STUDIES ON SEASONAL INCIDENCE OF MAJOR INSECT PESTS OF SOYBEAN AND ITS BIO-RATIONAL MANAGEMENT

M.Sc. (Ag.) Thesis

by

Chunni Kumari

DEPARTMENT OF ENTOMOLOGY
COLLEGE OF AGRICULTURE
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INDIRA GANDHI KRISHI VISHWAVIDYALAYA
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STUDIES ON SEASONAL INCIDENCE OF MAJOR INSECT PESTS OF SOYBEAN AND ITS BIO-RATIONAL MANAGEMENT

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

by

Chunni Kumari

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

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in

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CERTIFICATE - I

This is to certify that the thesis entitled **"Studies on seasonal incidence of major insect pests of soybean and its bio-rational management"** submitted in partial fulfilment of the requirements for the degree of **"Master of Science in Agriculture" (Entomology)** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Ms. Chunni Kumari** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate, award etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by her

Chairman
(Advisory Committee)

Date: 21.7.2017

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	(Dr. Y. K. Yadu)	
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Member	(Dr. R. Lakpale)	
Member	(Dr. (Smt.) G. Chandrakar)	

CERTIFICATE - II

This is to certify that the thesis entitled **"Studies on seasonal incidence of major insect pests of soybean and its bio-rational management "** submitted by **Ms. Chunni Kumari** to Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) in partial fulfilment of the requirements for the degree of **"Master of Science in Agriculture" (Entomology)** in the **Department of Entomology** has been approved by external examiner and student's advisory committee after an oral examination.

Date: 2.8.2017

Signature External Examiner

(Name: Dr. S. A. Dixit)

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Head of the Department/ Section _____

Faculty Dean _____

Approved/ Not approved

Director of Instructions _____

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LIST OF ABBREVIATIONS

%	per cent
@	At the rate of
a.i.	Active ingredient
B:C	Benefit cost ratio
Cm	Centimeter
d.f.	degree of freedom
DAS	Days after sowing
EC	Emulsifiable concentrate
et al.	And others/co-workers
Fig.	Figure
G	Gram
Ha	Hectare
Hrs	Hours
i.e.	That is
K	Potash
Kg	Kilogram
M	Meter

THESIS ABSTRACT

a) Title of the Thesis	:	"Studies on seasonal incidence of major insect pest of soybean and its bio-rational management".
b) Full Name of the Student	:	Chunni Kumari
c) Major Subject	:	Entomology
d) Name and Address of the Major Advisor	:	Dr. Y.K. Yadu (Principal Scientist) Department of Entomology IGKV, Raipur (C.G.) 492012
e) Degree to be Awarded	:	Master of Science in Agriculture (Department of Entomology)

Chunni kumari
Signature of the Student

Signature of Major Advisor

Date: 21.7.2017

Signature of Head of the Department

ABSTRACT

Studies on seasonal incidence of major insect pests of soybean and its bio-rational management was studied during *Kharif* season of 2016 at research area of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). tobacco caterpillar, *Spodoptera*

litura Fabricius; green semilooper, *Chrysodeixis acuta* Walker; white fly, *Bemisia tabaci* Gennadius; and thrips, *Thrips tabaci* were observed as major insect pests of soybean.

The peak activity of defoliators pests *i.e. S. litura* (1.9 larvae per meter row) and *C. acuta* (2.1 larvae per meter row) was recorded during third week of September and second week of September and that of sucking pests *i.e. B. tabaci* (9.1 whiteflies per three leaves) and *Thrips tabaci* (3.4 thrips/plant) in last week of September to first week of October, respectively.

Two species of lady bird beetle, *M. sexmaculata* and *C. septumpunctata* and orb weaver spider, *Neoscona* sp. were found predating mainly upon white flies, and thrips. Whereas, lynx spider, *Oxyopes* sp. and a predatory pentatomid bug, *E. furcellata* was noticed sucking the body sap of lepidopterous larvae. Correlation between spiders and sucking pests was found to be positive and significant with "r" values 0.740.

However, Correlation between coccinellid beetles and sucking pests, and between spiders and leaf defoliator pests was found to be positive and significant with "r" values and regression equation [r = 0.867; regression equation y= 10.94x + 2.414], and [r = 0.652; regression equation y =0.469X + 0.419], respectively.

Genotype PS-1589 with least number of lepidopterous caterpillars per meter row (1.0 number of larvae per meter row) and genotypes NSO-626 with least number of sucking pests per plant (6.0 numbers of sucking pests per plant) were found to be tolerant against these insect pests. However, the highest yield was recorded with genotypes NRC-126 (675 gm/plot) as against 350, 560, 390, and 365gm/plot grain yields from check varieties, which were found least susceptible against different insect-pests in soybean.

Genotype RV S-2010-1 and RVS-2008-24 with minimum larval count (0.7 larvae per meter row) and minimum sucking pests (whiteflies and thrips) with 11.0 per plant was identified to be tolerant against lepidopterous defoliators and

sucking pests. The highest grain yield was recorded with genotype PS-1572 (0.976 q/ha) which was found tolerant to sucking pests and lepidopterous defoliators.

In the evaluation of plant products against major insect pests of soybean garlic+green chilli @ 8.75 kg/ha was most effective against defoliators *S. litura* and *C. acuta* after first spray having 0.29, 0.57 and in second spray having 0.16, 0.27 larva/mrl, respectively and karanj seed extract @ 2% was most effective in sucking pests having 3.85 whiteflies/plant and 1.16 thrips/plant after first spray and after second spray 3.90 whiteflies per plant, 2.12 thrips/plant, respectively with benefit cost ratio of garlic+green chilli @ 8.75 kg/ha 6.99 and karanj seed extract @ 2% 6.59.

Garlic+green chilli @ 8.75 kg/ha was comparatively more safer for both natural enemies *i.e* coccinellids and spider after first spray having maximum population of 1.57 coccinellid/plant, 1.34 spiders/plant and after second spray 1.45 coccinellid/plant, 1.25 sspiders/plant.

