus on soybean crops. A basal application of phorate (1.5 kg a.i./ha) at the time of sowing followed by 3 sprays with 0.07% endosulfan at 10- to 15-day intervals gave good results.

Salama *et al.* (1990) reported that one spray application with Dipel (a formulation of *Bacillus thuringiensis* [subsp. *kurstaki*]) or fenvalerate reduced infestation of *Spodoptera exigua* on soybean and increased crop yields significantly, depending on dosages. A combination of the 2 insecticides at the lowest dose tested (62 g Bt. subsp. *kurstaki* + 50 ml fenitrothion per feddan) was promising, and increased yield 2.8-fold.

Singh and Singh (1991) tested 7 insecticide against thrips, *Caliothrips indicus* on soybean and found that Fenvalerate @ 0.01 per cent triazophos @. 0.04 per cent and cypermethrin @ 0.005 per cent were the most effective and should be applied to the middle region of soybean plants between the 2nd week of September and 1st week of October.

Khandwe *et al.* (1992) tested ovicidal action of 15 commercially available insecticides on eggs of *Rivula spp.*, a serious defoliator of soybean in Madhya Pradesh, India. Quinalphos (0.025%) and formothion (0.025%) were highly toxic, caused 100% egg mortality, followed by Methylparathion (0.05%) and triazophos (0.04%) both causing 95.53% egg mortality.

Kundu and Trimohan (1992) tested the efficacy of neem oil, neem seed kernel extract and phorate 10-G (soil placement), followed by sprays of endosulfan against stem fly infestation. They found phorate 10G followed by 3 spray of endosulfan 35EC (0.07%) highly effective in reducing stem tunneling by stem fly, followed by 2 per cent Neem oil and 1 per cent Neem seed oil. The treatment of 1 per cent and 2 per cent neem seed kernel extract were least effective.

Sharma (1994) reported that seed dressing of soybean with phosalone (35 EC) or carbosulfan (25-SD) controlled *M.sojae*, *B. tabaci*, *Empoasca sp*. and *Ayyaria chatophora*.

Singh (1994) reported biobit @ 1 Kg/ha and Dipel @ l/ha as highly effective against the *M.sojae*, *G.gemma*, *C.acuta*, *A.gosypii*, major insect pests of soybean and this two formulations of *Bacillus thurigiensis* either gave more or less equal yield to that of chemical pesticide.

Venkatesan and Kundu (1994) studied the effectiveness of 10 insecticides for the control of *M.sojae* and *Bemisia tabaci* on soybean in India, during *Kharif*, 1989. The least tunneling (31.8%) was observed in plots treated with (0.07%) endosulfan. The endosulfan treatment was at par with (0.05%) quinalphos, (0.018%) Phenetrothion, (0.003%) fenvalerate, (0.03%) phosalone and (0.017%) Carbosulfan. Highest yield and C:B ratio was obtained with endosulfan (1: 6.16) followed by carbosulfan (1:4.61).

According to Bhalkar (1996), application of endosulfan (0.05%) successfully checked the incidence of pest complex in soybean crop. He also reported that, the high grain yield of soybean was harvested from the plot treated with endosulfan (0.05%) and it proved to be the most ecologically viable treatment giving maximum ICBR of 1:8.18 .

Welland *et al.* (1997) evaluated the effect of Dimilin in combination with transgenic cotton (Bollgard), which incorporates the genes to manufacture the *Bacillus thuringiensis* (Bt) endotoxin, on several lepidopteran species. Bollgard was highly effective in minimizing leaf feeding and causing mortality of third instar larvae of tobacco budworm, *Heliothis virescens*, cotton bollworm, *Helicoverpa zea* and soybean looper, *Pseudoplusia includens* [*Chrysodeixis includens*], but was less effictive for beet armyworm, *Spodoptera exigua* and fall armyworm, *Spodoptera frugiperda*. For *S.exigua* diflubenzuron (Dimilin) in combination with Bt cotton was more effective in reducing larval leaf feeding and increasing larval mortality than either diflubenzuron or Bt cotton alone. Instances of synergistic responses to diflubenzuron and Bt cotton for both larval feeding and mortality were found for this species. Although diflubenzuron alone was highly effective on fall armyworm, the advantage of diflubenzuron on Bt cotton over diflubenzuron on non-Bt cotton was not evident for this species.

Dubey *et al.* (1998) compared the bioefficacy and economics of six microbial agents with triazophos in the field against *Gesonia gemma*, *C.acuta* and *M.sojae* infesting soybeans in Madhya Pradesh, India. Triazophos was significantly more toxic and offered the maximum net profit of Rs. 2968/ha. All the microbial agents were also found effective in reducing larval populations and stem tunnelling. However, because of the high market price of microbial pesticide formulations, they did not prove very profitable.

Singh *et al.* (1998) tested efficacy of 11 insecticides against green semilooper, *C. acuta*, grey semilooper *Gesonia gemma*, Aphid, *Aphis gossypii* and stem fly, *M.sojae* in

Kharif, 1995. All the insecticides except phosphamidon and profenophos were highly toxic upto 15 days after treatment (DAT) against green and grey similooper larvae. Against aphids all insecticides were effective up to 3 DAT; but monocrotophos, phosphamidon and triazophus were best upto 7 DAT. All the insecticides recorded significantly greater yield than the control, although the maximum yield 23.75 q/ha was recorded in triazophos.

Vaishampayan *et al*. (1998) studied three commercial formulations of neem (Azadirachtin) compared with endosulfan 35EC, triazophos and untreated control under field conditions. Insecticides was applied at flowering stage of crop. Five and fifteen days after treatment, the larval population was significantly lower in all the treatments compared to control. Among insecticides, endosulfan proved significantly better than others after 5 days of spray. After 15 days, however, trizophos and neem (Nethrin 2 1/ha) were at par with endosulfan and proved superior to neem formulations namely, Neemark, Neemol and Nethrin (1 l/ha.) Overall results indicated relatively poor performance of neem based insecticides against *Helicoverpa armigera* on chick-pea crop.

Duffield and Jordan (2000) evaluated seven insecticides against first-, third and fifth instar *H. armigera* (Hubner) and *Helicoverpa punctigera* (Wallengren) larvae using a leaf disc bioassay of field treated soybean. Significant differences were detected in age specific mortality, time to effect (LT50) and field persistence of the insecticides tested. The mortality of first instar larvae was similar in the different treatments to the commercial standard, methomyl. The mortality of third and fifth- instar larvae in the spinosad and chlorpyrifos treatments was also similar to that in the methomyl treatment, while the age-specific mortality of the insecticides based on *Bacillus thuringiensis* and NPV declined more rapidly, resulting in low mortality to fifth-instar larvae.

Hall *et al*. (2000) evaluated the efficacy of thiodicarb (Larvin 3.2F), spinosad (Tracer 4SC), and indoxacarb (Steward 1.25SC) against the soybean looper, *Pseudoplusia includens* (Walker) [*Chrysodeixis includens*] on conventional cotton (cv. DP 5415) and transgenic *Bacillus thuringiensis* (Bt) (Berliner) cotton (cv. NuCOTN 33B). Plots within each variety received an application of either thiodicarb at 0.125, 0.25, 0.375, 0.5 lb a.i./acre; spinosad at 0.012, 0.025, 0.037, 0.05 lb a.i./acre; indoxacarb at 0.05, 0.07, 0.09, 0.11 lb a.i./acre; or remained untreated. Foliage from each cultivar was placed into a 9.9 cm Petri dish along with three soybean looper larvae (L3 stage; 20 to 30 mg) within 1 hour after treatment (HAT). Larval mortality was rated at 72 hours after infestation (HAI). All rates of thiodicarb and all rates of spinosad (except 0.037 and 0.05 lb a.i./acre) caused greater mortality when larvae were placed on treated foliage of NuCOTN 33B compared to DP 5415. Indoxacarb toxicity was not influenced by the two crop hosts. All rates of indoxacarb provided similar levels of soybean looper mortality on NuCOTN 33B and DP 5415.

Knight *et al.* (2000) studied the efficacy of 3 new insecticides, DPX-MPO62 (indoxacarb), RH 2485 [methoxyfenozide] and Tracer [spinosad], and Dipel SC (*Bacillus thuringiensis* subsp. *kurstaki*), at different rates, for the control of soybean looper, *Thysanoplusia orichalcea*, in soybean. *Helicoverpa armigera* control by DPX-MP062, Tracer and Dipel was assessed in trials 1 and 2. Dipel SC showed very good control of loopers in 2 out of 3 trials. RH 2485 showed good potential with regards to looper control, and the control achieved by all rates was comparable with that of the standard Decis. Tracer also showed good potential for looper and *H.armigera* control. Its potential is even greater as it had little to no effect on most beneficial species.

Sharma (2000) evaluated the effectiveness of 5 formulations of *Bacillus thuringiensis* compared with endosulfan against *S. litura* and *Spilarctia obliqua* under controlled conditions at 26±1°C and 75 per cent RH. All the formulations were found to be effective against both the test insects, causing 66.66 to 100 per cent mortality in 3-5 days. The effectiveness of some of the formulations was found to be at par with that of endosulfan.

Son-Changki *et al.* (2000) investigated damage by stink bugs in the soybean. Stink bugs collected in the soybean fields were *Riptortus clavatus*, *Nezara antennata*, *Piezodorus hybneri*, *Dolycoris baccarum* and *Halyomorpha halys*. The damage rates by stink bug were 5.0-12.5per cent in determinate types and 36.1 to 50.0 per cent in indeterminate types, which indicated that stink bugs preferred indeterminate types. Fenitrothion, triazophos and carbaryl controlled stink bugs by 83.4, 69.5 and 87.0 per cent, respectively.

Upadhyay and Sharma (2000) tested seven insecticides for their effects on eggs and larvae of girdle beetle, *Oberea brevis* on sorghum in Madhya Pradesh, India. Insecticides were applied to 44 days old crop @ chlorpyriphos 0.05%, profenofos plus 0.5%, cypermethrin 0.05%, and Triazophos 0.05%. Triazophos gave the greatest egg mortality (80%).

Maleque *et al.* (2001) conducted a study on the efficacy and economics of some granular and foliar insecticides against the stem flies attacking soybean in Bangladesh during 1999-2001 cropping seasons. Out of the tested insecticides, Furadan 5G [carbofuran]-treated plots had the lowest stem tunneling (6.79% in 1999-2000 and 18.24% in 2000-2001) and yielded the highest (1.94 t/ha in 1999-00 and 1.28 t/ha in 2000-2001), followed by Marshal 6G [carbosulfan]-treated plots compared to the highest stem tunneling (11.74% in 1999-2000 and 26.91% in 2000-2001) and lowest yield (0.60 t/ha in 1999-00 and 0.40 t/ha in 2000-2001) in the untreated control plots. Furadan 5G-treated plots offered the highest benefit cost ratio

(BCR) (1.92 in 1999-2000 and 1.40 in 2000-2001), closely followed by Marshal 6G-treated plots. A strong negative correlation was found between yield and percentage of stem tunneling.

Yadav *et al.* (2001) conducted an experiment at the National research Centre for soybean (NRCS) Indore, during *Kharif*, 1998, where eight insecticides, including six new ones, which were hitherto not recommended for use in soybean crops in Madhya Pradesh. Carbosulfan 25EC was found to be the most toxic to girdle beetle, *O.brevis* followed by chloropyrifos 5 EC + cypermethrin 5EC and lambda cyhalothrin 5EC.

Keshbhat *et al.* (2002) conducted a field experiment with eleven insecticides revealed that all insecticides were effective in minimizing larval population. Spraying with 0.05 per cent quinalphos, 0.0025 per cent decamethrin and 0.15 per cent profenofos were found effective in reducing larval population. Maximum grain yield was recorded in quinalphos (31.24 q/ha), followed by profenofos (29.62 q/ha), acephate (29.50 q/ha) and decamethrin (29.39 q/ha) were at par with each other.

Rajkumar *et al.* (2002) tested the effect of chemical (one and two sprays of triazophos 40 EC at 800 ml/ha), natural (one and two sprays of neem seed kernel extract at 24 kg/ha), biological (*Beauveria bassiana* Dispel) and *Bacillus thuringiensis* subsp. *kurstaki* (Biobit), both @ 1 litre/ha) and mechanical (one and two hand pickings of larvae using 5 persons) methods of controlling defoliators *S.litura* and *Plusia orichalcea* [*Thysanoplusia orichalcea*] on the yield of soybean. The treatments consist a total spray volume of 600 l/ha and additional spot treatment of triazophos were applied at 35 and 60 days after germination (DAG). Triazophos, neem seed kernel extract, Dispel, Biobit and hand picking resulted in 40.13 to 152.30 per cent increase in yield compared to the control. The two sprays of Biobit resulted in 152.30 per cent increase in yield. The two sprays of triazophos resulted in 116.25 per cent increase in yield, which is 36.05 per cent less compared to plots treated with two sprays of Biobit. One and two hand pickings of larvae resulted in 83.12 and 40.13 per cent increase in yield, respectively. One and two spot treatments of triazophos resulted in 62.88 and 56.60 per cent increase in yield, respectively, which were the lowest in terms of percent increase in yield when compared with other treatments. The highest cost-benefit ratio was recorded with one-hand picking of larvae and one spot treatment with triazophos at 35 DAG.

Purwar and yadav (2003) tested the efficacy of chemical insecticides, plant extracts, insecticides of animal origin, insect growth regulators and entomopathogenic fungi against tobacco caterpillar, *S.litura* infesting soybean cultivars PK-1029 and PK-416. Triazophos was the most effective against *S.litura* larvae followed by the chitin inhibitor Dimilin (diflubenzuron). The entomopathogenic fungi, *Beauveria bassiana* was more effective than the botanical insecticide, neem seed kernel extract and insecticides with animal origin such as cow urine and cow dung ash in suppressing the population of tobacco caterpillar.

Taware *et al.* (2003) tested the efficacy of 9 insecticides during rainy season 1998 in Pune, Maharashtra, India, against the leaf miner, *A. modicella*, infesting soybean. The treatments comprised carbosulfan 25 EC @ 0.8 litre/ha, cartap hydrochloride 50 SP @ 1.0 kg/ha, ethofenprox [etofenprox] 10 EC @ 1.0 litre/ha, profenofos+cypermethrin 44 EC @ 1.0 litre/ha, chlorpyriphos+cypermethrin 44 EC @ 1.0 litre/ha, lambda-cyhalothrin 5 EC @ 0.3 litre/ha, chlorpyriphos [chlorpyrifos] 20 EC @1.5 litres/ha, quinalphos 20 AF @ 1.25 litres/ha, triazophos 40 EC @ 0.8 litre/ha and a control. Spraying of carbosulfan 20 EC at 0.8 litre/ha at 25 and 50 days after sowing was found to be the most effective treatment, followed by chlorpyriphos 20 EC at 1.5 litres/ha, quinalphos 20 AF at 1.25 litres/ha, lambda-cyhalothrin 5 EC at 0.3 litre/ha, ethofenprox 10 EC at 1.0 litre/ha and triazophos 40 EC at 0.8 litre/ha.

Sharma and Ansari (2004) tested the efficacy of five commercially available Bt formulations *viz.*, Delfin, Biolep, Dipel, Biosap and Biobit against two major defoliator of Soybean vig. *S.litura* and *S. obliqua* under controlled conditions and field conditions and found that larval population started declining in 3 day after treatment. 10 DAT, the mortality with Bt was comparable with that of triazophos.

Purwar and Yadav (2004) reported that neem seed cake (NSKE) 4 per cent, cow urin 10 per cent and diflubenzuran 25 wp and NSKE 6 per cent showed considerable reduction in stem fly infestation. Chemical insecticide triazophos was more effective than bio-rational insecticides in the management of girdle beetle.

Bajpai *et al.* (2004) tested the efficacy of seven liquid formulations of insecticides against insect pest of soybean revealed that the average highest grain yield of both the tested years 25.7 q/ha with maximum benefit cost ratio, 9.67 was observed with triazophos, followed with endosulfan, 7.97. Triazophos also gave maximum per cent avoidable yield loss, 34.98 and per cent increase in grain yield, 53.8 per cent.

3. MATERIALS AND METHODS

The present investigations on "Evaluation of IPM Components Against Major Insect Pests of Soybean *Glycine Max* (L) Merril in South-Eastern Zone of Rajasthan" were carried out at Agricultural Research Station Kota, MPUAT, Udaipur, during *Kharif,* 2002 and 2003. The methodology adopted for various aspects was as under -

3.1 FIELD PREPARATION AND SOWING OF CROPS

The experimental field was prepared in second week of June by ploughing through cultivator followed by cross harrowing and planking. In order to study the seasonal incidence of major insect pests of soybean, estimation of losses due to insect pest complex, effect of inter cropping on incidence of major insect pests, varietal screening for host plant resistance and relative efficacy of bio-pesticides and some newer insecticides, the crop, Cv JS-335, was sown on 10th July, 2002 and 12th July, 2003, respectively. Row to row and plant to plant distance for all 5 experiments were maintained at 30 cm and 8-10cm, respectively.

In order to study the effect of sowing date and row to row spacing on insect pests incidence the crop was sown on 25th June, 10th July and 25th July 2002 and 2003, respectively, within sowing dates three row spacing i.e. 22.5 cm, 30 cm and 45 cm were maintained.

The recommended dosages of fertilizers were used as basal application, all other agronomical practices e.g. hoeing, weeding and irrigation were performed as per recommendations of the zone.

3.2 METEOROLOGICAL DATA

The meteorological data for different weather parameters prevailed during the period of experimentation were obtained from Central Soil and Water Conservation Research and Training Institute, Kota. The meteorological data are presented in Table 2 and 3.

3.3 SPECIFIC DETAILS OF DIFFERENT EXPERIMENTS

3.3.1 Seasonal incidence of major insect pest of soybean in relation to abiotic factors.

3.3.1.1 Layout of experiment

The Seasonal incidence of major insect pests of soybean was studied on the crop sown in the plot area of 49 sqm (7x7m), which was replicated 4 times by using soybean variety JS-335. Row to row and plant to plant distance was maintained at 30 x 8-10 cm, respectively.

3.3.1.2 Observations

The observations on nature and extent of damage, first appearance of the pest, peak period of incidence and total duration of incidence were recorded. The observations on population of major insect pests were recorded at weekly intervals from germination to harvest during morning hours between 7.00 to 8.30 A.M. without disturbing the insect pest fauna, as per the following methods.

3.3.1.2.1 Caterpillars

To estimate the population of lepidopteron caterpillars e.g. semilooper and tabacco caterpillar. The plant shaking method was used, for the purpose rectangular beating sheet, 30 x 50 cm of cloth was used. For recording observation the cloth was spread between two rows at the ground level and plants of both the rows were vigorously shaken over the cloth to give a sample of 1m row length. In each replication at random three sample were taken.

3.3.1.2.2 Girdle beetle

Girdle beetle infestation was observed by counting the girdles formed on ten randomly selected plants. Only fresh girdles were recorded to note the percent infestation at different stages of crop growth.

3.3.1.2.3 Stem fly

To estimate the infestation of Stem fly plant splitting method was used. Ten plants were uprooted at random from each plot and each one of them was split open with the help of knife to note the percentage of infested plants through the tunnel formed.