शोधग्रंथ सारांश

अ) शोधग्रंथ का शीर्षक	:	"सोयाबीन के पीड़क कीटों का सामयिक आगमन पर अध्ययन एवं उनका जैव युक्ति संगत प्रबंधन"
ब) छात्रा का नाम	:	चुन्नी कुमारी
स) प्रमुख विषय	:	कीटशास्त्र
द) मुख्य सलाहकार का नाम एवं पता	:	डॉ. वाय. के. यदु (प्रमुख वैज्ञानिक) कीट विज्ञान विभाग, कृषि महाविद्यालय, इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर–492012 (छ.ग.)
इ) प्रदान की जाने वाली उपाधी	:	एम.एस.सी. (कृषि) कीट शास्त्र

Chunni Kumari
छात्रा के हस्ताक्षर

मुख्य सलाहकार के हस्ताक्षर

दिनांकः 21-7-2017

विभागाध्यक्ष के हस्ताक्षर

शोध सारांश

सोयाबीन (*ग्लाईसीन मैक्स*) के "सोयाबीन के पीड़क कीटों का सामयिक आगमन पर अध्ययन एवं उनका जैव युक्ति संगत प्रबंधन" विभिन्न पीड़क कीटों का विस्तार एवं उनका प्रबंधंन खरीफ 2016 में कृषि महाविद्यालय, इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर (छ.ग.) में किया गया। सोयाबीन के प्रमुख कीटों के रुप में तम्बाकू इल्ली(*स्पोडोपटेरा लीटयुरा*) अर्द्धकुंडलक इल्ली, (*कायसोडेक्सिस एक्यूटा*) सफेद मक्खी (*बेमिसिया टेबेकी*) तथा थ्रिप्स (*थ्रिप्स टेबेकी*) को देखा गया।

पत्ती खाने वाले कीटों में तम्बाकु इल्ली (*एस लीटयुरा*) की अधिक संख्या (1.9 इल्ली प्रति मीटर पंक्ति) तथा अर्द्धकुंडलक इल्ली (*एस एक्यूटा*) (2.1 इल्ली प्रति मीटर पंक्ति), सितम्बर माह के तीसरे सप्ताह में तथा सितम्बर माह के दूसरे सप्ताह में देखा गया। चूसक कीट सफेद मक्खी (*बी टेबेकी*) (9.1 सफेद

*yhV;qjk*½ v)zZdqaMyd bYyh] ¼*dzk;lksMsfDll ,D;wVk*½ lQsn eD[kh ¼*csfefl;k Vscsdh*½ rFkk fFkzIl ¼*fFkzIl Vscsdh*½ dks ns[kk x;kA

iRrh [kkus okys dhVksa esa rEckdq bYyh ¼*l yhV;qjk*½ dh vf/kd la[;k ¼1-9 bYyh izfr ehVj iafDr½ rFkk v)zZdqaMyd bYyh ¼*l ,D;wVk*½ ¼2-1 bYyh izfr ehVj iafDr ½] flrEcj ekg ds rhljs lIrkg esa rFkk flrEcj ekg ds nwljs lIrkg esa ns[kk x;kA pwld dhV lQsn eD[kh ¼*ch Vscsdh*½ ¼9-1 lQsn eD[kh izfr rhu iRrh izfr ikS/kk½ flrEcj ekg ds vafre lIrkg esa ns[kk x;k rFkk fFkzIl ¼ fFkzIl *Vscsdh*½ dh lcls vf/kd la[;k ¼3-4 fFkzIl izfr rhu iRrh izfr ikS/kk ½ flrEcj ekg ds vafre lIrkg ls vDVwcj ekg ds izFke lIrkg rd ik;k x;kA

lQsn eD[kh vkSj fFkzIl ds ijHk{kh ds #i esa dksDlhusyhM chVy dh nks iztkfr ,e lsDleksdqykVk vkSj lh- lsIViadVkVk rFkk vkWjo ohohj ¼*fu;ksLdksuk* iztkfr½ tcfd ykbU,Dl edM+h ¼*vksDlh;ksfiDl iztkfr*½ rFkk isUVkVksfeM cx ¼bZ QjlhykVk½ dks ijHk{kh ds #i esa ysfiMksIVsjk ds ‘kjhj ls jl dks pwlrs ns[kk x;kA edfM+;ksa vkSj pwlus okys dhVksa ds chp lglaca/k ldkjkRed ysfdu vkj ewY; 0-740 ds lkFk xSj egRoiw.kZ ik;k x;kA

dksDlhusyhM chVy vkSj pwlus okys dhVksa rFkk edM+h vkSj iRrh [kkus okys dhV ds chp lglaca/k ldkjkRed vkSj vkj ewY;ksa ds lkFk egRoiw.kZ ik;k rFkk izfrxeu lehdj.k dze ¼r = 0.867; izfrxeu lehdj.k y = 10.94x + 2.414½ vkSj ¼r = 0.652; izfrxeu lehdj.k y = 0.469x + 0.419 ½A

ysihMksiVsju bYyh dh U;wure la[;k izfr ehVj iafDr ¼bYyh dh la[;k ,d izfr ehVj iafDr½ thuksVkbi ih,l&1589 rFkk pwlus okys dhV dh U;wure la[;k 6 izfr ikS/kk ¼pwlus okys dhVks dh la[;k N% izfr ikS/kk½ thuksVkbi ,u,lvks&626 esa bu dhVksa ds fo#) lgu’khyrk /kh ik;k x;kA gkaykfd vukt mit thuksVkbi ,uvkjlh&126 ¼675 xzke izfr IykWV½ ntZ fd;k x;k Fkk] tks fd lks;kchu ds psd fdLeksa ds vukt mit 350] 560] 390 rFkk 365 xzke izfr IykWV lks;kchu ds vyx&vyx dhVksa ds fo#) lgu’khyrk ik;k x;kA

U;wure bYyh fxurh ¼0-7 bYyh izfr ehVj iafDr½ rFkk U;wure pwlus okys dhV izfr lQsn eD[kh vkSj fFkzIl ¼11 izfr ikS/kk½ thuksVkbi vkj Ogh,l&2010&1 rFkk vkjOgh,l&2008&24 esa ysfIVksiVsju dhV rFkk pwlus okys dhV ds fo#) lgu’khyrk igpkuk

x;kA vf/kdre vukt mit thuksVkbi ih,l&1572 esa ¼0-976 fDoaVy uzfr gsDVs;j½ ntZ fd;k x;k tks fd ysfiMksiVsju dhV rFkk pwlus okys dhV ds fo#) lgu'khyrk ik;k x;kA

lks;kchu ds izeq[k ihM+d dhV ds fo#) ikni mRikn ds ewY;kadu esa yglwu$ gjhfepZ @8-75 fd-xzk izfr gs- ykHk vuqikr 6-99 ds lkFk izHkko okyh ik;k x;kA blds izFke fNM+dko ds ckn rEckdw bYyh vkSj v)zZdqaMyd bYyh dh vkSlr la[;k dze'k% 0-29] 0-57 izfr ehVj drkj ik;k x;k rFkk blds nwljs fNM+dko ds ckn 0-16] 027 bYyh izfr ehVj drkj ik;k x;k blh izdkj pwlus okys dhVs izFke fNM+dko ds ckn 3-85 lQsn eD[kh izfr ikS/kk vkSj 1-16 fFkzIl izfr ikS/kk vkSj nwljs fNM+dko ds ckn 3-90 lQsn eD[kh izfr ikS/kk rFkk 2-12 fFkzIl izfr ikS/kk ns[kk x;kA

ikni mRikn esa yglqu $ gjh fepZ @ 8-75 fd-xzk izfr gsDVs;j dh nj ls izkd`fre fe= dhV ds fy,s lcls lqjf{kr ik;k x;kA izFke fNM+dko ds ckn dksDlhusyhM chVy dh vf/kd la[;k 1-57 dksDlhusyhM chVy izfr ikS/kk vkSj edM+h dh l[a;k 1-34 edM+h izfr ikS/kk ik;k x;k rFkk nwljs fNM+dko ds ckn dksDlhusyhM chVy izfr ikS/kk 1-45 vkSj edM+h dh la[;k 1-25 izfr ikS/kk ik;k x;kA

CHAPTER - I
INTRODUCTION

Soybean is one of the most important oilseed commercial crop of India. It is world's most useful and cheapest sources of protein, vitamins, minerals, salts, carbohydrate and other ingredients and known as Miracle bean and Golden bean of the twentieth century. It was introduced to India across the Himalayan Mountains many years ago. Soybean is mainly grown for their seeds and is the second largest oil seed after groundnut in India. Though soybean is a legume crop, yet it is widely used as oilseed. The plant is classified as an oilseed and is considered as a pulse by the Food and Agriculture Organization (FAO). It is cheapest source of protein and contains 20% oil, 40% protein, 26.5% carbohydrate and 5.5% mineral nutrients. India's contribution is about 13 percent of world's oilseeds area, seven percent of world's oilseeds output and 10 per cent of world's edible oil consumption. **(**Alexander, 1974**)**

Soybeans are a legume classified by FAO as an oil crop. References to the crop have been found in China around 3,000 years ago. Soybeans were originally used for crop rotation, as a nitrogen fixing plant, and for the production of fermented food products. Until fairly recently, cultivation was limited largely to Asian countries and only gained popularity in the Americas and Europe in the early 1900s.

Although in some countries soybeans are transformed at the local level into food products for direct human consumption, much of today's production is crushed at industrial scale to obtain soybean oil and soybean meal, which account for about one third and two thirds of the crop's economic value, respectively. Soy-oil and soy-meal are consumed worldwide as food and animal foodstuff, respectively. In recent years, soybean oil also started to be used for the production of bio-diesel. Commercial production of genetically modified soybeans has increased fast in recent years, with important implications for consumption and trade.

Soybean can be grown in varied agro climatic conditions and is mainly cultivated in Indian States like Madhya Pradesh, Maharashtra, Uttar Pradesh and Rajasthan. The shape of the bean is oval and mostly of cream color.

In the world, soybean occupies an area of 108.51 million ha with production potential of 345.96 million metric tons and average productivity of 3.18 metric tons/ha (USDA, 2016). United States Department of Agriculture (USDA) estimates that the World Soybean Production 2016/2017 will be 345.96 million metric tons, around 5.18 million tons more than the previous month's projection.

In India, soybean occupies an area of 109.714 lakh ha with production potential of 114.907 lakh tons. Major production comes from Madhya Pradesh (57.168 lakh t) followed by Maharashtra (39.456 lakh t) and Rajasthan (9.499 lakh t). Other soybean producing states are Andhra Pradesh, Karnataka, Chhattisgarh and Gujarat. (SOPA, 2016)

In Chhattisgarh, out of 137.00 lakh hectares geographical area, 43 percent area comes under cultivation in which soybean occupies an area of 1.340 lakh ha with a production potential of 1.307 lakh tons. (SOPA, 2016)

Among all the districts, maximum area and production of soybean comes under Rajnandgaon followed by Durg, Kabirdham, Raipur and has proved to be a remunerative crop in Kanker upland area.

Soybean is the world’s first rank crop as a source of vegetable oil. The worldwide markets for vegetable oils, soybean ranked first followed by olive, canola, sunflower and safflower, corn, palm, coconut, and others **(**Global Vegetable Oils Industry, 2013). India is the sixth largest soybean oil producing country in the world (USDA, 2016).

But there are many problems in cultivation of soybean in India as well as Chhattisgarh, as all stages of this crop are prone to heavy infestation by pest complex. The luxuriant crop growth, soft and succulent foliage attracts many insects and provides unlimited source of food, space and shelter. Insect pests caused severe damage and consequent reduction in yield (Singh *et al*., 1991 and Sharma, 1999). During the introduction of soybean in India in the early seventies, only about a dozen minor insect pests were recorded, while in 1997 this number

has swelled to an alarming figure 270, besides one mite, two millipedes, 10 vertebrates and one snail pest (Singh, 1999).

In Chhattisgarh, soybean crop is attacked by many species of insect-pests *viz*., girdle beetle, *Obereopsis brevis* Swedenbord; tobacco caterpillar, *Spodoptera litura* Fabricius, green semilooper, *Chrysodeixis acuta* Walker; white fly, *Bemisia tabaci* Gennadius and jassid, *Empoasca kerri* Pruthi.

The grub of girdle beetle is creamish white and soft bodied worm with a dark head. The freshly emerged adult is yellow, red and brown on the head, thorax and bases of elytra. The larvae were noticed girdling the stem and petioles. The internal content of the stem was eaten by the larvae resulting in formation of tunnels inside the stem. The infested portions of the plant were unable to get the nutrients and dried up. At a later stage, the plant was broken at about 15-25 cm above the ground.