3.3.1.3 Statistical analysis

The population data obtained for major insect pests were analyzed to find out the coefficient of correlation with abiotic factors like temperature, relative humidity and rainfall. Following formula was used for correlation coefficient.

$$Tx_1y_1 = \frac{\Sigma x_1 y_1 - \dfrac{\Sigma x_1 \Sigma y_1}{n}}{\sqrt{\left[\Sigma x^2_1 - \dfrac{(\Sigma x_1)^2}{n}\right]\left[\Sigma y^2_1 - \dfrac{(\Sigma x_1)^2}{n}\right]}}$$

`Where Tx_1y_1 = Simple correlation coefficient

x_1 = Independent variable i.e. Abiotic component.

y_1 = Dependent variable i.e. insect pests

n = Number of observations.

3.3.2 Estimation of losses due to insect pest complex

3.3.2.1 Layout of experiment

To estimate the avoidable losses due to insect pests infesting soybean on variety JS-335, the experiment was laid out in paired plot design as suggested by Leclerg (1971). There were only two treatments *viz.*, protected and unprotected and each treatment was replicated 13 times. One set of plots was under complete protection with dimethoate, (0.03%) and endosulfan (0.07%) alternatively, at 10 days interval throughout the growth stage of the crop. In another set of plots, which we called "unprotected plots", no insecticide was used and the crop was exposed to natural insect pest infestation till harvest.

3.3.2.2 Observations :

To know the losses due to insect pest complex 10 plants were uprooted at harvest from each replication in both protected and unprotected plots and the observations pertaining to the various yield attributing characters *viz.* plant height, number of pods per plant, number of grains per pod, yield of grains per plant, weight of 100 grains and yield from net plot, 9.6 m^2, were recorded. The net plot yield was converted into hectare yield.

3.3.2.3 Statistical analysis :

The avoidable losses consequent to infestation by naturally occurring surface feeders were calculated by the formula given by Leclerg (1971).

$$\text{Per cent loss in yield} = \frac{X_1 - X_2}{X_1} \times 100$$

Where X_1=yield of treated plots

X_2= yield of untreated plots

The yield data and yield attributing characters of plant were also subjected to statistical analysis and their significance was tested by using ‘t’ test.

$$S - \sqrt{\frac{\text{Sum of square of deviation from the mean of difference}}{\text{No of paired plots-1}}}$$

$$Sd = \frac{S}{\sqrt{n}}$$

$$t\ calculated = \frac{\overline{X}_1 - \overline{X}_2}{Sd}$$

Where $\overline{X}_1$ = Average yield in treated plot

$\overline{X}_2$= Average yield in untreated plot

S= Standard deviation

N= Number of paired plots

3.3.3 Effect of cultural practices on incidence of major insect pests

In order to study the effect of cultural practices on incidence of major insect pests of soybean three experiments were conducted as under;

(i) Effect of sowing date and row to row spacing on incidence of major insect pest.

(ii) Effect of inter-cropping on incidence of major insect pests.

(iii) Relative preference of soybean varieties against major insect pests.

3.3.3.1 Effect of sowing date and row to row spacing

In order to study the effect of sowing date and row to row spacing on incidence of major insect pests the experiment was laid out in Factorial RBD. Crop was sown on 25 June, 10 July, 25 July, 2002 and 2003 respectively. The sowing date was considered an main plot whereas the different row spacing were called as sub plots. In sub plots within the sowing dates three spacing for rows i.e. 22.5 cm (Farmers practice), 30 cm and 45 cm were maintained. The area for main plot was 54.00 sqm whereas the total rows for sub plots were 16, 12 and 8 for 22 cm, 30 cm and 45 cm row spacing, respectively. Four replications of each treatment set were maintained. The observations on pest population were recorded at weekly interval.

3.3.3.2 Effect of inter cropping on incidence of major insect pests in soybean

To study the effect of inter cropping on incidence of major insect pests, the experiment was laid out, in Randomized Block Design. Soybean was sown as sole crop and intercropped with different crops *viz.* pigeonpea, maize, sorghum and sesame in respective sub plots after every two row of soybean. Treatment combinations were as follows :

T_1=soybean sole crop var. JS-335

T_2=soybean + sorghum var. CSV-10

T_3=soybean + maize var. Ganga-5

T_4=soybean + pigeonpea var. Manak

T_5=soybean + sesame var. RT-46

Thus, there were five treatments including the control (Soybean alone) and each treatment was replicated four times. Insect pest population was recorded at weekly interval. Significance of different intercropping treatments on the incidence of major insect pests was tested by analysis of variance.

3.3.3.3 Relative preference of soybean varieties against major insect pests

To screen soybean varieties for host plant resistance the experiment was laid out in R.B.D. soybean varieties *viz.* Pratap Soya, JS-335, NRC-12, NRC-37, PK-472, MACS-450 and JS80-21 were sown in separate plots according to randomization, each treatment was replicated 4 times with the plot area 15 sqm each. Each plot had 10 rows of plants in 30 cm row to row spacing and 8-10 cm plant to plant distance. Total treatment of experiment were seven.

The observations were recorded at weekly interval after germination of the crop till harvest by appropriate sampling techniques mentioned above. The varieties were categorized as per insect pests preference as least, moderate and most preferred, based on their numerical abundance over the season.

3.3.4 Relative efficacy of bio-pesticides and newer insecticides against major insect pests of soybean

The efficacy of bio-pesticides like Bt., Spinosad, neem oil and some newer insecticides *viz.* profenophos, diflubenzuron, carbosulfan and triazophos were tested. The detail information about insecticidal formulation dosage and concentrations used are given in table 4. These insecticides were tested alone and in combination as below mentioned.

Details of treatment schedules

S. No.	Treatment	Dose

1.	Bt + ½ dose of endosulfan at 35 and 60 DAS	1 kg + 625 ml/ha
2.	Spinosad (alone) at 35 and 60 DAS	250 ml/ha
3.	Neem oil alone at 35 and 60 DAS	0.5% Conc. 3 Litre/ha
4.	Neem oil at 35 DAS and profenophos at 60 DAS	0.5% + 1.5 Litre/ha
5.	Carbosulfan at 35 DAS and spinsosad at 60 DAS	1 Litre + 250 ml/ha
6.	Diflubenzuron alone at 35 and 60 DAS	300 gm/ha
7.	Diflubemzuron at 35 DAS and spinosad at 60 DAS	300 gm + 250 ml/ha
8.	Carbosulfan at 35 DAs and at 60 DAS	1 Litre/ha
9.	Triazophose at 35 and 60 DAS	800 ml/ha
10.	Triazophos at 35 DAS and spinosad at 60 DAS	800 ml + 250 ml
11.	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 DAS and at 60 DAS	150 gm + 625 ml/ha
12.	Endosulfan (check) at 35 and 60 DAS	1250 ml/ha
13.	Control	(No Insecticide)

The experiment was layout in randomize block design, each treatment was replicated 3 times with the plot area 15 sqm each. Each plot had 10 rows of plants in 30 cm row to row and 8-10 cm plant to plant distance. Total treatments of experiment were thirteen.

3.3.4.1 Observations:

Pre-treatment observations were taken one day before the spray of insecticide. The post treatment observations were recorded at 1, 3, 7 and 10 days after treatment. Two sprays were given first at 35 DAS and the second at 60 DAS.

3.3.4.2 Statistical analysis

The data recorded on girdle beetle and stem fly per cent infestation were transformed to angular values. The transformed values were analyzed to analysis of various. In case of semilooper the data on mortality after treatment were corrected by applying the correction factor given by Henderson & Tilton (1955) As under.

$$\text{Corrected per cent mortality} = 100 \times \left[1 - \frac{T_a \times C_b}{T_b \times C_a} \right]$$

Where,

T_a= No. of insect after treatment

T_b=No. of insect before treatment

C_a=No. of insect in control after treatment

C_b=No. of insect in control before treatment

The total grain yield obtained from net plot (9.6 m^2) was computed on hectare basis. The increase in grain yield was calculated as yield increase in treated plots compared to untreated plots as follows:

$$\text{Per cent increased yield} = \frac{\text{Increase yield in treated plot}}{\text{yield in control plot}} \times 100$$

Cost benefit ratio was calculated by deducting the cost of insecticidal treatment from price of increased yield over control.

4. RESULTS

4.1 Seasonal incidence of major insect - pests of soybean in relation to the abiotic factors.

Soybean crop was infested by many insect-pests throughout its growth. Among the major insects causing significant reduction in yield were girdle beetle, semilooper and stem fly. The appearance of tobacco caterpillar in 2000 as an out-break caused serious economic damage to soybean crop hence was also considered for the observation.

The studies on seasonal incidence of major insect pests carried out during *Kharif*,-2002 and 2003 revealed occurrence of these insect pests at different stages of crop growth. The infestation data of these pests in relation to meteorological parameters are given in table 5 and 6.

4.1.1 Seasonal incidence of Stem fly, *Melanagromyza sojae* (Zehnt.)

Table 5 and fig.7 indicated that first appearance of Stem fly was observed in the 31st meteorological week (30 July to 5 Aug.2002) with 5 per cent initial infestation which increased gradually and reached its peak to 15 per cent in 32nd meteorological week (6-13 Aug. 2002). However, the infestation was constant in 33rd meteorological week (13-19 Aug.,2002) and declined there after. There was no fresh infestation after 36th meteorological week (3-9 Sept. 2002).

The corresponding mean temperature, relative humidity and rainfall during peak period were 28.45 ^{o}C, 81.00 per cent and 134.3 mm, respectively. There was no significant correlation between mean temperature, relative humidity and rainfall with stem fly infestation.

The similar trend of observations were recorded in 2003 (Table 6 and Fig. 8) The first appearance of stem fly was observed in 30th meteorological week (23-29 July, 2003) with (7.5%) initial infestation which reached its peak to 25 per cent, in 33rd meteorological week (13-19 Aug., 2003) and declined there after. There was no fresh infestation in the 37th meteorological week (10-16 Sept., 2003) onwards.

The mean temperature, relative humidity and rainfall during peak period were 28.30 ^{o}C, 79 per cent and 15.5 mm respectively. There was no significant correlation between mean temperature, relative humidity and rainfall with stem fly infestation.

4.1.2 Seasonal incidence of Girdle beetle, *Oberia brevis (*Swed.)

The data given in table 5 and fig. 9 indicated the first appearance of girdle beetle was observed in the 31st meteorological week (30 July-5 Aug., 2002) with 2.5 per cent initial infestation. The damage of girdle beetle increased gradually and reached its peak of. 22.5 per cent, in the 35th meteorological week (27 Aug. - 02 September, 2002). The fresh infestation started declining from 36th meteorological week and there was no fresh infestation in the 37th week (10-16 Sept. 2002) onward.

The mean temperature, relative humidity and rainfall during peak infestation were 28.95 ^{o}C, 73 per cent and 12 mm, respectively. There was no significant correlation between mean temperature, relative humidity and rain fall with girdle beetle infestation.

Similarly, the first appearance of girdle beetle during 2003 was reported in 31st meteorological week (30 July - 5 Aug. 2003) with 2.5 per cent initial infestation. The infestation of girdle beetle increased gradually and reached its peak of 45 per cent during 35th meteorological week (27 Aug. - 02 Sept - 2003) and then started declining from 36th meteorological week. There was no fresh infestation in the 39th meteorological week (24-30 Sept., 2003) and after ward.

The mean temperature and relative humidity during peak infestation were 26-95 ^{o}C and 84 per cent respectively. The rainfall during peak was 22.1 mm. There was no significant correlation between mean temperature and rainfall with girdle beetle infestation, whereas, mean relative humidity indicated significant positive relationship (r_2=0.865), (Table 6, Fig 10) during *Kharif,* 2003.

4.1.3 Seasonal incidence of Semilooper, *Chrysodeixis acuta* (Walker)

The data (Table 5 and Fig 11) revealed that the first appearance of semilooper larvae was observed in the 31st meteorological week (30 July - 5 Aug. 2002) with initial larval population, 1.5 larvae per meter row length (mrl) and reached its peak in 34th, meteorological week (20-26 Aug., 2002). The population remained static in the 35th week with (3 larvae/mrl) and then start declining and disappeared during 38th meteorological week (17-23 Sept., 2002). During peak period of incidence the corresponding mean temperature, relative humidity and rainfall were 28.40^{0}C, 28.95^{0}C and 76, 73 per cent and 13.8, 12mm, respectively. There was no significant correlation between mean temperature, relative humidity and rainfall with semilooper population.

Similarly in 2003 it appeared in the 31st meteorological week with initial population 2.5 larvae/ mrl and reached its peak of 4.5 larvae/mrl in the 35th meteorological week (27 Aug. to 02 Sept., 2003). The larval population declined from 36th meteorological week and no population was recorded in 39th meteorological week (24-30 Sept.2003). The mean temperature, relative humidity and rainfall during peak period of incidence were 26.95^{o}C, 84 per cent and 22.1mm respectively. There was no significant correlation between mean temperature, relative humidity and rainfall with semilooper population (Table-6, Fig. 12).

4.1.4 Seasonal incidence of Tobacco caterpillar, *Spodoptera litura* (Feb.)

During the period of experimentation (two years) very low population of *S.litura* was recorded. Therefore, the observations recorded on *S.litura* were not considered for result and discussion.

4.2 Estimation of avoidable losses

The observations obtained regarding the damage caused by insect-pests in soybean during *Kharif,* 2002 and 2003 are given in (Table 7 and 8). The data revealed that infestation of insect pest in soybean did not affect the plant height, number of grains per pod and weight of 100 seeds significantly in protected and unprotected plots. But the insect pest infestation significantly affected the number of pods per plant, grains per plant, yield per plant and yield per plot.

The number of pods per plant in protected plots were more in both the years of investigation compared to unprotected. The mean number of pods per plant in protected and unprotected plots during *Kharif,* 2002 were 62.00 and 43.00, respectively, whereas, in 2003 it was 64.08 and 42.69, respectively.

The mean difference in the number of pods per plant during *Kharif,* 2002 in protected and unprotected plants was 19 which showed 30.62 per cent pod loss whereas in 2003 it was 21.38 less pod which leads to 33.32 per cent pod loss, respectively.

Similarly, the number of grains per plant in protected plots were more in both the years than to unprotected plants. The mean numbers of grains per plant in protected and unprotected were 146.62 and 100.46 respectively, during *Kharif,* 2002, whereas in 2003 it was 151.69 and 99.23, respectively. The plants under protection had on an average 46.15 more grains per plant than unprotected during *Kharif,* 2002 whereas in 2003 it was 52.46, resulting into 31.43 and 34.53 per cent loss respectively.

The yield data on weight basis indicated that the plants under protection gave significantly higher yield than the unprotected plants. The mean yield per plant in protected and unprotected during 2002 was 17.69 and 12.03 g respectively, whereas in 2003 it was 18.76 and 11.87 g respectively. The mean difference in yield per plant in 2002 was 5.67 g that led to an estimated loss of 31.94 per cent, whereas in 2003 it was 6.89g with 36.70 per cent loss respectively (Table - 7 and 8).

The yield computed for the plot as a whole also indicated that protection gave significantly more yield than unprotected. The mean yield per plot in *protected and unprotected plots during 2002 was 26.45 q/ha and 16.97 q/ha respectively, whereas in 2003 it was 27.60 q/ha and 16.97 q/ha respectively. The mean difference in plot yield was 9.48q/ha and 10.63 q/ha with consequent loss estimated as 35.76 and 38.43 per cent respectively.*

4.3. Effect of cultural practices on incidence of major insect-pests

In order to study the effect of cultural practices on incidence of major insect-pests of soybean following three experiments were undertaken.

4.3.1 Effect of sowing date and row spacing on incidence of major insect pests

The data recorded on incidence of insect pests in different sowing dates and rows spacing indicate that there was no significant difference in the interaction between sowing date and row spacing. But the seasonal means within different date of sowing differed significantly. Much alike the seasonal means within row spacing also showed a significant difference.

4.3.1.1 Incidence of stem fly under different sowing dates

The data table 9 indicates that early sown crop (25^{th} June 2002) had significantly lower infestation (2.16%) of stem fly while the crop sown on 10^{th} July (mid) and 25^{th} July 2002 (late) had more infestation of stem fly (7.51 and 11.55%) respectively. The infestation recorded on 25^{th} June (Early), 10^{th} July (mid) and 25^{th} July (late) sowing dates was statistically different in each dates of sowing.

Similar observations were recorded during 2003 (Table 10) where in early sowing (25^{th} June 2003) showed 4.66 per cent infestation while the infestation recorded in mid (10^{th} July 2003) and late (25^{th} July 2003), sowings were 15.93 and 17.87 per cent, respectively. However, the infestation recorded on 10^{th} July (mid) and 25^{th} July (late) was statistically at par.

4.3.1.2 Incidence of girdle beetle under different sowing dates

The data recorded on incidence of girdle beetle (Table 9) clearly indicate the significant difference in infestation levels at different sowing dates. During 2002 the maximum infestation 15.45 per cent was recorded in early sowing, while significantly less infestation was recorded in mid and late sowing 11.33 and 7.22 per cent, respectively.

The observations recorded during 2003 had similar trends with 24.04, 19.08 and 8.69 per cent infestation, respectively for early, mid and late sowing dates and the difference was significant among the treatments (Table 10).

4.3.1.3.Incidence of semilooper under different sowing dates

The data (Table 9) indicates that there was significant difference in the population of semilooper at different sowing dates. During 2002 the minimum larval population 1.22 larvae/mrl was recorded in early sowing followed by 1.86 larvae/ mrl and 2.59 larvae/mrl in mid and late sowing dates, respectively.

Similar observations were recorded during 2003, where in population of semilooper was 1.82, 2.78 and 3.46 larvae/mrl in early, mid and late sowing dates, respectively and there were significant difference among treatments (Table 10).

4.3.2 Effect of row to row spacing on incidence of major insect pest

4.3.2.1 Incidence of stem fly under different row spacing

The sowing of crop at different row spacing clearly indicate the impact over insect population (Table 9). During 2002 the maximum infestation of stem fly 8.89 per cent, was observed at 22.5 cm row spacing followed by that in plots with 30 cm row spacing 5.98 per cent. The minimum infestation 4.85 per cent, was recorded at 45 cm row spacing. However, these three treatments were statistically at par.

During 2003 the maximum infestation (14.54%) was recorded in the plots having 22.5 cm row spacing followed by 12.42 per cent in 30 cm row spacing. and 9.50 per cent in 45 cm row spacing (Table 10). However, the infestation of stem fly in plots having 22.5 cm and 30 cm row spacing was statistically at par. The infestation of stem fly in plots having 45 cm row spacing was significantly lower than that in 22.5 and 30 cm row spacing, respectively.

4.3.1.2 Incidence of girdle beetle under different row spacing

During *Kharif,,* 2002 significantly maximum infestation (13.61%) of girdle beetle was recorded in 22.5 cm row spacing followed by (10.62%) in 30 cm and (9.27%) in 45 cm row spacing, respectively (Table 9). However, the infestation level in plots at 30 cm and 45 cm row spacing were statistically at par.

A significant difference in infestation levels was recorded during *Kharif* 2003, where the infestation levels in plots having 22.5cm, 30 cm and 45 cm row spacing were 19.28, 16.43 and 13.76 per cent, respectively (Table 10).

4.3.1.3 Incidence of Semilooper under different row spacing

The data table 9 indicate that the incidence of Semilooper on soybean at different row spacing showed varied larval population. The plots having 22.5 cm row spacing had significantly higher population (2.38 larvae/mrl) followed by plots having 30 cm row spacing

(1.74 larvae/ mrl) and the minimum population (1.49 larvae/mrl) was recorded at 45 cm row spacing. All these three treatments were significantly different from each other.