The larvae of *S. litura* were noticed feeding on the early vegetative stage of the crop. Newly hatched caterpillars had characteristic gregarious feeding habit. They feed on the chlorophyll content of the leaves from under surface and skeletonized them. The grown up larvae fed on the leaves eating away the entire portion. The early instars of green semilooper, *C. acuta* feed on the leaves by scratching the green matter and grown up larvae consume the green leaves leaving behind only the mid ribs and veins. This pest was noticed defoliating at the vegetative stage of the crop.

White fly, *Bemisia tabaci* adults are small, yellow bodied insects with white wings which are densely covered with a waxy powder. Nymphs and pupae are black and round or oval. Pupae have marginal bristles. Jassid, *Empoasca kerri* adults and nymphs are light green in colour and suck the sap from leaves and stem. Infested leaves start yellowing from the margins. In case of severe attack, all the leaves become yellow and eventually fall off.

Therefore, keeping in view the economic importance of the crop and effective management strategies for the suppression of insect-pests, the present investigation was undertaken with the following objectives:

1) To study the seasonal incidence of major insect-pests of soybean and their bio-control agents.
2) To find out the performance of soybean genotypes against major insect pests.
3) To study the relative bio-efficacy of plant products against major insect pests.
4) To work out the benefit cost ratio of plant products.

CHAPTER- II
REVIEW OF LITERATURE

Several researchers have attempted through their research work from time to time to explore the various aspects of insect-pests of soybean and its management. The literature available from India and abroad on different aspects of the present study has been reviewed under the following heads:

2.1 To study the seasonal incidence of major insect-pests of soybean and their bio-control agents

Adimani (1976) recorded 59 insect species belonging to six orders occurring around Dharwad on soybean in Karnataka.

Singh and Singh (1987) studied the incidence and damage caused by the Noctuidae *Chrysodeixis acuta* to soybean pods and flowers in July-September 1984 in Madhya Pradesh, India. Larvae appeared during the 1st week of August and the maximum population was observed on 14th September. The larval population decreased by infection with *Spicaria rileyi* (*Nomuraea rileyi*). Damage to flowers and pods occurred mainly from 18th August to 1st September and during the 2nd week of September, respectively.

Panizzi *et. al.* (1985) observed that the nymphs and adults of pentatomid bug feed via stylet insertion primarily in seeds, reducing seed yield and quality and sometimes causing prolonged leaf retention and development of abnormal leaflets and pods. Colonization of soybean by pentatomids typically started during pre-blooming and peaks by late pod-filling stage.

Cui *et al.* (1995) recorded forty-seven insect species as leaf feeders on soybean in Nanjing, China. Among these the most important species were *Lamprosema indicate* Fab and *Spodoptera litura* (Fab.).

Chaturvedi *et al.* (1998) recorded, 17 insects and one mite species infesting soybean variety JS 72-44 (Gaurav) sown on 15 July, 1995 at Sehore, Madhya Pradesh, India. Of these, two damaged the stem, ten defoliated the plants, five sucked the cell sap and one damaged the roots at different growth stages of the

crop, starting just after the emergence of the cotyledons. The population density of some insects associated with soybean was estimated in a field experiment in India in *kharif*, 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 *Spodoptera litura* (Fab.) and *Spilosoma obliqua* Walker during the crop growth period were maximum around the second half of October. However, density of *Plusia orichalcea* (Fab.) was higher during the later part of September or early October. Significant correlations were observed between population densities of some insect species as reported by Kumar *et al.* (1998).

Van Den Berg, *et al.* (2000) studied the incidence levels of moths and larvae of *Etiella zinckenella* in the reproductive stage of soybean at eight farmers' field sites. A positive relationship was found between moths, caught by sweeping during flowering and pod-formation, and seed damage. Hence, rough predictions of damage can be made based on moth catches. Damage incidence was recorded in unsprayed plots and in plots sprayed with deltamethrin during flowering and pod-formation.

Three hundred species of insect pests infesting soybean was reported by Singh *et al.* (2000). Of which blue beetle, grey semi looper, green semi looper and stem fly were major insect pests in Madhya Pradesh.

Pests and natural enemies were surveyed in fields of 11 soybean cultivars, planted in strips of 40x8 m (320 sq. metre) in a 3520 sq. metre area in Brazil. An area of 80 sq. metre in each strip received no insecticide. Four samplings were made each week in each strip (two samplings each from controlled and uncontrolled areas). The most abundant insect pest was *Cerotoma tingomarianus*, which caused heavy defoliation in uncontrolled areas. The main predators were *Lebia concinna*, *Callida sp*. and *Tropiconabis sp* as reported by Thomazini (2001).

Alejandro and Douglas (2007) reported that the soybean aphid, *Aphis glycines* (Hemiptera: Aphididae), was the most important insect pest attacking soybean in North America since 2000. Several studies have documented strong impacts of generalist natural enemies on *A. glycines* populations using predator

exclusion cages and correlating predator and aphid abundances. However, to date no studies directly observed and quantified the natural enemy groups that attack *A. glycines* in North America under field conditions. In 2005, they conducted 72 h of direct observations of predation on natural populations of *A. glycines* in Michigan. A total of 643 predators within 12 groups and 211 predation events on *A. glycines* were observed. Transient predators such as *Harmonia axyridis* and *Coccinella septempunctata* (Coleoptera: Coccinellidae) accounted for most of the observed mortality and were very effective on a per capita basis, despite relatively short residence time in the observed patches. Transient predators responded positively to increased *A. glycines* field densities. Resident predators, particularly *Orius insidiosus* (Hemiptera: Anthocoridae), was abundant and accounted for many predation events, but that was not as effective on a per capita basis and did not respond to changes in aphid density. They concluded that coccinellids exerted most of the mortality observed and have the potential to rapidly respond to changes in aphid density with high per capita rates of predation.

The predatory pentatomid bug, *Eocanthecona furcellata* (Wolff) regarded a potential biological control agent against lepidopteran pests in Southeast Asia. However, no studies were available on the predation efficacy of *Eocanthecona furcellata* on *Helicoverpa armigera* larvae feeding on different host plants. This information regarded important with regard to releasing *E. furcellata* as a biocontrol agent for control of *H. armigera* in Myanmar as reported by Nyunt (2008).

Paik *et al*. (2007) observed that *S. litura* occurred significantly in late August in soybean field. The peak activity of *S.litura* was observed during the third week of August.

Naseri *et al.* (2009) studied *Helicoverpa armigera* (Hübner) as one of the major devastating and highly polyphagous insect pests in many parts of the world.