During *Kharif*, 2003 the observations recorded showed similar trend. The larval populations at different row spacing 22.5, 30.0 and 45.0 cm were 3.295, 2.562 and 2.158 larvae/mrl, respectively (Table 10).

4.3.2 Effect of inter cropping on incidence of major insect pest of soybean

The impact of inter cropping of soybean with sorghum, maize, pigeonpea and sesame on the insect pest incidence was studied during *Kharif,* 2002 and 2003, it showed varied response on the incidence of insect pests infesting soybean. The insect pest-wise incidence in different inter cropping have been described below.

4.3.2.1 Incidence of stem fly *M. sojae* under sole and inter crop situations.

The observations recorded on incidence of stem fly on soybean as a sole crop and inter cropped with sorghum, maize, pigeonpea and sesame during 2002 and 2003 are presented in (Table 11 and 12). The initial infestation of stem fly was recorded at 28 DAG in sole crop and inter cropped with sorghum, maize, pigeonpea and sesame, which peaked at 35 DAG. The infestation ranged from 12.23 to 14.64 per cent.

The seasonal mean indicated that maximum infestation of stem fly (8.23%) was recorded in soybean sole crop, followed by (7.88%) in soybean + pigeon pea; (7.69%) in Soybean + sesame; (6.39%) in soybean + maize while the lowest infestation (5.29%) was recorded in soybean + sorghum. However, all the treatments were statistically at par.

A similar trend was observed during *Kharif* 2003 where the initial infestation (12.23 to 14.67%) was recorded at 21 DAG in the sole crop and in different intercropping. The peak infestation was recorded at 35 DAG ranging from 22.37 to 24.83 per cent.

The seasonal mean indicated that maximum infestation (15.39%) each was recorded in soybean + pigeonpea and soybean + sesame followed by soybean sole (15.35%), soybean + sorghum (12.82%) and the lowest infestation (12.40%) was recorded in soybean + maize. However, all treatments were statistically as par.

4.3.2.2 Incidence of Girdle beetle under sole and intercrop situations

The data (Table 13) indicate that initial infestation of girdle beetle during 2002 was observed only in soybean as sole crop and the intercrop combination, soybean + pigeonpea at 21 DAG. Later on at 28 DAG, the infestation was observed in all the intercrops with the peak at 49 DAG ranging from 17.24 to 22.37 per cent in sole crop as well as the different inter cropping treatments.

The seasonal mean indicated that the maximum infestation (12.91%) was observed in soybean + pigenopea followed by 12.77 and 12.49 per cent in soybean sole crop and soybean + sesame intercropping system, respectively. The lowest infestation each (10.41%) was recorded in soybean + sorghum and soybean + maize. However, these treatments were statistically at par.

During *Kharif* 2003, the initial infestation was recorded in soybean sole crop only at 21 DAG. After one week the infestation was observed in all combinations that reached its peak at 49 DAG in all treatments. The peak infestation ranged from 37.44 to 44.97 percent. (Table 14)

The seasonal mean indicated that maximum infestation (23.32%) was recorded in soybean sole followed by soybean + sesame (23.31), soybean + pigeonpea (22.44%) , soybean + maize (20.39%) and the lowest infestation (19.53%) was recorded in soybean + sorghum. However, treatments of soybean + sorghum, soybean + maize and soybean + pigeonpea cropping system were statistically at par and soybean + sesame and soybean sole were also at par.

4.3.2.3 Incidence of semilooper under sole and intercrop situation.

The data given in Table 15 indicates that initial infestation of semilooper during *Kharif* 2002 was observed at 21 DAG in sole crop as well as intercrops, which peaked at 49 DAG, and population of semilooper ranged from 2.48 to 3.00 larvae/mrl in the different intercrops.

The seasonal mean indicated that maximum infestation (2.2 larvae/mrl.) was recorded in soybean + sesame followed by soybean sole crop (2.19 larvae/mrl), soybean + pigeonpea (2 larvae/mrl) and the lowest infestation (1.71 larvae/mrl) was recorded in soybean + sorghum and soybean + maize. respectively. However, the treatment of soybean + sorghum, soybean + maize and soybean + pigeonpea were statistically at par.

Similar observations were also recorded during *Kharif*, 2003, where initial infestation of semilooper was observed at 21 DAG in sole crop as well as in intercrops, which peaked at 49 DAG, ranging from 3.48 to 4.49 larvae/mrl in soybean sole as well as in different intercrops. (Table 16).

The seasonal mean indicated that the highest infestation (3.23 larvae/mrl) was recorded in soybean sole crop followed by soybean + sesame (3.21) larvae/mrl), soybean + pigeon pea (3.08 larvae/mrl), soybean + maize (2.62 larve/mrl) and the lowest infestation 2.50 larvae/mrl was recorded in soybean + sorghum.

4.3.3 Relative preference of different varieties of soybean against major insect pests

Seven varieties of soybean were evaluated for the relative preference by major insect-pests during *Kharif*, 2002 and 2003. The data recorded on incidence of major insect-pests i.e. stem fly, girdle beetle and semilooper have been presented in table 17 and 18.

In case of stem fly the seasonal mean infestation level indicated that variety JS80-21 had maximum infestation of stem fly (13.97%) followed by MACS-450 (13.46%), P.K. 472 (11.96%), NRC-37 (10.40%), NRC-12 (9.91%), Pratap Soya (8.97%) and the lowest infestation was recorded in JS-335 (8.87%). The variety Pratap Soya, JS-335, NRC-12 and NRC-37 were statistically at par and were least preferred by stem fly. The stem fly infestation levels for variety JS80-21 and MACS 450 were at par and both varieties were most preferred by this.

A similar trend was observed in *Kharif*, 2003 where maximum infestation (19.27%) was recorded in JS80-21 followed by MACS-450 (18.18%), PK-472 (16.41%), NRC-12 (15.34%), NRC-37 (15.32%), Pratap Soya (14.21%) and the minimum infestation (14.18%) was recorded in JS-335. The variety Pratap Soya, JS-335, NRC-12, NRC-37 were statistically at par and were least preferred by the stem fly. The other varieties *viz.*, PK-472, MACS-450 and JS80-21 were at par.

In case of girdle beetle the seasonal mean infestation level indicated that variety JS80-21 and PK-472 had maximum infestation (18.73% & 18.72%), followed by MACS-450 (16.65%), NRC-12 (14.54%), JS -335 (14.15%), NRC-37 (13.65%) and the lowest infestation 12.46 per cent was recorded in Pratap Soya. However, infestation level of Pratap Soya, JS-335, NRC-12 and NRC-37 was at par. The variety Pratap Soya was least preferred by the girdle beetle.

Almost same trend was observed during *Kharif* 2003, where maximum infestation (24.34%) was recorded in PK-472 followed by JS80-21 (23.71%), MACS-450 (22.16%), NRC-12 (20.93%), NRC-37 (19.95%), JS-335 (19.03%) and the lowest infestation 17.17 per cent was recorded in Pratap Soya.

In case of semilooper the seasonal mean population during 2002 indicated that maximum population of semilooper 2.42 larvae/mrl was found in NRC-12, followed by JS80-21 (2.31 larvae/ mrl), MACS-450 (2.25 larvae/mrl), NRC-37 (2.18 larvae/mrl), Pratap Soya (2.17 larvae/ mrl), PK-472 (2.04 larvae/mrl) and the lowest population 2.03 larvae/mrl was recorded in JS-335. The variety JS-335 and PK-472 were statistically at par and least preferred by the semilooper.

During *Kharif*, 2003 the maximum population (3.36 larvae/mrl) of semilooper was recorded in NRC-12 followed by NRC-37 (3.18 larvae/mrl), MACS-450 (3.11 larvae/mrl), JS-335 (3.00 larvae/mrl), JS80-21 (2.89 larvae/mrl), Pratap Soya (2.85 larvae/mrl) and the minimum population 2.64 larvae/mrl was recorded in PK-472. However all these varieties did not show a significant difference on screening.

4.4 Relative efficacy of different insecticides against major insect pests of soybean.

The bio-efficacy of different treatment schedules against stem fly, girdle beetle and semilooper was compared during *Kharif*, 2002 and 2003.

4.4.1 Efficacy of different treatment schedules against stem fly :-

The data (Table 19) reveal that the treatment schedule comprising spray of carbosulfan (0.04%) at 35 DAS and, triazophos (0.05%) at 35 DAS against stem fly proved significantly superior over the other treatment schedules. Where the fresh infestation was nil. The treatment schedules were followed by endosulfan (0.07%) with (4.53%) infestation level one day after first spray application. The efficacy of these treatment schedules were continued to be effective upto 10 days after first spray keeping the fresh infestation levels at zero.

The treatments schedules comprising Bt. + endosulfan 1/2 dose; spinosad (0.018%); neem oil (0.5%); diflubenzuran (0.0125%), and 1/2 dose of diflubenzuron +1/2 dose of endosulfan at 35 DAS were least effective at 1 and 3 days after first spray. Showing 10.00 to 13.01 per cent infestation as compared to 16.36 percent in the control. The stem fly infestation was 10 per cent in these treatment schedules up to 10 days after treatment.

As there was no fresh infestation due to stem fly at 60DAS during *Kharif*, 2002, hence observations were not recorded after second spray application.

Similar results were observed during *Kharif*, 2003. The treatment with carbosulfan (0.04%) and triazophos (0.05%) at 35 DAS were significantly superior over other treatments; followed by endosulfan (0.07%) at 35 DAS, one day after first spray. The efficacy of these treatment schedules continued up to 10 days after first spray keeping the fresh infestation at zero (Table 20).

After second spray 60 DAS the treatment with profenophos (0.125%) was equally effective as carbosulfan, triazophus and endosulfan, at 24 hrs after second spray. These treatments were effective up to 3rd day after second spray application keeping the infestation levels at zero percent. The overall efficacy of both applications showed that the treatment of crop with carbosulfan, triazophos, endosulfan and profenophos were highly effective in controlling the stem fly, while the treatment with Bt + 1/2 dose of endosulfan, spinosad, neemoil, diflubonzuran, 1/2 dose of diflubenzuran +1/2 dose of endosulfan were significantly less effective in controlling stem fly during both the years.

4.4.2 Efficacy of different treatment schedules against girdle beetle :-

The data (Table 21) indicate that the treatment with carbosulfan (0.04%), triazophos (0.05%) at 35 DAS followed by endosulfan (0.07%) at 35 DAS significantly superior over other treatments after one day of first spray application, keeping the fresh infestation zero for carbosulfan, triazophos schedules and 4.53 percent for endosulfan. These treatment were effective upto 7days after first spray applications keeping the fresh infestation at zero percent. The treatment schedule comprising Bt + 1/2 dose of endosulfan, spinosad, neem oil, diflubenzuran and 1/2 dose of diflubenzuran +1/2 dose of endosulfan at 35 DAS were less effective against the girdle beetle at 1,3,7 and 10 days after first application. These treatments were statistically at par with control. The infestation by girdle beetle in these treatment ranged from 10 to 13.01 per cent at 3 and 7 days after first spray application. The maximum infestation by girdle beetle at 10 days after first application was recorded in neem oil treatment which was least effective and statistically at par with control.

The treatment schedules of carbosulfan and triazophos were significantly superior over other treatments one day after second spray. However, the treatment schedules of profenophos and spinosad at 60 DAS were also found effective against the girdle beetle. The treatment schedules of profenophos, spinosad and endosulfan did not differ significantly in their efficacy. The treatments with carbosulfan, triazophos, profenophos, endosulfan were effective upto 10 days after second spray. The treatment schedule of Bt + 1/2 dose endosulfan, spinosad alone, neemoil, diflubenzuran, 1/2 dose of diflubenzuran +1/2 dose endosulfan at 60 DAS were significantly least effective in controlling girdle beetle at 1,3,7 and 10 days after second spray. These treatments were statistically at par with control at 3,7 and 10 days after second spray. A similar trend was observed during *Kharif*, 2003, where the treatment schedule comprising carbosulfan, triazophos and endosulfan at 35 DAS and 60 DAS and profenophous at 60 DAS were significantly superior over other treatments up to 10 days after treatment. Remaining treatments were less effective in controlling girdle beetle (Table 22).

4.4.3 Efficacy of different treatment schedules against semilooper

The data (Table 23) showed that treatment schedule comprising spinosad (0.18%), carbosulfan (0.04%) and triazophos (0.05%) at 35 DAS were significantly superior over other treatments, showing cent percent population reduction of semilooper one day after the first spray application. The efficacy of these treatment schedules continued upto 7 days after treatment bringing about cent percent population reduction. The treatment schedule of triazophos 35 DAS was most effective giving cent percent population reduction upto 10 days after treatment. The treatment schedule of neem oil was least effective showing a population reduction from 3.01 percent to 44.58 percent at upto 10 days after treatment.

The treatment with spinosad (0.018%), profenophos (0.125%), carbosulfan (0.04%) and triazophos (0.05%) were found most effective against semilooper after second application showing cent percent population reduction upto 10days after application. The treatment schedules of neem oil was least effective against the semilooper showing a population reduction from 15.33 per cent to 63.23 per cent at 1,3,7 and 10days after treatment respectively.

Similar observation were recorded during *Kharif*, 2003. Where treatment schedule of spinosad, profenophos, carbosulfan, triazophos and endosulfan, proved significantly superior in controlling semilooper, while the treatment schedule of Bt + 1/2 dose of endosulfan, diflubenzuran, neem oil and 1/2 dose diflubenzuran + 1/2 dose endosulfan were less effective (Table 24).

4.4.4 Effect of insecticidal treatments on soybean yield.

The data of (Table 25) reveal that all treatment schedules increased yield significantly over control. Among the different treatment schedules the treatment comprising triazophos (0.05%)at 35 and 60 DAS resulted into maximum yield (24.17 q/ha), followed by triazophos at 35 DAS and spinosad (0.018%)at 60 DAS (23.80 q/ha), carbosulfan (0.04%) at 35 DAS and spinosad at 60 DAS (23.41 q/ha), carbosulfan alone at 35 and 60 DAS (23.18 q/ha) and standard check (Endosulfan (0.07%) at 35 and 60 DAS) (22.57 q/ha). Remaining treatment schedules had a middle order of yield potential. The lowest yield (13.96 q/ha) was recorded from untreated plot (Control).

The different treatment schedules in descending order of effectiveness were: (triazophos at 35 and 60 DAS) > (triazophos at 35 DAS and spinosad at 60 DAS) > (carbosulfan at 35 DAS and spinosad at 60 DAS) > carbosulfan alone at 35 and 60 DAS) > (endosulfan at 35 and 60 DAS) > 1/2 dose diflubenzuran, + 1/2 dose endosulfan at 35 and 60 DAS) > (diflubenzuran at 35 DAS and spinosad at 60 DAS) > neem oil at 35 DAS and profenosphos at 60 DAS) > diflubenzuran alone at 35 and 60 DAS) > (spinosad alone at 35 and 60 DAS) > (Bt + 1/2 dose endosulfan at 35 and 60 DAS)> (neemoil alone at 35 and 60 DAS) > control.

4.4.5 Economics and cost benefit ratio of different insecticidal treatment schedules

Every treatment schedule was aimed to get an economic return by increasing the production and reducing the damage caused by the insect pest. Taking this into consideration the economics of each insecticidal treatment was worked out by taking into account the cost of insecticidal treatment schedule and the profit gained from these treatments in terms of reduced damage, increased yield over the control (Table 25). The net profit or loss was worked out by deducting the cost of treatment schedules (insecticide + labour) from the price of increased yield over the control.

The data (Table 25) depicted that all the treatment schedules were profitable over control. The maximum net profit and cost benefit ratio was obtained from triazophos (0.05%) at 35 and 60 DAS) Rs. 13246/ha and 1:12.63, followed by endosulfan (0.07%) (standard check) at 35 and 60 DAS Rs.11094/ha and 1:11.56 carbosulfan (0.04%) at 35 and 60 DAS, Rs.11188/ha and 1:6.50, respectively. The minimum net profit and lowest cost benefit ratio was obtained with treatment schedule of spinosad (0.018%) at 35 and 60 DAS i.e. Rs. 944/ha and 1:0.16 respectively.

5. DISCUSSION

5.1 Seasonal incidence of major insect-pests of soybean in relation to the abiotic factors.

Soybean crop was attacked by many insect pests throughout its growth. Among the major insect pests causing significant damage were stem fly, girdle beetle and semilooper. The appearance of tobacco-caterpillar, *Spodoptera litura* in 2000 as an out-break caused serious damage to soybean in the Agro climatic zone V (Kota Division) hence was also considered for observation. The results of experiments carried out during *Kharif,* 2002 and 2003 revealed presence of these insect pests at different stages of crop growth. However, during the period of experimentation very low population of *S. litura* was recorded in both the years. Therefore, the observation recorded for *S. litura* were not considered for result and discussion. Temperature and relative humidity played an important role in population build up. The population and infestation data recorded for these insect pests showed varied correlation to the abiotic factors *viz.* temperature, relative humidity and rainfall. The mean temperature during peak incidence of major insect pests was 28 ^{o}C $\pm$ 0.5 ^{o}C the relative humidity was 79 to 84 per cent respectively, during *Kharif*, 2002 and 2003, respectively.

5.1.1 Incidence of stem fly in relation to abiotic factors

In the present investigation the first appearance of stem fly was observed in 31st meteorological week (30 July - 5 Aug.) reached its peak in 32nd meteorological week (6-13 Aug.) during *Kharif*, 2002. Whereas the first appearance during 2003 was observed in 30th meteorological week (23- 29 July) which peaked in 33rd meteorological week (13-19 Aug.). Similar studies were made by Bhalkar (1996), who observed first appearance of stem fly *M. sojae* in 29th meteorological week and peak period of activities was observed in 31st meteorological week (30th July - 5th Aug., 1994).

5.1.2. Incidence of girdle beetle in relation to abiotic factors

The initial infestation of girdle beetle, *O. brevis* was observed in 31st meteorological week (30 July -5 Aug.) during both the years and reached its peak in 35th meteorological week (27 Aug- 2 Sept.). The mean temperature during peak incidence was 29.95 ^{o}C in (2002) and 26.95 ^{o}C in (2003) and mean relative humidity was 73 and 84 per cent respectively. However, there was no significant correlation between mean temperature and girdle beetle infestation but mean relative humidity indicated significantly positive correlation (r_2=0.865) with girdle beetle infestation during 2003.

The similar results were obtained by Rai and Patel (1990) who reported first appearance of girdle beetle on 10th Aug., 1988, where maximum and minimum temperature was 29.60°C and 24.70°C and the mean relative humidity was 84.5 per cent. The activity of girdle beetle was recorded until 12 Oct., 1988, and the infestation levels ranged from 9.86 to 12.09 per cent.

5.1.3. Incidence of semilooper in relation to abiotic factors.

The first appearance of semilooper was recorded in 31st standard week during both years and peaked during 34th and 35th week. The mean temperature during peak incidence was 28.95°C in 2002 and 26.95°C in 2003 and the relative humidity was 73 and 84 per cent respectively. Similar observation were recorded by Deepesh *et al.* (1997) who found that mean temperature around 26°C was most conducive for the population build up of key pest.