Sutaria *et al.* (2010) studied the seasonal incidence of jassid, *Empoasca kerri* infesting soybean and weather parameters and correlated them with a view to study the impact of different weather factors on pest incidence. The correlation matrix indicated that none of the weather parameters was found significantly

correlated with population of jassid on soybean during *kharif* season of 2007. Although, positive correlation existed between population of jassid and minimum temperature, morning and evening R.H. and sunshine hrs. While other factors *viz*., maximum temperature, rainfall and rainy days were negatively correlated.

Netam (2010) reported that girdle beetle, lepidopterous caterpillars and sucking pests were first observed on the crop during last week of July which was associated with 30.3oC and 25.6oC maximum and minimum temperatures, 91 and 78 percent morning and evening relative humidity and 277.8 mm rainfall. Peak activity of girdle beetle (3.7 damaged plants/ m row) and lepidopterous larvae (5.0 larvae/ m row) observed during last week of August was associated with minimum and maximum temperatures of 30.2^0C and 25.2^0 C, morning and evening relative humidity of 94 and 82 percent and 30.0 mm rainfall. The peak activity of sucking pests was recorded during third week of September which was associated with 32.2oC maximum and 24.5oC minimum temperature, 92% morning and 64% evening relative humidity and 51.0 mm rainfall.

Kujur (2011) reported the peak activity of the girdle beetle during the second week of September which was associated with 28.8˚C maximum temperature, 24.5˚C minimum temperature, 94% morning R.H., 87% evening humidity and 236.4 mm rainfall. The peak activity of *S. litura* and *E.kerri* was observed during last week of August with 31.2˚C maximum temperature, 24.4˚C minimum temperature, morning and evening R.H. 93% and 76%, respectively and a rainfall of 62.8 mm. The peak larval activity of *C. acuta* was observed during third week of August, which was associated with 29.8˚C maximum temperature, 24.6˚C minimum temperature, morning and evening R.H. 93% and 74%, respectively, and 80.7 mm rainfall. The peak density of *B. tabaci* was observed during last week of September which was associated with 31.1˚C maximum temperature, 24.3˚C minimum temperature, morning and evening R.H. 88% and 57%, respectively, and 2.4 mm rainfall.

Vieira *et al.* (2011) observed that when *Bemisia tabaci* occurs in large populations, the plants weakened by the extraction of large amounts of sap. This induces early defoliation and impacts the soybean plant development and yield, as observed in some soybean fields under attack of this pest.

Ahirwar (2013) observed the major insect-pests attacking soybean variety JS 335 were girdle beetle, *Obereopsis brevis*, tobacco caterpillar, *Spodoptera litura*, green semilooper, *Chrysodeixis acuta*, whitefly, *Bemisia tabaci* and jassids, *Empoasca kerri.* The biocontrol agent's three species of lady bird beetle, *Menochilus sexmaculata, Coccinella septumpunctata* and *Coccinella transversalis* and orb weaver spider, *Neoscona* sp. were found predating mainly upon whiteflies and jassids. Whereas, lynx spider, *Oxyopes* sp. and a predatory pentatomid bug, *Eocanthecona furcellata* was noticed sucking the body sap of lepidopterous larvae.

Netam *et al.* (2013) reported that during the course of study, five insects species, *viz.,* girdle beetle, *Obereopsis brevis,* tobacco caterpillar, *Spodoptera litura*, green semilooper, *Chrysodeixis acuta*, Jassids, *Empoasca kerri* and white flies, *Bemisia tabaci* were the major pests on soybean variety JS 93-05 causing damage at various stages of the crop. All these insects made their first appearance on the crop to a greater or lesser extent in the last week of July.

Gaur *et. al.* (2015) studied the population dynamics of insect-pests of soybean and their correlation with abiotic factors at Norman E Borlaug Crop Research Centre, GB Pant University of Agriculture and Technology, Pantnagar. Observations on the incidence of various insect-pests *viz. Spodoptera litura*, *Spilarctia obliqua*, *Thysanoplusia orichalcea*, *Obereopsis brevis*, *Bemisia tabaci* and *Melanagromyza sojae* were recorded at weekly intervals. On the basis of observations and correlation study of insect incidence in relation to weather parameters, it was found that stem fly having 100% infestation showed significant negative correlation with minimum temperature and its maximum damage (100% infestation, 33.84% tunneling) was highly significant and negatively correlated with the evaporation. *S. obliqua* incidence was significantly positively correlated with wind velocity. But all the weather parameters were non-significantly related to incidence of *S. litura*, *T. orichalcea*, *O. brevis* and *B. tabaci*. Thus, low temperature and evaporation have negative correlation with incidence of stem fly, whereas, wind velocity was found positively correlated in the case of *S. obliqua* incidence.

Yeotikar *et.al.*(2015) studied the incidence of leaf miner, *A. modicella* (maximum 0.02 larvae/plant in 32nd MW), *S. litura* (maximum 0.33 larvae/plant in 32nd & 35th MW) and *H. armigera* (maximum 0.66 larvae/plant in 32nd mw) was very low/negligible. The girdle beetle, *O. brevis* incidence started in 30th MW by recording 1.36% infestation which at harvest reached 61.22% whereas stem tunneling observed due to stemfly at physiological maturity was 59.45%. Green semiloooper, *G. gema* recorded a peak of 3.00 larvae/mrl during 34th MW. The infestation of *O. brevis* in relation to bright sunshine hours (0.714*) was positively significant and negatively significant with wind velocity (−0.674*). the population of *G. gema* in relation to wind velocity (r = 0.613*) was found positive and significant.

Yadav *et. al.* (2015) recorded, some major, minor insects, natural enemies and one entomopathogenic fungus on soybean at Tikamgarh (M.P.). Among these insects, population of blue beetle increased with the increase in minimum temperature, RH and rainfall. But population of semilooper, tobacco caterpillar, jassid decreased with increase in rainfall and RH. Similarly the population of white fly, stem fly and girdle beetle also decreased with the increase in rainfall. Population of some natural enemies i.e. coccinelids, predatory bug and *Beauveria bassiana* decreases with the increase in maximum temperature but population of predatory bug increases with increase in minimum temperature and RH. High RH and low temperature favours the incidence of *Beauveria bassiana.* Population of coccinelids and spiders increased with increase in rainfall.