5.2 Estimation of avoidable losses.

Soybean crop was attacked by three major insect-pests *viz.* stem fly, girdle beetle and semilooper causing significant damage and consequent reduction in yield. For estimating losses due to insect pests complex in any crop number of criteria can be taken into consideration. In the present investigation the effect of insect-pests on yield and various yield attributing characters *viz.* plant height, number of pods per plant, number of grains per pod, number of grain per plant, weight of 100 seeds, grain yield per plant and yield per plot were taken into consideration.

The results of present investigation revealed that infestation of insect-pests in soybean did not affect the plants height, number of grains per pod and weight of seeds significantly in protected and unprotected plots. But the insect pests infestation significantly affect the number of pods per plant, grain per plant, grain yield per plant and yield per plot. The mean number of pods per plant in protected and unprotected plots during 2002 were 62.00 and 43.00 respectively, whereas in 2003 it was 64.08 and 42.69 respectively which resulted into 30.62 and 33.32 per cent loss respectively. The mean number of grains per plant was 146.62 and 100.46 during 2002, whereas in 2003 it was 151.69 and 99.23, respectively resulted into 31.43 and 34.53 per cent loss. The mean yield per plant in protected and unprotected plots during 2002 was 17.69 g and 12.03 g, whereas in 2003 it was 18.76g and 11.87 g respectively, which led to an estimate loss of 31.94 and 36.70 per cent respectively. The mean yield per plot in protected and unprotected during 2002 was 26.45 q/ha and 16.97q/ha respectively, whereas in 2003 it was 27.60 q/ha and 16.97 q/ha, respectively. The mean difference in yield per plot was 9.48 q/ha and 10.63 q/ha with consequent loss estimated as 35.76 and 38.43 per cent respectively.

Similar studies on losses caused by insect pests were made by Singh and Singh (1990) who reported yield losses caused by *M.sojae* based on various parameter such as pod/plant (17.57%), pod weight/ plant in g (28.71%), seed/plant (30.37%), seed weight/plant in g (32.43%) and seed yield in q/ha (30.26%). Further, Singh and Singh (1991) reported yield losses due to semilooper, *C.acuta* 3-18 larvae/mrl at flowering stage ranged from 7.29 to 45.35 per cent and at pod filling stage losses ranged from 9.43 to 46.49 per cent. Singh and Singh (1992) also reported that a mean stem tunneling of 46 per cent by stem fly reduced the grain yield by 5.5 q/ha (30.2%). A loss of pod weight of 5.16 to 7.09 g or grain yield losses of 2.75-3.81 g per plant resulted into 24.84 to 33.96 per cent loss reported by Venkatesan and Kundu (1994). Kundu *et al.* (1995) reported yield losses from 18.6 to 40.1 per cent in variety P.K. 960 and Pusa-20 respectively. Sharma (1999) reported 58 per cent yield loss by girdle beetle, 15 to 30 per cent by stem fly. Bajpai *et al.* (2004) reported 20.65 to 34.98 per cent avoidable yield losses due to insect-insect pests in variety JS-335. The observations in this regard are in conformity with various workers.

5.3 Effect of cultural practices on incidence of major insects pests.

To study the effect of cultural practices on incidence of major insect pest of soybean three experiments were conducted.

5.3.1 Effect of Sowing date and row spacing on incidence of major insect pests.

The data recorded on incidence of major insect pest of soybean in different sowing dates and rows spacing indicate that there was no significant difference in the interaction between sowing dates and row spacing, but the seasonal mean within different dates of sowing differed significantly. Much alike the seasonal mean within different row spacing also showed a significant difference. This apparently indicated that in various treatments considerable difference in the damage pattern exists when different sowing dates and row spacing were used for the experiments.

5.3.1.1 Incidence of stem fly under different sowing dates

The results indicate that early sown (25th June) crop had significantly lower infestation (2.16%) of stem fly while the crop sown on 10th July (mid) and 25th July (late) had more infestation during 2002. Similar observations were recorded during 2003. However, the infestation recorded in 10 th July and 25 th July was statistically at par.

5.3.1.2 Incidence of girdle beetle under different sowing dates

In case of girdle beetle the maximum infestation (15.45%) was recorded in early sowing (25th June 2002), while significantly less infestation was recorded in mid (10th July 2002) and late (25th July 2002) sowing 11.33 and 7.22 percent, respectively. The observation recorded during 2003 were similar where it was 24.04, 19.08 and 8.69 percent infestation, respectively for early, mid and late sowing dates respectively.

5.3.1.3 Incidence of semilooper under different sowing dates.

During 2002, the minimum larval population (1.219 larvae/mrl) of semilooper was recorded in early sowing (25 th June), while 1.86 and 2.59 larvae/mrl were recorded in mid and late sowing dates respectively. Similar, trend was observed during 2003, where the population of semilooper was recorded as 1.82, 2.78 and 3.46 larvae/mrl in early, mid and late sowing dates respectively.

The present findings are in agreement with those of Rai and Patel (1990) who reported lower infestation (9.86 to 12.09%) due to girdle beetle in late planted soybean. Further, Kundu and Srivastva (1991) reported that sowing of the crop immediately after the monsoon break, attracted lower agromyzid, *M. sojae* than in case of delayed sowing. The maximum damage to soybean by girdle beetle, *O. brevis* in crop sown on 8th June and minimum damage in those sown on Ist July recorded by Parsai and Shrivastava (1993). Sharma (1999) also reported that soybean planted in last week of June had least stem fly, *M. sojae* infestation in the plains of northern India. But the soybean planted during this period is proven to attack by girdle beetle, *O. brevis*. Low population of semilooper, *C. acuta* in early sown (22nd June and 2nd July) soybean was also reported by Mandal *et al.* (1998).

5.3.1.4 Effect of row spacing on incidence of stem fly

Plant population and row spacing are important cultural factors, which influence the micro-climate and insect abundance. In the present investigations different row spacing showed difference in infestation level. During *Kharif*, 2002 the maximum 8.89 per cent infestation of stem fly was recorded in the plots having 22.5cm row spacing followed by that in plot with 30 cm row spacing (5.98%). The minimum infestation (4.85%) was recorded in plots having 45cm row spacing. During *Kharif*, 2003 the maximum infestation (14.54%) was recorded in plots having 22.5cm row spacing followed by that in plots with 30cm row spacing (12.42%). The minimum infestation (9.50%) was recorded in plots having 45cm row spacing.

5.3.1.5 Effect of row spacing on incidence of girdle beetle

In case of girdle beetle the maximum infestation (13.61%) during *Kharif* 2002 was recorded in plots having 22.5cm row spacing, followed by 10.62 and 9.27 per cent infestation levels in 30cm and 45cm row spacing respectively. However, the infestation level in plots having 30cm and 45cm row spacing was statistically at par. While a significant difference in infestation levels was recorded during *Kharif,* 2003, where the infestation levels in plots having 22.5cm, 30 cm and 45cm row spacing were 19.28, 16.43 and 13.76 percent respectively.

5.3.1.6 Effect of row spacing on incidence of semilooper

The incidence of semilooper in plots having different row spacing showed varied larval population. The plots having 22.5cm row spacing had significantly higher population (2.38 larvae/mrl) followed by plots having 30cm row spacing (1.74 larvae/mrl) and the minimum population (1.49 larvae/mrl) was recorded in plots having 45cm row spacing. The larval population showed similar trend during *Kharif,* 2003, where the larval population of semilooper in plots with row spacing of 22.5cm, 30cm, 45cm were 3.295, 2.562 and 2.158 larvae/mrl, respectively.

The present findings are comparable with the work of Mc. Pherson and Bondari (1991) who observed more number of *N.viridula* in narrow row planting than in wide row planting. Sharma (1999) also stated that narrow row spacing enhance the incidence of velvet-bean caterpilar, southern green stinkbug, green clover worm and loopers.

5.3.2 Effect of intercropping on incidence of major insect-pest of soybean.

The tactics of appropriate intercropping are gaining importance in overall strategies of pest management through its physical as well as biological influence on the incidence of insect pest. Different intercropping system brought about differential response on the pattern of incidence of insect-pest infesting soybean. Intercropping with non-host crop like sorghum, maize provided suppressing effect on the pest population build-up. Intercropping with similar host e.g. pigeonpea, sesame provided better conducive conditions for the multiplication of insect pest. The results indicated that there was a definite impact of intercropping on incidence of insect pests. An account of the seasonal mean in respect of individual pest in different intercropping combinations are presented as under.

5.3.2.1 Incidence of stem fly under sole and intercrop situations

The seasonal mean indicated that maximum infestation (8.23%) of stem fly was recorded in soybean as sole crop, followed by soybean + pigeonpea (7.88%); soybean + sesame (7.69%), soybean + maize (6.39%), while the lowest infestation was recorded in soybean + sorghum (5.29%), during 2002. Similar trend was observed during *Kharif,* 2003; where maximum infestation (15.39%) was recorded in soybean + pigeonpea, soybean + sesame (12.82%) and the lowest infestation (12.40%) was recorded in soybean + maize intercropping.

5.3.2.2 Incidence of girdle beetle under sole and intercrop situations

During *Kharif,* 2002 the maximum infestation was observed in soybean + pigeonpea (12.91%) followed by soybean as sole crop (12.77%), soybean + sesame (12.49%) whereas, the lowest infestation (10.41%) was recorded in soybean + sorghum and soybean + maize respectively. During, 2003 the maximum infestation (23.32%) was recorded in soybean sole crop followed by soybean + sesame (23.31%), soybean + pigeonpea (22.44%); soybean + maize (20.39%) and the lowest infestation (19.53%) by girdle beetle was recorded in soybean + sorghum treatment.

5.3.2.3 Incidence of semilooper under sole and intercrop situation.

The seasonal mean indicated that maximum infestation of semilooper (2.2 larvae/mrl) was recorded in soybean + sesame followed by soybean sole crop (2.19 larvae/mrl), soybean + pigeonpea (2.0 larvae/mrl) and the lowest infestation each (1.71 larvae/mrl) was recorded in soybean + sorghum and soybean + maize, combination. Similar observations were recorded during 2003, where the maximum infestation (3.23 larvae/mrl) was recorded in soybean sole crop followed by soybean + sesame (3.21 larvae/mrl), soybean + pigeonpea (3.08 larvae/mrl), soybean + maize (2.62 larvae/mrl) and the lowest infestation (2.50 larvae/mrl) was recorded in soybean + sorghum.

Not much work on effect of intercropping on incidence of insect pests of soybean seems to have been done so far. However, the present findings may be compared with the work of Singh *et al.*(1990) who studied the influence of intercropping of soybean varieties (JS72-74, JS-2, JS76-188) with sorghum CHS-5 on incidence of major pest of soybean. They reported higher population of *C. acuta* on variety JS76-188 in comparison to pure soybean crop, while lower larval population of *C. acuta* was recorded in variety JS-2 under sole and intercrop situation. The difference in larval population of *C. acuta,* may be due to variety of soybean and ratio of intercropping. In the present investigation the minimum larval population (1.71 larvae/mrl) of semilooper, *C. acuta* was recorded in soybean + sorghum and soybean + maize intercropping during *Kharif,* 2002 and (2.50 larval/mrl) and (2.62

larvae/mrl) during *Kharif*, 2003 respectively. The infestation of stem fly and girdle beetle was also low in soybean intercropped with sorghum and maize. Yang *et al*. (1994) also reported that incidence of stem fly, *M. sojae* and soybean pod borer, *L. glycinivorella* decreased if another crop was grown between soybean. Gupta *et al*. (1997) also reported 24 per cent yield loss in soybean sole crop and 18 per cent when intercropped with maize. The work conducted by Wang *et al.* (1998) showed 11.4 to 81.4 per cent and 20.9 to 76.0 per cent lower infestation of insect pest, when soybean was interplanted and mixed sown with maize. In these fields lady bird beetle (Coccinellidae) population increased by 84.0 and 86.5%, lacewing, (Crysopid) population by 58.9 and 80.6 per cent and spider population by 41.3 and 52.3 per cent compared with that in soybean monoculture.

5.3.3. Relative preference of different varieties of soybean against major insect pests.

Many scientists evaluated varieties against insect-pest of soybean but none of the cultivated varieties/ germplasm/ breeding line was completely free from insect infestation Sharma (1999). The screening of varieties for their relative preference against major insect pest of soybean led us to categorize the varieties, insect wise preference as least preferred, moderately preferred and most preferred based on their numerical abundance over the season. In the present investigations seven varieties were evaluated for their relative preference by major insect pest. The population/ infestation levels varied among these varieties.

In case of stem fly the seasonal mean infestation level indicated that variety JS80-21 had maximum infestation by Stem fly (13.97%), followed by MACS-450 (13.46%), PK-472 (11.96%), NRC-37 (10.40%), NRC-12 (9.91%), Pratap Soya (8.97%) and the lowest infestation was recorded in JS-335 (8.87%). Varieties Pratap Soya, JS-335, NRC-12 and NRC-37 were statistically at par and least preferred by stem fly. The variety JS 80-21 and MACS-450 were most preferred by stem fly. A similar trend was observed during *Kharif*, 2003. Where maximum infestation (19.27%) was recorded in JS80-21, followed by MACS-450 (18.18%), PK-472 (16.41%), NRC-12 (15.34%), NRC-37 (15.32%), Pratap Soya (14.21%) and the minimum infestation (14.18%) was recorded in JS-335.

In case of girdle beetle variety, JS80-21 had maximum infestation (18.73%) closely followed by PK-472 (18.72%), MACS-450 (16.65%), NRC-12 (14.54%), JS-335 (14.15%), NRC-37 (13.65%) and the lowest infestation 12.46 per cent was recorded in Pratap Soya. Almost same trend was observed during *Kharif*, 2003, where maximum infestation (24.34%) was recorded in PK-472 followed by JS 80-21 (23.71%), MACS-450 (22.16%), NRC-12 (20.98%), NRC-37 (19.95%), JS-335 (19.03%) and the lowest infestation 17.17 per cent was recorded in Pratap Soya. The variety Pratap Soya was least preferred by girdle beetle.

During *Kharif*, 2002 in case of semilooper maximum population 2.42 larvae/mrl was recorded in NRC-12, followed by JS80-21 (2.31 larvae/mrl), MACS-450 (2.25 larvae/mrl), NRC-37 (2.18 larvae/mrl), Pratap Soya (2.17larvae/mrl), PK-472 (2.04 larvae/mrl) and the lowest population 2.03/mrl was recorded in JS-335. Variety JS-335 and PK-472 were statistically at per and least preferred by the semilooper.

During *Kharif*, 2003 the maximum population (3.36 larvae/mrl) of semilooper was recorded in variety NRC-12 followed by NRC-37 (3.18 larvae/mrl), MACS-450 (3.11 larvae/mrl), JS-335 (3.00 larvae/mrl), JS 80-21 (2.89 larvae/mrl), Pratap Soya (2.85 larvae/mrl) and the minimum population 2.64 larvae/mrl was recorded in PK-472. However, all these varieties did not show a significant difference on screening.

Similar studies were made by Sharma *et al.* (1994 b) who screened 14 varieties for their resistance to Stem fly, *M. sojae* and none of the varieties was found free from infestation of the agromyzid. Similarly, Sharma (1995) evaluated 16 soybean varieties against girdle beetle, *O. brevis* and Stem fly, *M. sojae.* Variety JS-335 was found to be tolerant against these pest. Similarly, Shridhar *et al.* (2002) observed variety JS-335 as resistant to stem fly upto trifoliate leaf stage Sharma *et al.* (2003) reported JS-335 highly resistant to stem fly. While Gupta *et al.* (2004) reported JS 80-21 resistant to girdle beetle.

5.4 Relative efficacy of different treatment schedules against major insect pests

The bio-efficacy of different treatment schedules against stem fly, girdle beetle and semilooper was compared during *Kharif*, 2002 and 2003. The following aspects were taken into consideration.

1. Effect of insecticidal treatment schedule on the pest population
2. Effect of insecticidal treatment schedule on soybean yield
3. Economics and cost benefit ratio of different treatment schedules

5.4.1 Efficacy of different treatment schedules against stem fly

In the present investigations the treatment schedules comprising carbosulfan (0.04%), triazophos (0.05%) at 35 DAS against stem fly proved significantly superior over the other treatment schedules keeping fresh infestation at zero per cent. The treatment schedules of carbosulfan (0.04%) and triazophos (0.05%) were followed by endosulfan (0.07%) with (4.53%) infestation level one day after first spray. The efficacy of these treatment schedules continued to be effective up to 10 days after first spray maintaining fresh infestation levels at zero. After second spray at 60 DAS the treatment schedules comprising profenophos

(0.125%) was equally effective as carbosulfan, triazophos and endosulfan. The overall efficacy of both applications showed that the treatment of carbosulfan, triazophos, endosulfan and profenophos were highly effective in controlling the stem fly.

Present investigations are supported by the work of Venkatesan and Kundu (1994) who studied the effectiveness of 10 insecticides against *M.sojae*. The least tunnelling was observed in plots treated with endosulfan (0.07%), followed with carbosulfan (0.017%). Kundu and Trimohan (1992) also found endosulfan (0.07%) highly effective in reducing stem tunnelling. Dubey *et al.* (1998) compared the bioefficacy of microbial agents with triazophos against *Gesonia gemma, C. acuta* and *M sojae* infesting soybean. Triazophos was significantly more toxic and offered the maximum net profit of Rs. 2968/ ha. The treatment schedules comprising neem oil found least effective against stem fly, is in conformity with Kundu and Trimohan (1992) who reported that neem seed extract at various concentration were least effective against stem fly.

5.4.2 Efficacy of different treatment schedules against girdle beetle

The treatment schedules of carbosulfan (0.04%), triazophos (0.05%) at 35 DAS followed by endosulfan (0.07%) at 35 DAS significantly superior against girdle beetle over other treatment schedules after one day of first spray application, where the fresh infestation was zero for carbosulfan and triazophos schedule, whereas 4.53 per cent for endosulfan. The efficacy of these treatment schedules continued upto 7 days after first spray application keeping the fresh infestation at zero per cent. The treatment schedules comprising Bt + 1/2 dose endosulfan, spinosad (0.018%), neem oil (0.5%) diflubenzuran (0.0125%), 1/2 dose of diflubenzuram + 1/2 dose of endosulfan at 35 DAS were less effective against girdle beetle. However, the treatment schedule comprising propfenopus and spinosad were also effective against girdle beetle after second spray at 60 DAS.

The present findings are in conformity with those of Yadav *et al.* (2001). Who found that carbosulfan was the most toxic to *O brevis*. Similarly, Upadhya and Sharma (2000) tested 7 insecticides against egg and larvae of girdle beetle and found maximum egg mortality (80%), with triazophos.

5.4.3 Efficacy of different treatment schedules against semilooper

The treatment schedules comprising spinosad (0.018%), carbosulfan (0.04%) and triazophos (0.05%) at 35 DAS recorded significantly superior over other treatments showing cent per cent population reduction. The treatment of triazophos was most effective upto 10 DAT. The treatment schedule of profenophos (0.125%) was also equally effective after second spray at 60 DAS. The treatment schedule of endosulfan also showed cent per cent mortality after 3 days in both sprays. The treatment schedules of Bt. + 1/2 dose endosulfan, diflubenzuran (0.0125%), neem oil (0.5%) and 1/2 dose of diflubenzuran +1/2 dose of endosulfan were less effective. The present investigations are in conformity with those of Dubey *et al.* (1998) who reported triazophos as most toxic against, *C. acuta*. According to Singh *et al.* (1998) triazophos was best upto 7 DAT against green and gray semilooper alongwith maximum yield (23.75 q/ha). The results are also supported by the work of Purwar and Yadav (2003), where they reported triazophos as most effective against *S. litura* followed by diflubenzuran. The treatment of spinosad was effective against semilooper. Similar observations were also recorded by Duffield and Jardon (2000) and they observed mortality of *H. armigera* in treatment of spinosad as good as in methomyl treatment. Knight *et al.* (2000) also reported that Tracer (Spinosad) showed good potential against looper and *H. armigera* larvae and safest to beneficial species. According to Hall *et al.* (2000) spinosad caused greater mortality in soybean loopers at (0.012%) and (0.025%) concentrations.

5.4.4. Effect of different treatment schedules on soybean yield

The principal aim of working out an appropriate insecticidal treatment schedule is to obtain maximum yield. Therefore keeping this in view, the yield of soybean was recorded.

The results of present investigation reveal that all treatment schedules increased yield significantly over control. Among the different treatment schedules the treatment comprising triazophos at 35 and 60 DAS results into maximum yield (24.17q/ha), followed by triazophos at 35 and spinosad at 60 DAS (23-80 q/ha), carbosulfan at 35 DAS and spinosad at 60 DAS (23.41q/ha), carbosulfan alone at 35 and 60 DAS (23.18 q/ha) and endosulfan at 35 and 60 as (22.57 q/ha). Present investigations are in agreement with those of Singh *et al.* (1998) who obtained maximum yield of soybean (23.75 q/ha) with triazophos treatment. Similarly, Bajpai *et al.* (2004) also obtained highest yield of soybean (25.7 q/ha) from triazophos treatment.

5.4.5 Economics and cost benefit ratio of different treatment schedules

The maximum net profit and cost benefit ratio was obtained from triazophos at 35 and 60 DAS Rs. 13246 and 1:12.63, respectively, followed by endosulfan at 35 and 60 DAS Rs. 11084 and 1: 11.56 respectively. The minimum net profit and lowest cost benefit ratio was obtained with treatment schedule of spinosad at 35 and 60 DAS i.e. Rs. 944 and 1:0.16 respectively.

The literature screened revealed no information on effect of spinosad on soybean yield and cost benefit ratio of spinosad treatment, hence could not be critically compared.

The effectiveness of triazophos and endosulfan in giving higher yield and cost benefit ratio in present investigations is favoured by the work of Bhalker (1996), who obtained high grain yield from plots treated with endosulfan (0.05%) which was most economically viable treatment giving maximum ICBR of 1:8.18. Similarly, Venkatesan and Kundu (1994) obtained highest yield and C:B ratio with endosulfan (1:6.16) followed by carbosulfan (1:4.61). Maximum yield (23.75q/ha) of soybean was recorded in triazophos by Singh *et al.* (1998). Dubey *et al*. (1998) also reported maximum net profit of Rs. 2968/ha in triazophos treatment. The present investigations are in conformity with those of Bajpai *et al.* 2004 who obtained highest grain yield and cost benefit ratio from triazophos, 25.7 q/ha and 1:9.67 respectively followed by endosulfan (23.25q/ha) and 1:7.97, respectively.

6. SUMMARY

Studies on "Evaluation of IPM Components Against Major Insect Pest of Soybean, *Glycine max* (L) Merrill in South -Eastern Zone of Rajasthan" were conducted at Agricultural Research Station Kota, MPUAT, Udaipur, Rajasthan, during *Kharif,* 2002 and 2003. The studies were conducted on seasonal incidence of major insect pests of soybean in relation to abiotic factors, assessment of avoidable losses due to insect pests, effect of sowing date and row to row spacing on incidence of major insect pests effect of intercropping on incidence of major insect pests, relative preference of soybean varieties against major insect-pests and efficacy of different insecticidal treatment schedules against major insect pests of soybean.

The major insect pests, which infested soybean, were stem fly, girdle beetle and semilooper. The population of other insect-pest were very low. The population / infestation of major insect-pest were higher during *Kharif,* 2003 than in *Kharif,* 2002.

6.1 Seasonal incidence of major insect pests in relation to abiotic factors

The first appearance of stem fly was observed in 31st Meteorological week, which peaked in 32nd meteorological week during *Kharif,* 2002, whereas the first appearance during 2003 was observed in 30th meteorological week, which peaked, in 33rd meteorological week. The mean temperature and relative humidity during peak incidence during 2002 were 28.45 ^{o}C and 81 percent respectively, whereas in 2003 it was 26.30 ^{o}C and 79 percent respectively. There was no significant correlation between abiotic factors and stem fly infestation.

The first appearance of girdle beetle was observed in 31st meteorological week during both the years, which peaked in 35th meteorological week. The mean temperature and relative humidity during peak period of incidence in 2002 were 28.95^{o}C and 73 percent respectively, whereas in 2003 it was 26.95 ^{o}C and 84 percent respectively. There was no significant correlation between mean temperature and girdle beetle infestation but the mean relative humidity indicated significantly positive correlation (r)=(0.865) with girdle beetle infestation during 2003.

The first appearance of semilooper was observed in 31st meteorological week in both years both which reached at peak during 34th and 35th meteorological week. The mean temperature and relative humidity during peak incidence in 2002 was 28.40^{o}C, 28.95^{o}C and 73 percent respectively, whereas in 2003 it was 26.95 ^{o}C and 84 percent respectively. These was no significant correlation between temperature relative humidity and semilooper infestation.

6.2 Estimation of avoidable losses

Infestation of insect-pest in soybean did not affect the plant height, number of grains per pod and weight of 100 seed in protected and unprotected plots. But the pest infestation significantly affected the number of pods per plant, grains per plant, yield per plant and yield per plot. The mean number of pods per plant in protected and unprotected plots during 2002 were 62.00 and 43.00 respectively, whereas in 2003 it was 64.08 and 42.69 respectively which resulted into 30.62 and 33.32 percent loss respectively.

The mean number of grains per plant in protected and unprotected were 146.62 and 100.46 respectively, during 2002, whereas in 2003 it was 151.69 and 99.23 respectively, which resulted into 31.43 and 34.53 percent loss respectively.

The mean yield per plant in protected and unprotected plots during 2002, was 17.69g and 12.03g respectively , whereas in 2003 it was 18.76g and 11.87 g respectively which led to an estimated loss of 31.94 and 36.70 percent respectively.

The mean yield per plot in protected and unprotected pods during 2002 was 26.45 q/ha and 16.97 q/ha respectively, whereas in 2003 it was 27.6 q/ha and 16.97 q/ha respectively, with consequent loss estimated as 35.76 and 38.43 percent respectively.

6.3 Effect of cultural practices on incidence of major insect pests

6.3.1 Effect of Sowing date

The early sown (25 th June) crop had significantly lower infestation of stem fly, while the crop sown on 10th July (mid) and 25th July (late) had more infestation of stem fly in both the year.

The maximum infestation of girdle beetle was recorded in early sown crop (25th June), while significantly less infestation was recorded in mid (10th July) and late (25th July) sown crop.

The minimum larval population of semilooper was recorded in early sown (25th June) crop, while maximum larval population was recorded in late sown (25th July) crop in both the years.

6.3.2.1 Effect of row spacing

The maximum infestation (8.89%) of stem fly was observed in plots having 22.5 cm row spacing followed by that in 30 cm row spacing (5.98%). The minimum infestation (4.85%) was recorded in plots having 45 cm row spacing. During 2003 the infestation levels in plots having 22.5, 30 and 45 cm row spacing were 14.54, 12.42 and 9.5 per cent, respectively.

The maximum infestation (13.61%) of girdle beetle was recorded in plots having 22.5 cm row spacing followed by 10.62 and 9.27 per cent in 30 cm and 45 cm row spacing respectively. During 2003 the infestation levels in plots having 22.5, 30 and 45 cm row spacing were 19.28 , 16.43 and 13.76 percent respectively.

The plots having 22.5cm row spacing had significantly higher population of semilooper (2.38/larvae/mrl) followed by plots having 30 cm row spacing (1.74/larvae/mrl) and minimum population (1.49 larvae/mrl) was recorded in plots having 45 cm row spacing During 2003 the population of semilooper in plots with row spacing 22.5, 30, and 45 cm row spacing were 3.29, 2.56 and 2.16 larvae/mrl respectively.

6.3.2 Effect of intercropping on incidence of major insect pest:-

During *Kharif*, 2002 the maximum infestation (8.23%) of stem fly was recorded in soybean sole, while the lowest infestation (5.29%) was recorded in soybean + sorghum intercropping, during 2003 the maximum infestation (15.39 %) was recorded in soybean + pigeonpea, and the minimum infestation was recorded in soybean +maize combination.

The maximum infestation (12.91 %) of girdle beetle was also recorded in soybean + pigeonpea, whereas the lowest infestation (10.41%) was recorded in soybean + sorghum and soybean +maize respectively during 2002 while the maximum infestation of girdle beetle during, 2003 was recorded in soybean sole crop (23.32 %) . The lowest infestation (19.53%) by girdle beetle was recorded in soybean + sorghum treatment.

During *Kharif*,, 2002 the maximum infestation of semilooper (2.2 larvae/mrl) was recorded in soybean + sesame and the lowest infestation (1.71 larvae/ mrl) was recorded in soybean +sorghum and soybean + maize respectively. During 2003 the maximum infestation (3.23 larvae/ mrl) was recorded in soybean as sole crop while the lowest infestation (2.50 larvae/mrl) was recorded in soybean + sorghum intercropping .

6.3 Relative preference of different varieties of soybean against major insect pests

During 2002 variety JS80-2l had maximum infestation of stem fly (13.97%) closely followed by MACS-450 (13.46%) these verities most preferred by stem fly. The lowest infestation (8.87%) was recorded in JS-335 and least preferred by stem fly. Remaining varieties stands in middle order of preferences. Similar trend was observed during 2003.

In case of girdle beetle incidence the variety JS80-21 had maximum infestation (18.73%) closely followed by PK-472 (18.72%). The lowest infestation (12.46%) was recorded in Pratap Soya. Almost same trend was observed during *Kharif*, 2003, where maximum infestation (24.34%) was recorded in PK-472 closely followed by JS80-21 (23.71%). The lowest infestation 17.17 percent was recorded in Pratap Soya. Rest varieties showed middle order of infestation. The variety Pratap Soya was least preferred by girdle beetle.

In case of semilooper the maximum larval population recorded during 2002 was (2.42 larvae/mrl) in NRC-12, while the lowest population 2.03 larvae/mrl was recorded in JS-335. During 2003 the maximum larval population of semilooper (3.36 larvae/mrl) was also recorded in NRC-12 while the minimum population (2.64 larvae/mrl) was recorded in PK-472. The variety JS-335 and PK-472 were least preferred by semilooper.

6.4. Relative efficacy of different treatment schedules against major insect pests

After first spray the treatment schedule comprising carbosulfan (0.04%) and triazophos (0.05%) at 35 DAS, against stem fly and girdle beetle proved significantly superior over the other treatment schedules, followed by endosulfan (0.07%) at 35 DAS.

After second spray at 60 DAS, the treatment schedule comprising profenophos (0.015%) at 60 DAS was equally effective as carbosulfan (0.04%) and triazophos (0.05%).

The treatment schedules of spinosad, (0.018%), profenosphos (0.125%), carbosulfan (0.04%), triazophos (0.05%), and endosulfan (0.07%) at 35 and 60 DAS were effective in controlling semilooper; while treatment schedules of Bt+1/2 dose endosulfan, diflubenzuron, neemoil and 1/2 dose diflubenzuron +1/2 dose endosulfan were less effective against stem fly, girdle beetle and semilooper at 35 and 60 DAS during both the years.

6.4.4 Effect of insecticidal treatment on soybean yield

Among different treatment schedules evaluated against major insect pests of soybean the treatment comprising triazophos at 35 and 60 DAS resulted into maximum yield (24.17 q/ha) which was followed by triazophos at 35 DAS and spinosad at 60 DAS (23.80 q/ha), carbosulfan at 35 DAS and spinosad at 60 DAS, carbosulfan alone at 35 and 60 DAS (23.18 q/ha) and endosulfan at 35 and 60 DAS (22.57q/ha). Other treatment schedules had a middle order of yield potential. The lowest yield 13.96 q/ha was recorded from untreated plot (control).

6.4.5 Economics and cost benefit ratio of difference insecticidal treatment schedules

The maximum net profit and cost benefit ratio was obtained from triazophos at 35 DAS and 60 DAS i.e. Rs. 13246 and 1:12.63 respectively, followed by endosulfan (check) Rs. 11094 and 1:11.56 respectively. The minimum net profit and lowest cost benefit ratio was obtained with treatment schedules of spinosad at 35 and 60 DAS, i.e Rs. 944 and 1: 0.16, respectively.

Table- 2: Meteorological Data (Weekly average for *Kharif*, 2002

Standard Week	Duration	Temperature °C			Relative humidity (%)			Rain-fall (mm)
		Max.	Min.	Mean	infestation7.30 am	2.30 pm	Mean	
28	9-15 July	38.1	28.1	33.10	58	33	45.50	-
29	16-22 July	37.3	27.5	32.40	72	45	58.50	23.2
30	23-29 July	35.4	27.8	31.60	66	38	52.00	-
31	30 July- 5 Aug.	37.3	26.7	32.00	77	51	64.00	54.9
32	6-12 Aug.	31.4	25.5	28.45	88	74	81.00	134.3
33	13-19 Aug.	30.6	25.5	28.05	83	71	77.00	30.8
34	20-26 Aug.	31.9	24.9	28.40	86	66	76.00	13.8
35	27 Aug.- 2 Sept.	32.9	25.0	28.95	84	62	73.00	12.0
36	3-9 Sept.	34.1	24.1	29.10	86	60	73.00	23.4
37	10-16 Sept.	35.0	24.1	29.55	78	36	57.00	-
38	17-23 Sept.	35.8	23.3	29.55	74	35	54.50	2.0
39	24-30 Sept.	37.5	22.3	29.90	76	27	51.50	-
40	1-7 Oct.	38.8	19.6	29.20	67	22	44.50	-
41	8-14 Oct.	37.5	20.3	28.90	67	30	48.50	-
42	15-21 Oct.	36.3	19.1	27.70	73	25	49.00	-

Table- 3: Meteorological Data (Weekly average for *Kharif*, 2003

Standard Week	Duration	Temperature °C			Relative humidity (%)			Rain-fall (mm)
		Max.	Min.	Mean	infestation7.30 am	2.30 pm	Mean	
8	9-15 July	35.3	27.0	31.15	77	66	71.50	82.8
29	16-22 July	33.3	26.1	29.70	87	65	76.00	23.6
30	23-29 July	33.1	25.5	29.30	88	70	79.00	53.6
31	30 July- 5 Aug.	31.8	25.5	28.65	88	62	72.50	3.5
32	6-12 Aug.	34.1	25.1	29.60	87	68	77.50	31.8
33	13-19 Aug.	31.5	25.1	28.30	85	73	79.00	15.5
34	20-26 Aug.	33.2	24.2	28.70	86	69	77.50	43.2
35	27 Aug.- 2 Sept.	30.0	23.9	26.95	89	79	84.00	22.1
36	3-9 Sept.	30.6	24.4	27.50	86	66	76.00	1.0
37	10-16 Sept.	31.7	23.7	27.70	86	69	77.50	67.0
38	17-23 Sept.	33.4	24.6	29.00	88	61	74.50	9.3
39	24-30 Sept.	32.2	22.9	27.55	91	62	76.50	14.9
40	1-7 Oct.	34.2	19.1	26.65	85	32	58.50	-
41	8-14 Oct.	35.8	18.1	26.95	78	24	51.00	-
42	15-21 Oct.	34.7	14.6	24.65	82	20	51.00	-

Table -4: Insecticides tested for efficacy against major insect pests of soybean

S. No.	Technical Name	Trade Name	Conc. (%)	Dose l/ha	Cost per lit	Source of supply/ manufactured by
1.	Endosulfan	Thiodan 35 EC	0.07	1.25	240	Bayer Crop Science
2.	Carbosulfan	Marshal 25 E	0.04	1.00	680	FMC- Rallis India Ltd
3.	Profenophos	Curacran 50 EC	0.125	1.50	520	Syngenta India
4.	Triazophos	Hostathian 40 EC	0.05	0.80	430	Bayer India Ltd
5.	Bt	Halt 5 WP	0.166	1.00	1200	Wockhardt India
6.	Spinosad	Tracer 45% SC	0.018	0.25	11000	DE-NOCIL Crop Protection Ltd.
7.	Diflubenzuron	Dimilin 25 WP	0.0125	0.30	2000	Northern Minerals Ltd.
8.	Neem Oil	Neem Tel	0.50	3.00	180	Dabur India

Table 5 : Seasonal incidence of major insect pest of soybean in relation to the abiotic factors during *Kharif*, 2002

Standard Week	Duration	Temperature °C			Relative humidity (%)			Rain-fall (mm)	Per cent infestation		Semi looper Larvae/ mrl*
		Max.	Min.	Mean	infestation 7.30 am	2.30 pm	Mean		Stem fly	Girdle beetle	
28	9-15 July	38.1	28.1	33.10	58	33	45.50	-			-
29	16-22 July	37.3	27.5	32.40	72	45	58.50	23.2	-	-	-
30	23-29 July	35.4	27.8	31.60	66	38	52.00	-	-	-	-
31	30 July- 5 Aug.	37.3	26.7	32.00	77	51	64.00	54.9	5.0	2.5	1.5
32	6-12 Aug.	31.4	25.5	28.45	88	74	81.00	134.3	15	12.5	1.75
33	13-19 Aug.	30.6	25.5	28.05	83	71	77.00	30.8	15	15.0	2.0
34	20-26 Aug.	31.9	24.9	28.40	86	66	76.00	13.8	7.5	17.5	3.0
35	27 Aug.- 2 Sept.	32.9	25.0	28.95	84	62	73.00	12.0	2.5	22.5	3.0
36	3-9 Sept.	34.1	24.1	29.10	86	60	73.00	23.4	-	7.5	2.0
37	10-16 Sept.	35.0	24.1	29.55	78	36	57.00	-	-	-	1.0
38	17-23 Sept.	35.8	23.3	29.55	74	35	54.50	2.0	-	-	-
39	24-30 Sept.	37.5	22.3	29.90	76	27	51.50	-	-	-	-
40	1-7 Oct.	38.8	19.6	29.20	67	22	44.50	-	-	-	-
41	8-14 Oct.	37.5	20.3	28.90	67	30	48.50	-	-	-	-
42	15-21 Oct.	36.3	19.1	27.70	73	25	49.00	-	-	-	-
								(r_1)	-0.532	-0.713	-0.443
								(r_2)	0.705	0.550	0.593
								(r_3)	0.577	-0.308	-0.220

r_1= Coefficient of correlation between mean temperature and pest incidence

r_2= Coefficient of correlation between mean relative humidity and pest incidence

r_3= Coefficient of correlation between mean rainfall and pest incidence

* Meter row length

Table- 6 : Seasonal incidence of major insect pest of soybean in relation to the abiotic factors during *Kharif*, 2003