Ramesh Babu *et. al.* (2015) carried out an investigation to study the effect of various weather parameters on the occurrence of larva and adult population of *Spodoptera litura* and their factors for outbreak of this pest in soybean in Banswara, Rajasthan. The moth populations of *S. litura* were active from August to mid-October and decreased sharply in late October. The peak appearance was observed during September-October months and corresponded with peak activity of egg masses and larval population in soybean contributed to the outbreak of this pest during the reproductive stage of the crop. Overall correlation studies confirmed that the fluctuations in the male moth catches of *S. litura* per pheromone

trap is mainly due to weather factors like, maximum temperature, rainfall, sunshine and wind speed. Moth population in pheromone traps will be used as a warning situation indicating the occurrence of larvae in the host for potential attack and to initiate timely management of *S. litura* in soybean.

Kushram (2016) observed that six different insect pests damaged the soybean crop from time to time. Among these *O. brevis, S. litura, C. acuta, B. tabaci, E. kerri and Thrips tabaci* were most serious pests of soybean in this region. The activity of girdle beetle increased gradually with peak density was observed during the fourth week of September recorded 1.2 girdle beetle damaged plants/meter row with a seasonal mean of 0.23 number of girdle beetle damaged plants. The peak activity of defoliators pests *i.e. S. litura* (1.4 larvae per meter row) and *C. acuta* (1.2 larvae per meter row) was recorded during last week of August and that of sucking pests *i.e. B. tabaci* (10.0 whiteflies per three leaves) and *E. kerri* (0.65 jassids per plant) was recorded during second week of August and *Thrips tabaci* (6.1 thrips/plant) in third week of August, respectively. Two species of lady bird beetle, *M. sexmaculata* and *C. septumpunctata* and orb weaver spider, *Neoscona* sp. were found predating mainly upon white flies, jassids and thrips. Whereas, lynx spider, *Oxyopes* sp. and a predatory pentatomid bug, *E. furcellata* was noticed sucking the body sap of lepidopterous larvae.

Kushram (2016) observed the effect of different weather parameters on seasonal incidence of girdle beetle, lepidopterous caterpillars and sucking pests on the soybean crop during last week of July. The peak activity of the girdle beetle was noticed during the fourth week of September which was associated with 30.1^0 C maximum temperature, 25.1˚C minimum temperature, 94% morning R.H., 78% evening humidity, 135.4 mm rainfall and sunshine hours 3.1 lux. The peak activity of defoliator pests (*S. litura* and *C. acuta*) was observed during last week of August with 32.3^{0C} maximum temperature, 25.9^0C minimum temperature, 87% morning and 65% evening R.H, a rainfall of 23.6 mm, respectively and sunshine hours 6.5 lux. The peak density of total sucking pests was observed during last week of August which was associated with 32.3^0C maximum temperature, 25.9^0C

minimum temperature, morning and evening R.H. 87 % and 65 % , rainfall 23.6 mm respectively, and sunshine hours 6.5 lux.

2.2. To find out the performance of soybean genotypes against major insect pests

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

Sandhya (1999) screened the 20 soybean varieties for girdle beetle and stem fly incidence, six varieties showed moderate resistance to these pests. Varieties with higher total phenol content showed low incidence of stem fly and girdle beetle.

Haq-ul-Ihsan *et al*. (2003) studied the ten varieties Psc-62, NARC-VII, Ajmeri V-I, Soy 95-1, Davis, NARC-VI, S-69-94,Psc-56 and S-72-60 for relative resistance against white fly (*Bemisia tabaci*), jassid (*Amrasca bigutlla Ishida*) and soybean looper (*Pseudoplusia includens* Walker). The variety V-I and Ajmeri were comparatively more resistant having population of white fly 1.29, jassid 0.62 per leaf respectively. Psc-56 suffered minimum infestation percentages of soybean looper. Davis was most susceptible to all three insect pests having infestation of white fly, jassid, soybean looper (6.39, 2.09, 33. 33%, respectively).

Savajji (2006) observed that genotypes NRC-55 had significantly least (1.40%) seedling mortality and is on par with MACS-798, MACS-740, MACS-694, NRC-52, NRC-51 and DSb (PR)-101 genotypes which recorded seedling mortality of 1.70, 1.60, 1.50, 1.60, 1.58 and 1.70 per cent respectively. The remaining genotypes, MRSB-342 (6.25%), MACS-212 (5.5%) and DSb (PR)-103 (4.10%) were recorded higher per cent seedling mortality. The genotypes JS (SH) 93-37 (2.89%), UGM-20075 (3.22%), MACS-871 (2.70%) and PK-1347 (2.89%) were on par with each other.

Sinha (2009) observed the reaction of twelve advanced varieties of soybean (AVT) against girdle beetle (*Obereopsis brevis*) in the form of percentage of girdle beetle infested plants. Based on seasonal mean of girdle beetle infestation the percent plant damage ranged from 1.57 to 7.91 percent. The variety NRC – 37 with 1.57 percent infested plant was least infested by girdle beetle followed by Bragg, JS -20-06 and NRC-77 with 1.73, 2.73 and 2.74 percent infested plants, respectively. Variety RKS-54 with 7.91 percent infested plants was most damaged by girdle beetle. The grain yield from different varieties ranged from 1720 to 2220 kg/ha. Highest yield was recorded in NRC- 77 which was almost similar to that obtained from Bragg and NRC-37 with 2210 and 2200 kg/ha, respectively.

Netam (2010) worked on "Evalution of key insect pests management components on soybean" at I.G.K.V. during *kharif* , 2010 and reported that genotype L129, with least number of girdle beetle damaged plants and lepidopterous larvae per meter row and minimum density of sucking pests per plant and most tolerant to these insects recording 31.1q/ha grain yield.

Kujur (2011) worked on "population dynamics of major insect-pests of soybean and management of defoliators and girdle beetle" at I.G.K.V. during *kharif* , 2011 and reported that among the soybean genotypes screened for resistance against major insect-pests of soybean, MACS 1336 was identified as resistant against girdle beetle. MACS 1039 showed resistance against lepidopterous defoliators, whereas, DSb 63 was identified as resistant against sucking pests and lepidopterous defoliators. With respect to yield, DSb 63 recorded highest grain yield (21.4 q/ha) compared to all the other genotypes.

Field screening of AVT entries for resistance to major insect-pests of soybean was conducted during *kharif*, 2011 at Parbani sub-centre. Soybean genotypes MACS 1336 and MACS 1140 with 18.76 and 19.04 per cent plant infestation were reported to be highly resistant against girdle beetle followed by DSb 16 and MACS 1039 which were considered as moderately resistant against the same insect-pests with 22.46 and 23.22 percent plant infestation, respectively. MACS1039 was found to be resistant against lepidopterous defoliators (Anonymous, 2011).

2.3. To study the relative bio-efficacy of plant products against major insect pests

Kumar *et. al* (1984) applied neem (*Azadirachta indica*) seed kernel extract, neem oil and honge (*Pongamia glabra* [*P. pinnata*]) oil in Bengal gram (*Cicer arietinum*) at 3% and 5% it reduced the mean percentage of the pods damaged by *Heliothis armigera* to 1.05-3.10 (as compared with 7.45% for no treatment), but had no significant effect on yields.

Chari *et. al.*(1985) observed that the antifeedant activity of neem (*Azadirachta indica*) kernel suspension at 2, 3 and 5% and neem leaf suspension at 5 and 10% on 4th-instar larvae of the noctuid ;*Achaea janata*, a pest of castor (*Ricinus communis*), in the laboratory. After 24 h, none of the larvae had touched the castor leaves treated with either neem suspension. Larvae moved to treated castor leaves after 48 and 72 h when the food in the untreated control was exhausted, but excreta was only produced at the lowest concentration of the neem leaf extract. In the untreated control, the leaves were completely devoured. Thus neem seed suspension at 2% or neem leaf extract at 10% was an effective and economical treatment for the control of the pest.

Vijayalakshmi *et al*. (1997) reported that ginger extract as natural pesticide, alone and in combination with other plant products like chilli, garlic and cow urine was found effective against *H. Armigera*.

Lakshmanan (2001) reported garlic bulb extract alone or in combination with other plant extracts effective in managing several lepidopteran pests viz., *Earias vitella*, *Chilo partellus* (Swinhoe), *Corcyra cephalonica* Staint., *Helicoverpa armigera* and *Spodoptera litura* and also effectively managed sucking pests like aphids, whiteflies, thrips and tetranychid mites infesting several crops.

Ladaji, (2004) carried out investigations under field conditions and confirmed the higher efficacy of the indigenous materials *viz*., pongamia leaf extract (10%) + NSKE (10%) + aloe (5%) + cow urine (30%), GCA (2%) + GCK (0.5%) and vitex leaf extract (20%) + clerodendron extract (4%) + cow urine (17%) by recording maximum reduction in larval population.

Purwar and Yadav (2004) reported that *M. sojae* infestation was significantly reduced by 4% NSKE, 10% cow urine and cow dung ash in PK 1029 and by diflubenzuron 25 WP and 6% NSKE in PK416. *O.brevis* infestation was recorded for all treatments except diflubenzuron 25 WP and triazophos 40 EC triazophos 40 EC resulted in the highest grain yields of PK 1029 (28.95 quintal/ha) and PK 416 (25.06 quintal/ha).

Choudhary and Shrivastava (2007) conducted a field experiment at Zonal Agricultural Research Station, Powarkheda, Madhya Pradesh, on soybean during kharif 2004 and 2005. Among the neem-based products, application of neem seed kernel extract (NSKE) at 5% + neem leaf extract (NLE) at 10% reduced the maximum larval population (51.59%) and recorded a seed yield of 987.66 kg/ha.

Pande *et al*. (2008) stated that soybean crop was attacked by various pest in which white fly considered as a key pest. The population data recorded indicates that triazophos and NSKE 5% considerably reduced the population of white fly. The spraying of NSKE 5% with dipel, triazophos and sandovit (as additives) increased its efficacy.

Vinodhini *et. al.* (2009) studied to find out the effect of different botanical pesticides and chemical pesticide on the sucking pests of cotton, *Gossypium hirsutum.* In situ count of leafhopper (*Amrasca devastans*) and aphids (*Aphis gossypii*) were made prior to the pesticide application and on 1^{st} , 3^{rd} , and 7^{th} day after application of pesticides. Of the different botanicals used, neem seed kernel extract (5%) was found to be effective followed by *Pongamia glabra* seed kernel extract (5%), neem oil (3%) and *Pongamia glabra* oil (3%) against the sucking pests (leafhopper and aphids) of cotton. Maximum population reduction was noticed on the 3rd day after treatment.

Iqbal *et.al*. (2014) investigated the botanicals as an alternative approach to control sucking insect pests of okra crop. The plant extracts of eight indigenous plants viz., tumha (*Citrullus colosynthis* L.), datura (*Datura innoxia* M.), neem (*Azadirachta indica* A.), castor (*Ricinus communis* L.), hing (*Ferula asafetida* L.), eucalyptus (*Eucalyptus spp*.) bitter gourd (*Memordica chrantia* L.) and garlic (*Allium sativum* L.) were tested for their potential insecticidal efficacy against

sucking insect pests, jassid (*Amrasca bigutulla bigutulla* I.), whitefly (*Bemisia tabaci* G.) and thrips (*Thrips tabaci* L.). The mean sucking insect population and fruit damage caused by the chewing borers was monitored to evaluate the efficacy of targeted plant extracts. It was revealed that, neem followed by garlic significantly reduce the mean population of jassid (6.31, 6.86), whitefly (7.41, 8.21) and thrips (11.99, 12.43), respectively. Neem also showed minimum fruit damage percentage (3.38%) followed by garlic (6.67%). The maximum pod yield (3178.7 kg/ha) was observed in neem treated plots. It was concluded that the plants could be the possible alternate option in insect pest management program.