Standard Week	Duration	Temperature °C			Relative humidity (%)			Rain-fall (mm)	Per cent infestation		Semi looper Larvae/ mrl*
		Max.	Min.	Mean	infestation 7.30 am	2.30 pm	Mean		Stem fly	Girdle beetle	
28	9-15 July	35.3	27.0	31.15	77	66	71.50	82.8	-	-	-
29	16-22 July	33.3	26.1	29.70	87	65	76.00	23.6	-	-	-
30	23-29 July	33.1	25.5	29.30	88	70	79.00	53.6	7.5	-	-
31	30 July- 5 Aug.	31.8	25.5	28.65	88	62	72.50	3.5	15.0	2.5	2.5
32	6-12 Aug.	34.1	25.1	29.60	87	68	77.50	31.8	22.5	15.0	3.0
33	13-19 Aug.	31.5	25.1	28.30	85	73	79.00	15.5	25.0	25.0	3.5
34	20-26 Aug.	33.2	24.2	28.70	86	69	77.50	43.2	12.5	30.0	4.0
35	27 Aug.- 2 Sept.	30.0	23.9	26.95	89	79	84.00	22.1	10.0	45.0	4.5
36	3-9 Sept.	30.6	24.4	27.50	86	66	76.00	1.0	7.50	25.0	2.0
37	10-16 Sept.	31.7	23.7	27.70	86	69	77.50	67.0	-	10.0	1.5
38	17-23 Sept.	33.4	24.6	29.00	88	61	74.50	9.3	-	10.0	1.0
39	24-30 Sept.	32.2	22.9	27.55	91	62	76.50	14.9	-	-	
40	1-7 Oct.	34.2	19.1	26.65	85	32	58.50	-	-	-	
41	8-14 Oct.	35.8	18.1	26.95	78	24	51.00	-	-	-	
42	15-21 Oct.	34.7	14.6	24.65	82	20	51.00	-	-	-	
								(r_1)	0.369	-0.570	-0.201
								(r_2)	-0.105	0.865**	0.692
								(r_3)	-0.135	0.011	0.055

r_1= Coefficient of correlation between mean temperature and pest incidence

r_2= Coefficient of correlation between mean relative humidity and pest incidence

r_3= Coefficient of correlation between mean rainfall and pest incidence

* Meter row length

** Significant at 1 % level of significance.

Table-7 : Effect of insect-pests complex on various yield attributing characters in soybean during *Kharif*, 2002

S. No.	Plant characters	Protected	Unprotected	Difference	% reduction	t at 5% Calculated
1.	Plant height (cm)	62.43	60.48	1.95	3.11	9.140
2.	No. of pods/plant	62.00	43.00	19.00	30.62	39.552
3.	No. of grains/plant	146.62	100.46	46.15	31.43	33.638
4.	No of grains/ pod	2.36	2.33	0.03	1.29	3.162
5.	Weight of 100 seeds (g)	12.06	11.88	0.18	1.46	5.842
6.	Grain yield / plant (g)	17.69	12.03	5.67	31.94	27.713
7.	Grain yield / plot (kg)	2.54	1.63	0.91	35.76	23.211

Table- 8: Effect of insect-pests complex on various yield attributing characters in soybean during *Kharif*, 2003

S. No.	Plant characters	Protected	Unprotected	Difference	% reduction	t at 5% Calculated
1.	Plant height (cm)	63.61	61.39	2.22	3.47	10.505
2.	No. of pods/plant	64.08	42.69	21.38	33.32	20.788
3.	No. of grains/plant	151.69	99.23	52.46	34.53	22.379
4.	No of grains/ pod	2.36	2.32	0.04	1.71	3.164
5.	Weight of 100 seeds (g)	12.37	11.95	0.42	3.35	12.334
6.	Grain yield / plant (g)	18.76	11.87	6.89	36.70	26.598
7.	Grain yield / plot (kg)	2.65	1.63	1.02	38.43	26.805

Table-9 : Effect of sowing date and row spacing on incidence of major insect pest of soybean during 2002

Particulars	Stem fly (% infestation)	Girdle beetle (% infestation)	Semi Looper (larvae/mrl.)
I sowing date 25th June	8.5* (2.16)	23.10* (15.45)	1.311** (1.219)
II sowing date 10th July	15.9 (7.51)	19.70 (11.33)	1.537 (1.863)
III sowing date 25th July	19.9 (11.55)	16.60 (7.22)	1.759 (2.594)
SEm ±	1.086	0.665	0.013
CD at 5%	3.170	1.943	0.038
Row spacing 22.5 cm	17.3 (8.89)	21.60 (13.61)	1.698 (2.384)
Row spacing 30.0 cm	14.2 (5.98)	19.00 (10.62)	1.497 (1.741)
Row spacing 45.0 cm	12.7 (4.85)	17.7 (9.27)	1.412 (1.493)
SEm ±	1.086	0.665	0.013
CD at 5%	3.170	1.943	0.038

* Angular transformed values

** Square root transformed values

Figure in parenthesis are retransformed values

Table 10 : Effect of sowing times and row spacings on incidence of major insect pest of soybean during 2003

Particulars	Stem fly (% infestation)	Girdle beetle (% infestation)	Semi Looper (larvae/mrl.)
I sowing date 25th June	12.5* (4.66)	28.7* (23.04)	1.524** (1.824)
II sowing date 10th July	23.5 (15.93)	25.9 (19.08)	1.813 (2.788)
III sowing date 25th July	25.0 (17.87)	17.1 (8.69)	1.990 (3.462)
SEm ±	0.0823	0.480	0.021
CD at 5%	2.404	1.401	0.062
Row spacing 22.5 cm	22.4 (14.54)	26.0 (19.28)	1.948 (3.295)
Row spacing 30.0 cm	20.6 (12.42)	23.9 (16.43)	1.750 (2.562)
Row spacing 45.0 cm	18.0 (9.50)	21.8 (13.76)	1.630 (2.158)
SEm ±	0.823	0.480	0.021
CD at 5%	2.404	1.401	0.062

* Angular transformed values

** Square root transformed values

Figure in parenthesis are retransformed values

Table-11: Seasonal incidence of stem fly on soybean under sole and inter crop situations during *Kharif*, 2002

Treatment	Per cent infestation DAG							
	7	14	21	28	35	42	49	Seasonal mean
Soybean alone	0.00 (0.00)	0.00 (0.00)	9.217* (2.57)	20.467 (12.23)	22.500 (14.64)	13.826 (5.71)	4.609 (0.65)	16.667* (8.23)
Soybean + Sorghum	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	15.859 (7.47)	20.467 (12.23)	9.217 (2.57)	0.00 (0.00)	13.421 (5.39)
Soybean + Maize	0.00 (0.00)	0.00 (0.00)	9.217 (2.57)	10.00 (18.435)	20.467 (12.23)	9.217 (2.57)	0.00 (0.00)	14.644 (6.39)
Soybean + Pigeonpea	0.00 (0.00)	0.00 (0.00)	9.217 (2.57)	20.467 (12.23)	22.500 (14.64)	13.826 (5.71)	0.00 (0.00)	16.300 (7.88)
Soybean + Sesame	0.00 (0.00)	0.00 (0.00)	9.217 (2.57)	20.467 (12.23)	22.500 (14.64)	13.826 (5.71)	0.00 (0.00)	16.105 (7.69)
SEm ±			5.048	3.064	2.376	5.118	2.061	1.541
CD at 5%			NS	NS	NS	NS	NS	NS

* Angular transformed values
Figure in parenthesis are retransformed values
DAG = Days after germination

Table - 12: Seasonal incidence of stem fly on soybean under sole and inter crop situations during *Kharif*, 2003

Treatment	Per cent infestation DAG								
	7	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**Seasonal mean**
Soybean alone	0.00	0.00	22.500*	28.227	29.888	20.467	15.859	13.826	23.069
	(0.00)	(0.00)	(14.64)	(22.37)	(24.83)	(12.23)	(7.47)	(5.71)	(15.35)
Soybean + Sorghum	0.00	0.00	20.467	26.565	28.227	15.859	13.826	9.217	20.980
	(0.00)	(0.00)	(12.23)	(20.00)	(22.37)	(7.47)	(5.71)	(2.57)	(12.82)
Soybean + Maize	0.00	0.00	20.467	26.194	28.227	18.435	9.217	9.217	20.621
	(0.00)	(0.00)	(12.23)	(19.48)	(22.37)	(10.00)	(2.57)	(2.57)	(12.40)
Soybean + Pigeonpea	0.00	0.00	22.500	28.227	29.888	20.467	18.435	13.826	23.099
	(0.00)	(0.00)	(14.64)	(22.37)	(24.83)	(12.23)	(10.00)	(5.71)	(15.39)
Soybean + Sesame	0.00	0.00	22.500	28.227	29.888	20.467	18.435	9.217	23.099
	(0.00)	(0.00)	(14.64)	(22.37)	(24.83)	(12.23)	(10.00)	(2.57)	(15.39)
SEm ±			2.376	1.825	1.742	3.064	3.404	4.531	0.931
CD at 5%			NS	NS	NS	NS	NS	NS	NS

* Angular transformed values
Figure in parenthesis are retransformed values
DAG = Days after germination

Table-13: Seasonal incidence of girdle beetle on soybean under sole and inter crop situations during *Kharif*, 2002

Treatment	Per cent infestation DAG								
	7	14	21	28	35	42	49	56	Seasonal mean
Soybean alone	0.00	0.00	4.609*	20.467	22.500	24.533	28.227	13.826	20.938
	(0.00)	(0.00)	(0.65)	(12.23)	(14.67)	(17.24)	(22.37)	(5.71)	(12.77)
Soybean + Sorghum	0.00	0.00	0.00	10.00	20.467	22.500	26.565	9.217	18.821
	(0.00)	(0.00)	(0.00)	(18.435)	(12.23)	(14.67)	(20.00)	(2.57)	(10.41)
Soybean + Maize	0.00	0.00	0.00	20.467	20.467	22.500	24.533	9.217	18.821
	(0.00)	(0.00)	(0.00)	(12.23)	(12.23)	(14.67)	(17.24)	(2.57)	(10.41)
Soybean + Pigeonpea	0.00	0.00	4.609	20.467	22.500	24.533	28.227	13.826	21.054
	(0.00)	(0.00)	(0.65)	(12.23)	(14.67)	(17.24)	(22.37)	(5.71)	(12.91)
Soybean + Sesame	0.00	0.00	0.00	20.467	22.500	24.533	28.227	13.826	20.695
	(0.00)	(0.00)	(0.00)	(12.23)	(14.67)	(17.24)	(22.37)	(5.71)	(12.49)
SEm ±			3.033	1.892	2.376	2.257	1.694	4.207	0.738
CD at 5%			NS	NS	NS	NS	NS	NS	NS

* Angular transformed values
Figure in parenthesis are retransformed values
DAG = Days after germination

Table- 14: Seasonal incidence of girdle beetle on soybean under sole and inter crop situations during *Kharif*, 2003

Treatment	Per cent infestation DAG								
	7	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**Seasonal mean**
Soybean alone	0.00	0.00	4.609*	22.500	29.888	33.055	42.116	28.27	28.877
	(0.00)	(0.00)	(0.65)	(14.64)	(24.83)	(29.75)	(44.97)	(22.37)	(23.32)
Soybean + Sorghum	0.00	0.00	0.00	20.467	27.85	29.888	37.226	26.565	26.224
	(0.00)	(0.00)	(0.00)	(12.23)	(21.83)	(24.83)	(37.44)	(20.00)	(19.53)
Soybean + Maize	0.00	0.00	0.00	20.467	28.227	31.549	39.168	26.194	26.840
	(0.00)	(0.00)	(0.00)	(12.23)	(22.37)	(27.38)	(39.89)	(19.48)	(20.39)
Soybean + Pigeonpea	0.00	0.00	0.00	22.500	29.888	33.055	40.674	28.227	28.278
	(0.00)	(0.00)	(0.00)	(14.64)	(24.83)	(29.75)	(42.48)	(22.37)	(22.44)
Soybean + Sesame	0.00	0.00	0.00	22.500	29.888	33.055	42.116	29.888	28.872
	(0.00)	(0.00)	(0.00)	(14.64)	(24.83)	(29.75)	(44.97)	(24.83)	(23.31)
SEm ±			2.061	2.376	2.210	2.400	1.908	2.052	0.693
CD at 5%			NS	NS	NS	NS	NS	NS	NS

* Angular transformed values
Figure in parenthesis are retransformed values
DAG = Days after germination

Table-15 : Seasonal incidence of semilooper on soybean under sole and inter crop situations during *Kharif*, 2002

Treatment	Larval/ mrl * DAG**								
	7	14	21	28	35	42	49	56	Seasonal mean
Soybean alone	0.707	0.707	1.403*	1.475	1.564	1.861	1.871	1.564	1.641
	(0.00)	(0.00)	(1.47)	(1.68)	(1.95)	(2.96)	(3.00)	(1.95)	(2.19)
Soybean + Sorghum	0.707	0.707	0.966	1.403	1.492	1.726	1.726	1.403	1.485
	(0.00)	(0.00)	(0.43)	(1.47)	(1.73)	(2.48)	(2.48)	(1.47)	(1.71)
Soybean + Maize	0.707	0.707	0.966	1.403	1.403	1.726	1.798	1.403	1.485
	(0.00)	(0.00)	(0.43)	(1.47)	(1.47)	(2.48)	(2.73)	(1.47)	(1.71)
Soybean + Pigeonpea	0.707	0.707	0.837	1.492	1.564	1.871	1.861	1.581	1.581
	(0.00)	(0.00)	(0.20)	(1.73)	(1.95)	(3.00)	(2.96)	(2.00)	(2.00)
Soybean + Sesame	0.707	0.707	1.403	1.492	1.564	1.861	1.861	1.581	1.645
	(0.00)	(0.00)	(1.47)	(1.73)	(1.95)	(2.96)	(2.96)	(2.00)	(2.21)
SEm ±			0.131	0.118	0.117	0.077	0.838	0.937	0.035
CD at 5%			NS	NS	NS	NS	NS	NS	NS

* Square root transformed values
Figure in parenthesis are retransformed values
DAG = Days after germination

Table - 16: Seasonal incidence of semilooper on soybean under sole and inter crop situations during *Kharif*, 2003

Treatment	Per cent infestation DAG								
	7	14	21	28	35	42	49	56	Seasonal mean
Soybean alone	0.707	0.707	1.726*	1.861	1.996	2.115	2.233	1.564	1.932
	(0.00)	(0.00)	(2.48)	(2.96)	(3.48)	(3.97)	(4.49)	(1.95)	(3.23)
Soybean + Sorghum	0.707	0.707	1.492	1.726	1.798	1.861	1.996	1.403	1.731
	(0.00)	(0.00)	(1.73)	(2.48)	(2.73)	(2.96)	(3.48)	(1.47)	(2.50)
Soybean + Maize	0.707	0.707	1.581	1.726	1.798	1.933	2.177	1.492	1.767
	(0.00)	(0.00)	(2.00)	(2.48)	(2.73)	(3.24)	(4.24)	(1.73)	(2.62)
Soybean + Pigeonpea	0.707	0.707	1.564	1.861	1.933	2.115	2.177	1.581	1.892
	(0.00)	(0.00)	(1.95)	(2.96)	(3.24)	(3.97)	(4.24)	(2.00)	(3.08)
Soybean + Sesame	0.707	0.707	1.726	1.871	1.996	2.121	2.177	1.564	1.925
	(0.00)	(0.00)	(2.48)	(3.00)	(3.48)	(4.00)	(4.24)	(1.95)	(3.21)
SEm ±			0.087	0.094	0.013	0.0929	0.054	0.102	0.045
CD at 5%			NS	NS	NS	NS	NS	NS	1.38

* Square root transformed values
DAG = Days after germination
Figures in parenthesis are retransformed values

Table-17 : Relative preference of different soybean varieties against major insect pests during *Kharif*, 2002

S. No.	Variety	Stem fly % infestation	Girdle beetle % infestation	Semi looper Larvae/ mrl
1.	Pratap Soya	17.432* (8.97)	20.669 (12.46)	1.635** (2.17)
2.	JS 335	17.328 (8.87)	22.100 (14.15)	1.591 (2.03)
3.	NRC-12	18.349 (9.91)	21.683 (13.65)	1.636 (2.18)
4.	NRC-37	18.818 (10.40)	21.683 (13.65)	1.636 (2.18)
5.	PK 472	20.236 (11.96)	25.635 (18.72)	1.592 (2.04)
6.	MACS-450	21.522 (13.46)	24.083 (16.65)	1.658 (2.25)
7.	J.S.80-21	21.948 (13.97)	25.644 (18.73)	1.676 (2.31)
	SEm ±	1.013	0.755	0.034
	CD at 5%	3.010	2.245	0.101

* Angular transformed values
** Square root transformed values
Figures in parenthesis are re-transformed values

Table-18 : Relative preference of different soybean varieties against major insect pests during *Kharif*, 2003

S. No.	Variety	Stem fly % infestation	Girdle beetle % infestation	Semi looper Larvae/ mrl
1.	Pratap Soya	22.443*	24.935	1.829**
		(14.21)	(17.77)	(2.85)
2.	JS 335	22.122	25.862	1.871
		(14.18)	(19.03)	(3.00)
3.	NRC-12	23.057	27.224	1.964
		(15.34)	(20.96)	(3.36)
4.	NRC-37	23.040	26.526	1.918
		(15.32)	(19.95)	(3.18)
5.	PK 472	23.895	29.561	1.772
		(16.41)	(24.34)	(2.64)
6.	MACS-450	25.234	28.083	1.899
		(18.18)	(22.16)	(3.11)
7.	J.S.80-21	26.038	29.138	1.840
		(19.27)	(23.71)	(2.89)
	SEm ±	0.789	0.720	0.032
	CD at 5%	2.346	2.140	NS

* Angular transformed values
** Square root transformed values
Figures in parenthesis are re-transformed values

Table-- 19: Effect of different insecticides on stem fly in soybean during *Kharif*, 2002

	Treatments Schedules	Ist Spray per cent infestation after			
		1 DAT	**3 DAT**	**7 DAT**	**10 DAT**
1	Bt + ½ dose of endosulfan at 35 and 60 DAS	18.43* (10.00)	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)
2	Spinosad alone at 35 and 60 DAS	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)
3	Neem oil alone at 35 and 60 DAS	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)
4	Neem oil at 35 DAS and profenophos at 60 DAS	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)
5	Carbosulfan at 35 DAS and spinsosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
6	Diflubenzuron alone at 35 and 60 DAS	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	18.43 (10.00)
7	Diflubenzuron at 35 DAS and spinosad at 60 DAS	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	18.43 (10.00)
8	Carbosulfan alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
9	Triazophos alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
10	Triazophos at 35 DAS and spinosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
11	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 and 60 DAS	21.14 (13.01)	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)
12	Endosulfan (check) at 35 and 60 DAS	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
13	Control	21.14 (13.01)	23.86 (16.36)	23.86 (16.36)	21.14 (13.01)
	SEm ±	1.362	1.265	0.434	0.434
	CD 5 %	3.975	3.692	1.267	1.267

Table-20: Effect of different insecticides on stem fly in soybean during *Kharif*, 2003

	Treatments Schedules	Ist Spray per cent infestation after				IInd Spray per cent infestation after			
		1 DAT	3 DAT	7 DAT	10 DAT	1 DAT	3 DAT	7 DAT	10 DAT
1	Bt + ½ dose of endosulfan at 35 and 60 DAS	28.78* (23.18)	26.57 (20.00)	26.57 (20.00)	23.86 (16.36)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
2	Spinosad alone at 35 and 60 DAS	28.78 (23.18)	26.57 (20.00)	26.57 (20.00)	23.86 (16.36)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
3	Neem oil alone at 35 and 60 DAS	26.57 (20.00)	26.57 (20.00)	26.57 (20.00)	23.86 (16.36)	12.29 (4.53)	12.29 (4.53)	0.00 (0.00)	0.00 (0.00)
4	Neem oil at 35 DAS and profenophos at 60 DAS	31.00 (26.52)	31.00 (26.52)	28.78 (23.18)	26.57 (20.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
5	Carbosulfan at 35 DAS and spinsosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
6	Diflubenzuron alone at 35 and 60 DAS	28.78 (23.18)	28.78 (23.18)	26.57 (20.00)	26.57 (20.00)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
7	Diflubenzuron at 35 DAS and spinosad at 60 DAS	28.78 (23.18)	28.78 (23.18)	26.57 (20.00)	26.57 (20.00)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
8	Carbosulfan alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
9	Triazophos alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
10	Triazophos at 35 DAS and spinosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
11	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 and 60 DAS	28.78 (23.18)	26.57 (20.00)	26.57 (20.00)	26.57 (20.00)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
12	Endosulfan (check) at 35 and 60 DAS	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
13	Control	31.00 (26.52)	33.21 (30.00)	28.78 (23.18)	26.57 (20.00)	18.43 (10.00)	4.53 (12.29)	0.00 (0.00)	0.00 (0.00)
	SEm ±	1.039	1.144	0.512	0.782	2.649	2.710		
	CD 5 % level	3.033	3.339	1.494	2.283	7.733	7.909		

Table -21: Effect of different insecticides on girdle beetle in soybean during *Kharif*, 2002

	Treatments Schedules	Ist Spray per cent infestation after				IInd Spray per cent infestation after			
		1 DAT	3 DAT	7 DAT	10 DAT	1 DAT	3 DAT	7 DAT	10 DAT
1	Bt + ½ dose of endosulfan at 35 and 60 DAS	18.43* (10.00)	18.43 (10.00)	18.43 (10.00)	21.14 (13.01)	18.43 (10.00)	18.43 (10.00)	12.29 (4.53)	6.14 (1.15)
2	Spinosad alone at 35 and 60 DAS	18.43 (10.00)	18.43 (10.00)	21.14 (13.01)	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	12.29 (4.53)	6.14 (1.15)
3	Neem oil alone at 35 and 60 DAS	18.43 (10.00)	18.43 (10.00)	21.14 (13.01)	23.86 (16.36)	21.14 (13.01)	18.43 (10.00)	18.43 (10.00)	12.29 (4.53)
4	Neem oil at 35 DAS and profenophos at 60 DAS	18.43 (10.00)	21.14 (13.01)	21.14 (13.01)	23.86 (16.36)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
5	Carbosulfan at 35 DAS and spinsosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	6.14 (1.15)	6.14 (1.15)	12.29 (4.53)	6.14 (1.15)
6	Diflubenzuron alone at 35 and 60 DAS	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	21.14 (13.01)	23.86 (16.36)	21.14 (13.01)	18.43 (10.00)	12.29 (4.53)
7	Diflubenzuron at 35 DAS and spinosad at 60 DAS	23.86 (16.36)	21.14 (13.01)	18.43 (10.00)	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	12.29 (4.53)	6.14 (1.15)
8	Carbosulfan alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
9	Triazophos alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
10	Triazophos at 35 DAS and spinosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	6.14 (1.15)	12.29 (4.53)	12.29 (4.53)	6.14 (1.15)	6.14 (1.15)
11	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 and 60 DAS	23.86 (16.36)	21.14 (13.01)	18.43 (10.00)	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	12.29 (4.53)	6.14 (1.15)
12	Endosulfan (check) at 35 and 60 DAS	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	12.29 (4.53)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
13	Control	21.14 (13.01)	23.86 (16.36)	26.57 (20.00)	26.57 (20.00)	26.57 (20.00)	23.86 (16.36)	18.43 (10.00)	12.29 (4.53)
	SEm ±	1.36	1.431	0.782	2.120	2.230	1.851	2.493	3.033
	CD 5 % level	3.899	4.177	2.283	6.188	6.509	5.403	7.275	8.852

Table-22: Effect of different insecticides on girdle beetle in soybean during *Kharif*, 2003

	Treatments Schedules	I[st] Spray per cent infestation after				II[nd] Spray per cent infestation after			
		1 DAT	**3 DAT**	**7 DAT**	**10 DAT**	**1 DAT**	**3 DAT**	**7 DAT**	**10 DAT**
1	Bt + ½ dose of endosulfan at 35 and 60 DAS	18.43* (10.00)	18.43 (10.00)	12.29 (4.53)	18.43 (10.00)	18.43 (10.00)	18.43 (10.00)	12.29 (4.53)	6.14 (1.15)
2	Spinosad alone at 35 and 60 DAS	21.14 (13.01)	18.43 (10.00)	18.43 (10.00)	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	12.29 (4.53)	6.14 (1.15)
3	Neem oil alone at 35 and 60 DAS	21.14 (13.01)	18.43 (10.00)	21.14 (13.01)	23.86 (16.36)	26.57 (20.00)	18.43 (10.00)	12.29 (4.53)	12.29 (4.53)
4	Neem oil at 35 DAS and profenophos at 60 DAS	18.43 (10.00)	18.43 (10.00)	21.14 (13.01)	23.86 (16.36)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
5	Carbosulfan at 35 DAS and spinsosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	6.14 (1.15)	6.14 (1.15)	6.14 (1.15)	0.00 (0.00)
6	Diflubenzuron alone at 35 and 60 DAS	21.14 (13.01)	21.14 (13.01)	26.57 (20.00)	28.78 (23.18)	28.78 (23.18)	23.86 (16.36)	12.29 (4.53)	12.29 (4.53)
7	Diflubenzuron at 35 DAS and spinosad at 60 DAS	23.86 (16.36)	21.14 (13.01)	26.57 (20.00)	28.78 (23.18)	28.78 (23.18)	21.14 (13.01)	12.29 (4.53)	6.14 (1.15)
8	Carbosulfan alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
9	Triazophos alone at 35 and 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
10	Triazophos at 35 DAS and spinosad at 60 DAS	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	6.14 (1.15)	12.29 (4.53)	12.29 (4.53)	6.14 (1.15)	6.14 (1.15)
11	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 and 60 DAS	23.86 (16.36)	21.14 (13.01)	18.43 (10.00)	21.14 (13.01)	21.14 (13.01)	18.43 (10.00)	12.29 (4.53)	6.14 (1.15)
12	Endosulfan (check) at 35 and 60 DAS	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	12.29 (4.53)	12.29 (4.53)	6.14 (1.15)	0.00 (0.00)	0.00 (0.00)
13	Control	26.57 (20.00)	28.78 (23.18)	33.21 (30.00)	35.22 (33.26)	31.00 (26.52)	21.14 (13.01)	12.29 (4.53)	12.29 (4.53)
	SEm ±	1.392	1.284	1.182	2.051	2.219	2.162	3.059	2.883
	CD 5 % level	4.062	3.747	3.449	5.987	6.477	6.311	8.930	8.414

Table-23 Effect of Different insecticides on soybean Semilooper during *Kharif*, 2002

	Treatments Schedules	I[st] Spray per cent mortality after				II[nd] Spray per cent mortality after			
		1 DAT	3 DAT	7 DAT	10 DAT	1 DAT	3 DAT	7 DAT	10 DAT
1	Bt + ½ dose of endosulfan at 35 and 60 DAS	41.15* (43.31)**	54.94 (67.00)	75.00 (93.30)	62.46 (78.63)	23.05 (15.33)	40.46 (42.11)	57.45 (71.05)	61.02 (76.53)
2	Spinosad alone at 35 and 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	70.63 (89.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
3	Neem oil alone at 35 and 60 DAS	37.45 (36.97)	41.89 (44.58)	52.60 (63.10)	50.79) (60.03)	23.05 (15.33)	33.21 (30.00)	43.49 (47.37)	52.67 (63.23)
4	Neem oil at 35 DAS and profenophos at 60 DAS	10.00 (3.01)	24.25 (16.88)	41.77 (44.38)	41.89 (44.58)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
5	Carbosulfan at 35 DAS and spinsosad at 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	67.05 (84.80)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
6	Diflubenzuron alone at 35 and 60 DAS	8.03 (1.95)	45.00 (50.00)	60.00 (75.00)	62.46 (78.63)	23.05 (15.33)	43.49 (47.37)	54.25 (65.86)	64.16 (81.01)
7	Diflubenzuron at 35 DAS and spinosad at 60 DAS	8.03 (1.95)	33.73 (30.83)	52.60 (63.10)	65.07 (82.24)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
8	Carbosulfan alone at 35 and 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	70.63 (89.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
9	Triazophos alone at 35 and 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
10	Triazophos at 35 DAS and spinosad at 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
11	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 and 60 DAS	32.59 (29.01)	55.17 (67.39)	76.60 (94.63)	63.20 (79.67)	37.26 (36.66)	53.86 (65.22)	71.93 (90.38)	65.82 (83.23)
12	Endosulfan (check) at 35 and 60 DAS	55.89 (68.55)	90.00 (100.00)	90.00 (100.00)	65.07 (82.24)	62.66 (78.91)	90.00 (100.00)	62.23 (78.29)	90.00 (100.00)
	SEm ±	1.875	2.902	4.328	2.854	0.652	3.011	3.269	3.691
	CD 5 % level	5.500	8.512	12.693	8.369	1.912	8.832	9.587	10.826

Figures in parenthesis are re-transformed values. * Angular transformed values DAT = Days after treatment

Table-24: Effect of different insecticides on soybean semilooper during *Kharif*, 2003

	Treatments Schedules	Ist Spray per cent mortality after				IInd Spray per cent mortality after			
		1 DAT	**3 DAT**	**7 DAT**	**10 DAT**	**1 DAT**	**3 DAT**	**7 DAT**	**10 DAT**
1	Bt + ½ dose of endosulfan at 35 and 60 DAS	28.13* (22.22)**	40.81 (42.71)	35.91 (34.39)	30.00 (25.00)	25.31 (18.28)	39.05 (39.69)	52.19 (62.42)	59.00 (73.47)
2	Spinosad alone at 35 and 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	71.02 (89.42)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
3	Neem oil alone at 35 and 60 DAS	18.43 (10.00)	34.11 (31.45)	35.00 (32.90)	30.00 (25.00)	25.19 (18.12)	29.83 (24.74)	43.24 (46.93)	60.13 (75.20)
4	Neem oil at 35 DAS and profenophos at 60 DAS	11.11 (19.47)	21.70 (27.76)	16.67 (24.09)	7.50 (15.89)	65.24 (82.42)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
5	Carbosulfan at 35 DAS and spinsosad at 60 DAS	61.87 (77.78)	90.00 (100.00)	90.00 (100.00)	65.07 (82.27)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
6	Diflubenzuron alone at 35 and 60 DAS	0.00 (0.00)	21.86 (13.86)	24.09 (16.67)	15.89 (7.50)	1.86 (0.10)	24.72 (17.49)	43.52 (47.41)	60.64 (75.97)
7	Diflubenzuron at 35 DAS and spinosad at 60 DAS	0.00 (0.00)	27.76 (21.70)	30.00 (25.00)	16.67 (24.09)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
8	Carbosulfan alone at 35 and 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	63.42 (16.67)	73.07 (91.52)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
9	Triazophos alone at 35 and 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	73.31 (91.75)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
10	Triazophos at 35 DAS and spinosad at 60 DAS	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	72.38 (90.83)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
11	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 and 60 DAS	15.89 (7.50)	29.00 (23.50)	30.00 (25.00)	24.09 (16.67)	18.37 (9.93)	24.04 (16.60)	39.89 (41.12)	59.00 (73.47)
12	Endosulfan (check) at 35 and 60 DAS	54.74 (66.67)	68.25 (86.27)	90.00 (100.00)	64.44 (81.39)	66.02 (83.49)	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)
	SEm ±	1.389	2.782	1.962	2.200	3.216	1.902	1.582	2.126
	CD 5 % level	4.075	8.161	5.756	6.454	9.432	5.578	4.640	6.237

Figures in parenthesis are re-transformed values. * Angular transformed values DAT = Days after treatment

Table - 25: Economics and cost benefit ratio of different treatment schedules in soybean during *Kharif*, 2002-03

	Treatment Schedule	Grain yield q/ha		Ave. grain yield q/ha	Increase in yield over control		Cost of increased yield over control (Rs/ha)	Cost of insecticide application (Rs/ha)	Net profit (Rs.)	C:B ratio
		2002	2003		q/ha	%				
1	Bt + ½ dose of endosulfan at 35 and 60 DAS	18.23	19.48	**q/ha**18.86	4.90	35.10	6860	2860	4000	1.39
2	Spinosad alone at 35 and 60 DAS	18.09	19.55	18.82	4.86	34.81	6804	5860	944	0.16
3	Neem oil alone at 35 and 60 DAS	15.97	16.77	16.37	2.41	17.26	3374	1440	1934	1.34
4	Neem oil at 35 DAS and profenophos at 60 DAS	18.72	20.28	19.50	5.54	39.68	7756	1680	6076	3.62
5	Carbosulfan at 35 DAS and spinsosad at 60 DAS	22.99	23.82	23.41	9.45	67.69	13230	3790	9440	2.49
6	Diflubenzuron alone at 35 and 60 DAS	18.16	19.63	18.90	4.94	35.38	6916	1560	5356	3.43
7	Diflubenzuron at 35 DAS and spinosad at 60 DAS	18.87	20.49	19.68	5.72	40.97	8008	3710	4298	1.16
8	Carbosulfan alone at 35 and 60 DAS	22.74	23.61	23.18	9.22	66.04	12908	1720	11188	6.50
9	Triazophos alone at 35 and 60 DAS	23.78	24.55	24.17	10.21	73.13	14294	1048	13246	12.63
10	Triazophos at 35 DAS and spinosad at 60 DAS	23.33	24.27	23.80	9.84	70.48	1377	3454	10322	2.99
11	½ dose of Diflubenzuron + ½ dose of Endosulfan at 35 and 60 DAS	18.89	20.49	19.69	5.73	40.04	8022	1260	6762	5.37
12	Endosulfan (check) at 35 and 60 DAS	22.19	22.95	22.57	8.61	61.67	12054	960	11094	11.56
13	Control	13.58	14.34	13.96	-		-	-	-	-
	SEm ±	0.488	0.565							
	CD 5 % level	1.425	1.650							

Fig. 13: Seasonal incidence of major insect pests of soybean under sole and intercrop situations during *Kharif* , 2002

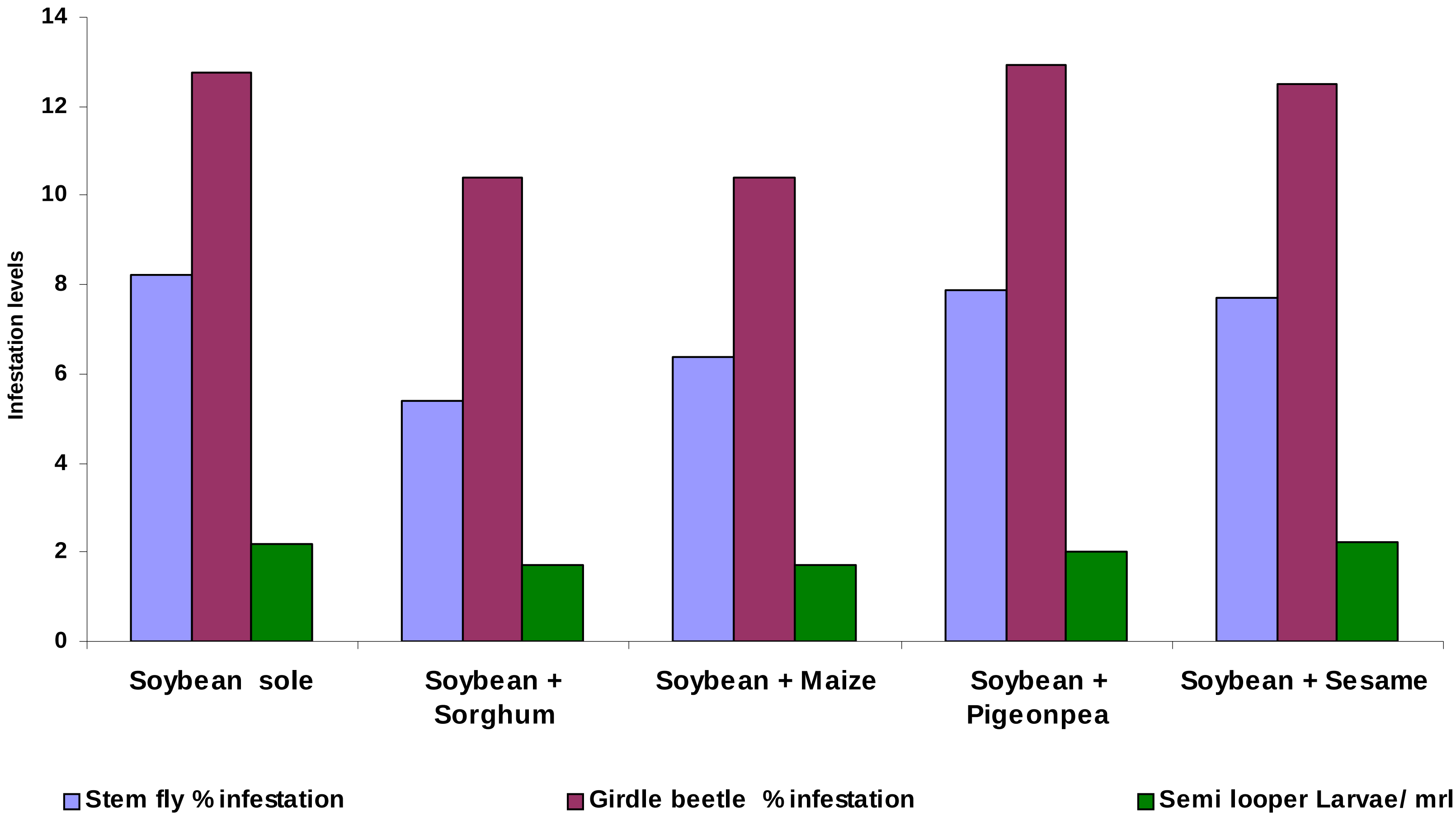


Fig. 14: Seasonal incidence of major insect pests of soybean under sole and intercrop situations during *Kharif*, 2003

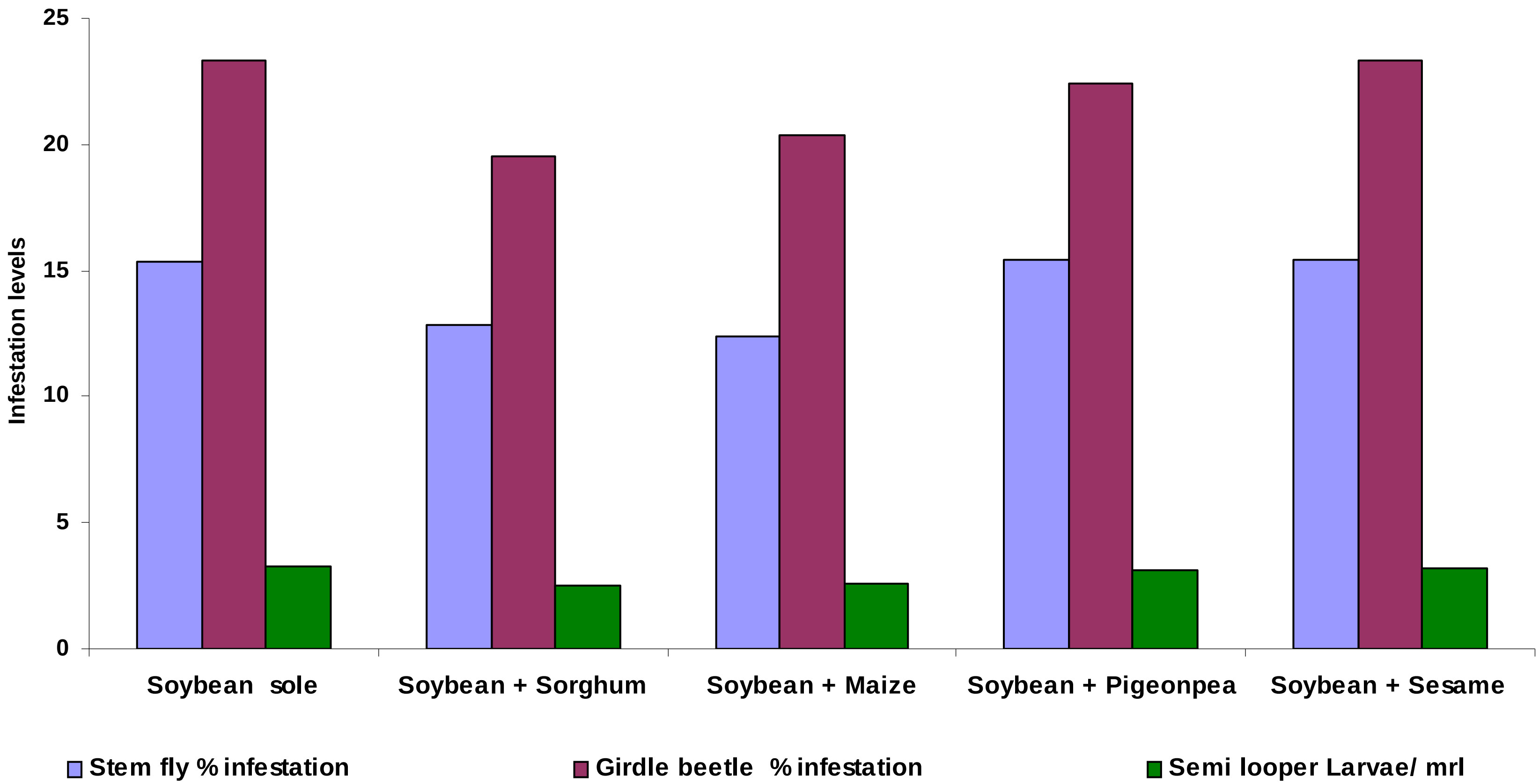


Table 15 : Effect of different treatment schedules in soybean yield during *Kharif*, 2002-2003

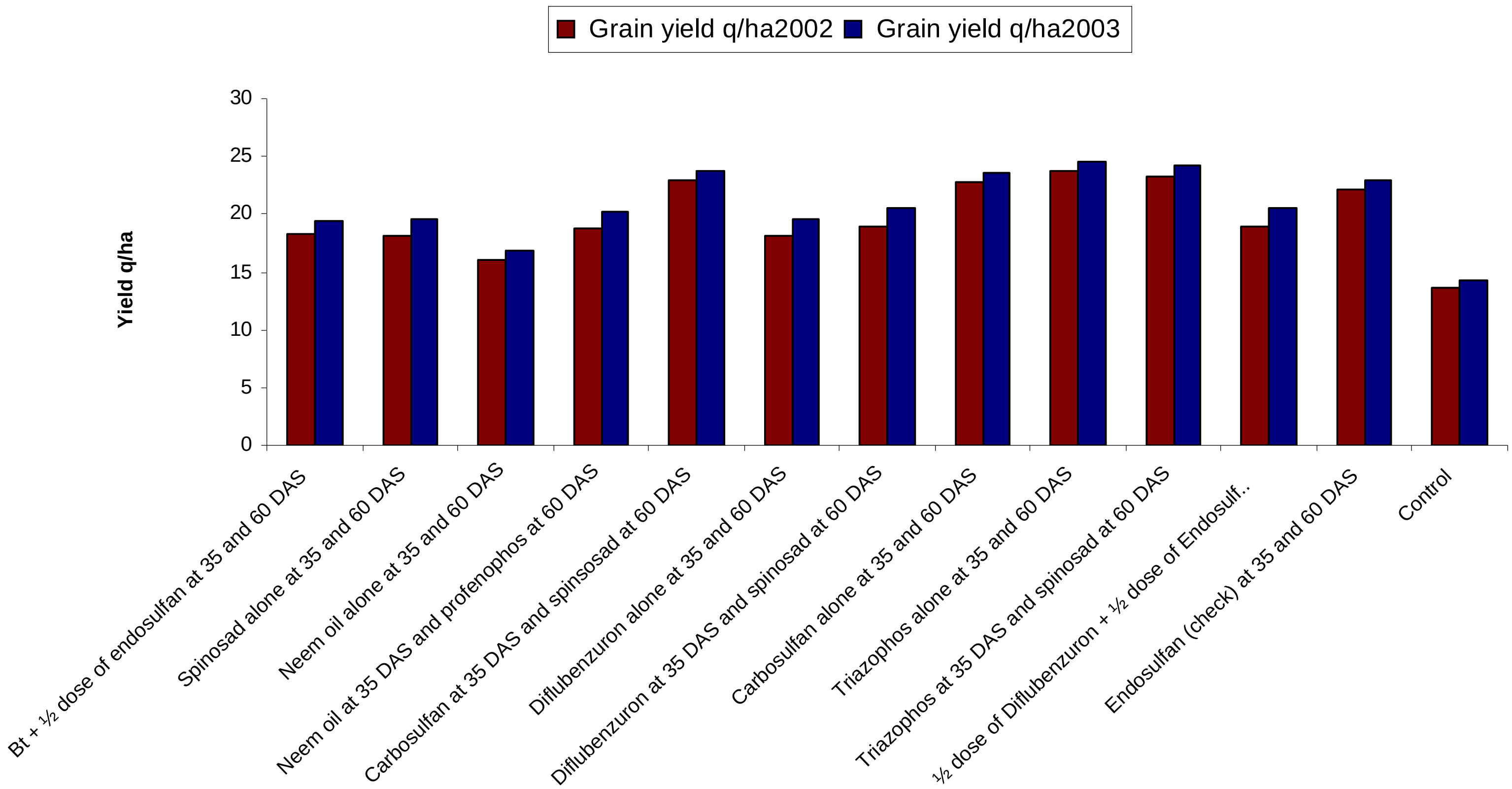
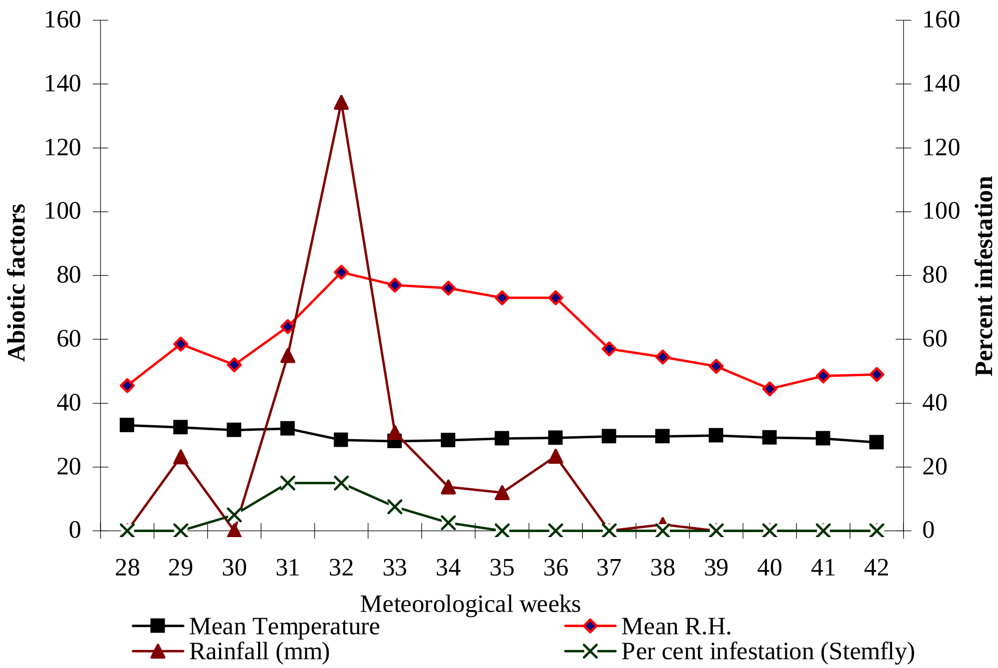


Fig. 7 : Seasonal incidence of stem fly on soybean in relation to the abiotic factors during *Kharif*, 2002



iotic factors during *Kharif*, 2003

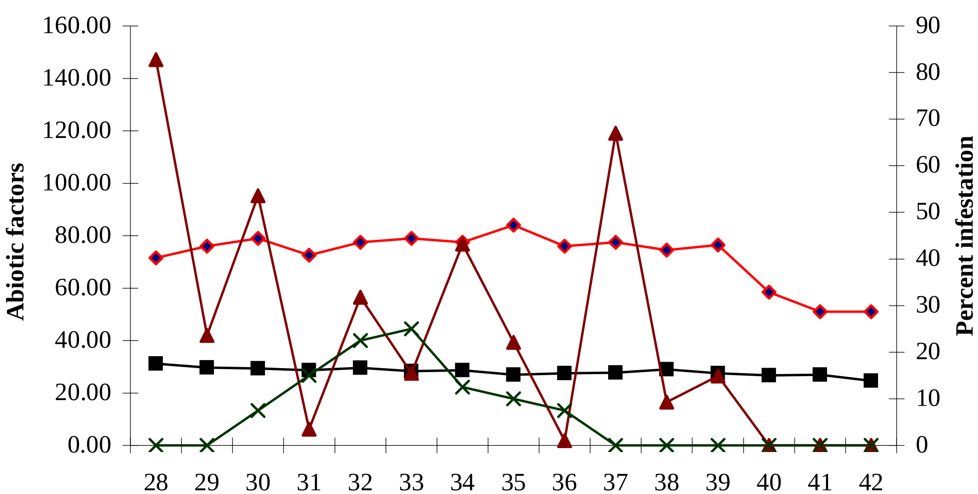


Fig. 9 : Seasonal incidence of girdle beetle on soybean in relation to the abiotic factors during *Kharif*, 2002

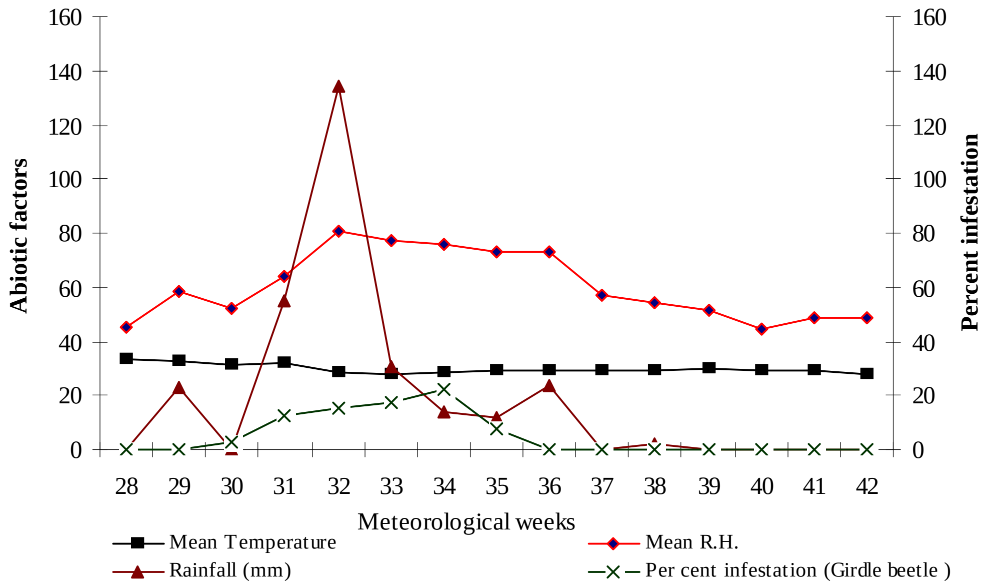
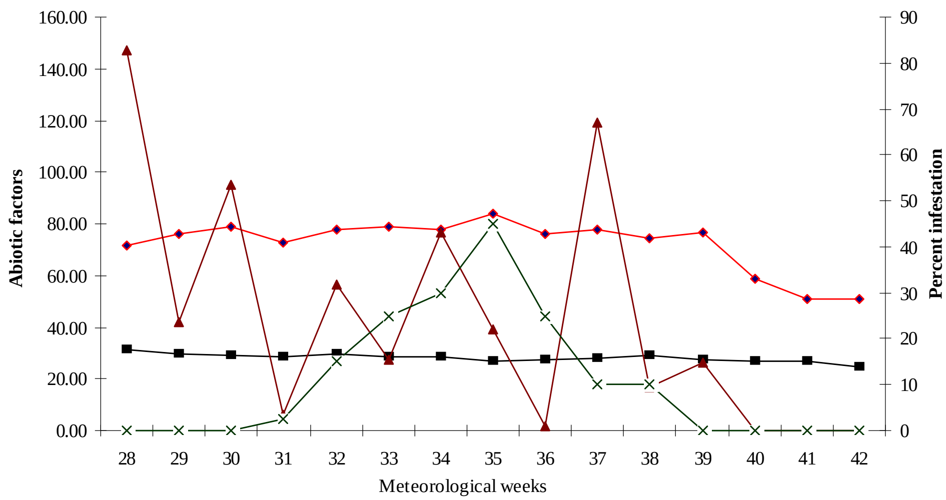


Fig. 10 : Seasonal incidence of girdle beetle on soybean in relation to the abiotic factors during *Kharif*, 2003



the abiotic factors during *Kharif*, 2002

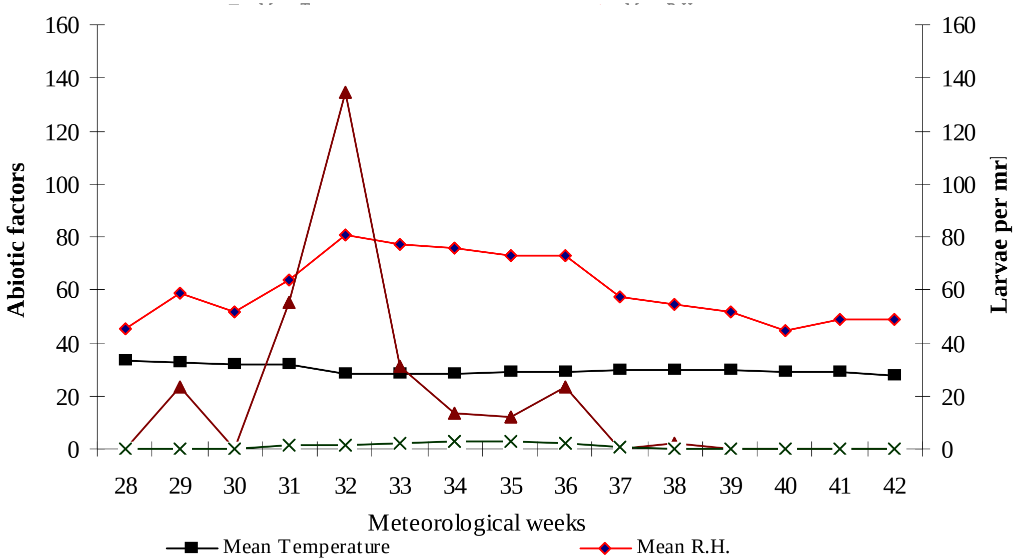


Fig. 12 : Seasonal incidence of semilooper on soybean in relation to the abiotic factors during *Kharif*, 2002

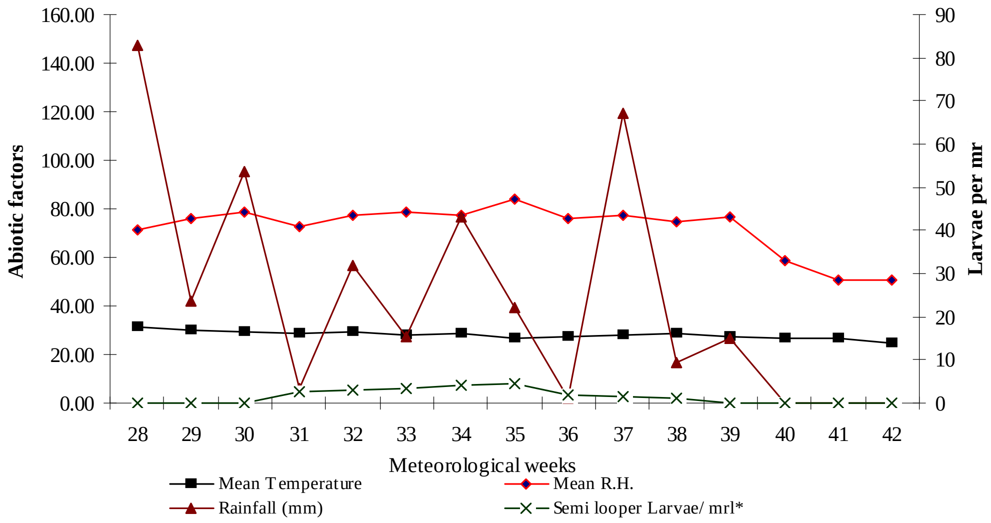
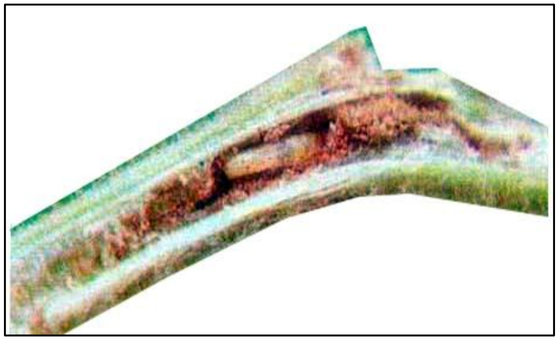
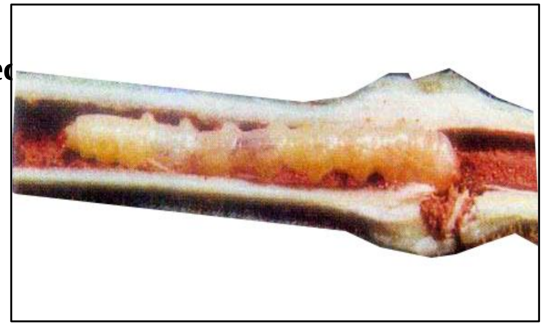


Plate -1 : Major insec

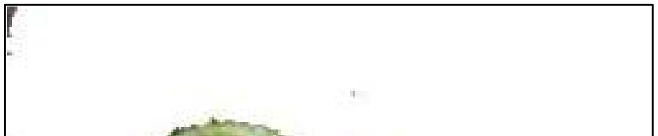




Plat Girdle beetle feeding in soybean nter croppings

Soybean+ Sesame

Soybean + Pigeonpea



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