Sreerag *et. al.*(2014) investigated an effective bio pesticide formulation against two major sucking pests of field crops. Neem oil, surfactant and cassava leaf extract were the three constituents used in the formulations. Major field pests, the papaya mealy bug, *Paracoccus marginatus* and cowpea aphid, *Aphis craccivora* were selected for the study. A total of six formulations at concentration of 2, 1 and 0.5 were sprayed on mealy bug infested papaya seedlings and aphid infested cowpea plants. The mortality percentage varied according to formulations and 1% formulation which contained 50 ml neem oil, 30 ml surfactant and 20 ml cassava leaf extract proved to be most effective bio pesticide formulation against these sucking pests. Accordingly, the amount of neem oil required for control of these pests was reduced due to the additive action of other constituents

Kushram (2016) conducted an experiment on the efficacy of plant products in the management of defoliator *S. litura*, the minimum overall larval population was recorded in garlic+green chilli @ 8.75 kg/ha after first spray having 0.43 and after second spray 0.43 larva/mrl. It was followed by NSKE @ 5% having 0.50, 0.48 larvae per meter row length after first spray and second spray, respectively showed the best treatment as compare to other treatment. And Overall mean larval population of *C. acuta* was recorded minimum in garlic+green chilli @ 8.75 kg/ha having only 0.52, 0.37 larva/mrl after first spray and second spray , followed by NSKE @ 5% with 0.53, 0.47 larva/mrl after first spray and second spray. In the present investigation, efficacy of plant products in the management of sucking pests white fly. It was found that garlic+green chilli @ 8.75 kg/ha after first spray having 4.12 whiteflies per plant and second spray with 4.24 was most effective

followed by Neem oil @ 2% after first spray with 4.80 and second spray with 4.56 white fly per plant.

Raghavendra1 *et. al.* (2016) used Neem leaf extract for the control of defoliators and sucking pests. garlic extract was used for control of *Spodoptera litura* (leaf eating caterpillar), *Helicoverpa armigera* (fruit borer), and other lepidopteran pests. garlic + chilli extract was used for control of *Helicoverpa armigera* (fruit borer), *Spodoptera litura* (leaf eating caterpillar), *Leucinodes arbonalis* (brinjal fruit & shoot borer), *Amsacta albistriga* (red headed hairy caterpillar). Chilli , Neem, Garlic extract was used for control of Lepidopteran pests in Pigeon pea.

2.4. Benefit Cost Ratio of Plant Products

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

Purwar and Yadav (2004) reported that *M. sojae* infestation was significantly reduced by 4% NSKE, 10% cow urine and cow dung ash in PK 1029 and by diflubenzuron 25 WP and 6% NSKE in PK416.

Choudhary and Shrivastava (2007) recorded the ICBR. The application of NSKE at 5% (2.44) proved economically most viable amongst the neem-based treatments, followed by NLE at 5% (2.20).

Kushram (2016) found that among the plant products, the maximum benefit cost ratio was found in the treatment garlic+green chilli @ 8.75 kg/ha having 8.02. In rest of the plant products, more or less similar benefit cost ratio was obtained like 3.48 in Karanj seed extract @ 2.5% which was followed by green chilli @ 9kg/ha (3.15), red chilli @ 9kg/ha (3.00), Karanj oil @ 2% (2.32), Neem oil @ 2% (2.10) and the minimum benefit cost ratio was recorded in the treatment NSKE @ 5% having only 2.03 and among the chemical treatment triazophos @ 750ml/ha which was used for management of insect pests of soybean the benefit cost ratio was maximum with 17.27.

CHAPTER - III
MATERIALS AND METHODS

This chapter deals with a concise description of materials used and methods adopted during the course of investigation. The present investigation entitle "STUDIES ON SEASONAL INCIDENCE OF MAJOR INSECT PESTS OF SOYBEAN AND ITS BIO-RATIONAL MANAGEMENT" was conducted during *Kharif* season, 2016. Details of the materials used and the experimental techniques adopted during the course of study are briefly described in this chapter.

3.1 Location of experimental site:

The field experiment was conducted at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Kharif* season of 2016.

3.2 Geographical situation:

Raipur, is situated in the central- eastern part of Chhattisgarh at 21°14' N latitude, 81°38' E longitude and at an altitude of 298.15 meters from mean sea level. The climate of Raipur is characterized as dry sub-humid with normal rainfall of 1200 mm per annum, mostly concentrated during the monsoon months *i.e.* June to September.

3.3 Climatic condition:

Raipur, the capital of Chhattisgarh state, comes under the seventh agroclimatic region of India *i.e.* eastern plateau and hills which is termed as under dry moist, sub humid region. The source of rainfall is South-western monsoon. The region receives 1200-1400 mm rainfall annually, of which nearly 75-80 percent is received during the rainy season (June to September) and the rest 20-25 percent is received during winter season (October to February). January is the coolest and May is the hottest month. Temperatures remain moderate throughout the year,

except from March to June, which can be extremely hot. The temperature in April - May sometimes rises above 46˚C. These summer months also have dry and hot winds. Winters last from November to January and are mild, although minimum temperature can fall upto 9˚C. The minimum and maximum temperature ranged from 20.4 to 31.4˚C and 29.6 to 43.7˚C, respectively. The relative humidity is high from June to October; varying from 70 to 90 per cent and wind velocity is high from May to August with its peak in June-July months.

3.3.1 Weather conditions during the cropping period:

The meteorological data of temperature, relative humidity, rainfall and wind velocity during cropping period *i.e.* (July 2016 to October 2016) is presented in table 3.1 and fig 3.1.

The crop received 821.2mm of rainfall during the entire cropping period. The maximum temperature during this period varied between 26.5˚C in first week of October and 32.3˚C in the second week of August, whereas, minimum temperature varied between 21.6˚C in the third week of August and 28.6˚C in the second week of August.

Relative humidity throughout the cropping season varied between 87 and 97 percent in the morning and 67 and 89 percent in the evening. The wind velocity during cropping period varied between 2.5 km per hour in third week of September and 9.4 km per hour in second week of August.

Table 3.1: Weekly meteorological data during crop growth period (from 16 July, 2016 to 7 Oct, 2016)

SMW	Month	Date	Temperature (^{o}C)		Rainfall (mm)	Relative Humidity (%)		Wind Velocity (Km/h)
			Max.	Min.		I	II	
29	Jul	16-22	30.6	24.5	207.0	94	79	6.1
30		23-29	31.9	25.4	56.2	91	69	3.9
31		30-05	30.7	25.3	28.0	92	81	7.0
32	Aug	06-12	32.3	28.6	22.0	91	77	8.7
33		13-19	28.7	21.6	11.6	89	77	9.4
34		20-26	31.9	25.6	4.2	90	70	5.0
35		27-02	32.2	26.0	22.2	90	67	3.6
36	Sep	03-09	30.7	25.3	62.8	87	68	5.9
37		10-16	31.1	24.3	132.8	95	80	2.9
38		17-23	32.2	24.9	91.6	94	69	2.5
39		24-30	30.0	24.5	134.6	97	89	2.8
40	Oct	01-07	26.5	24.8	48.2	95	72	2.7

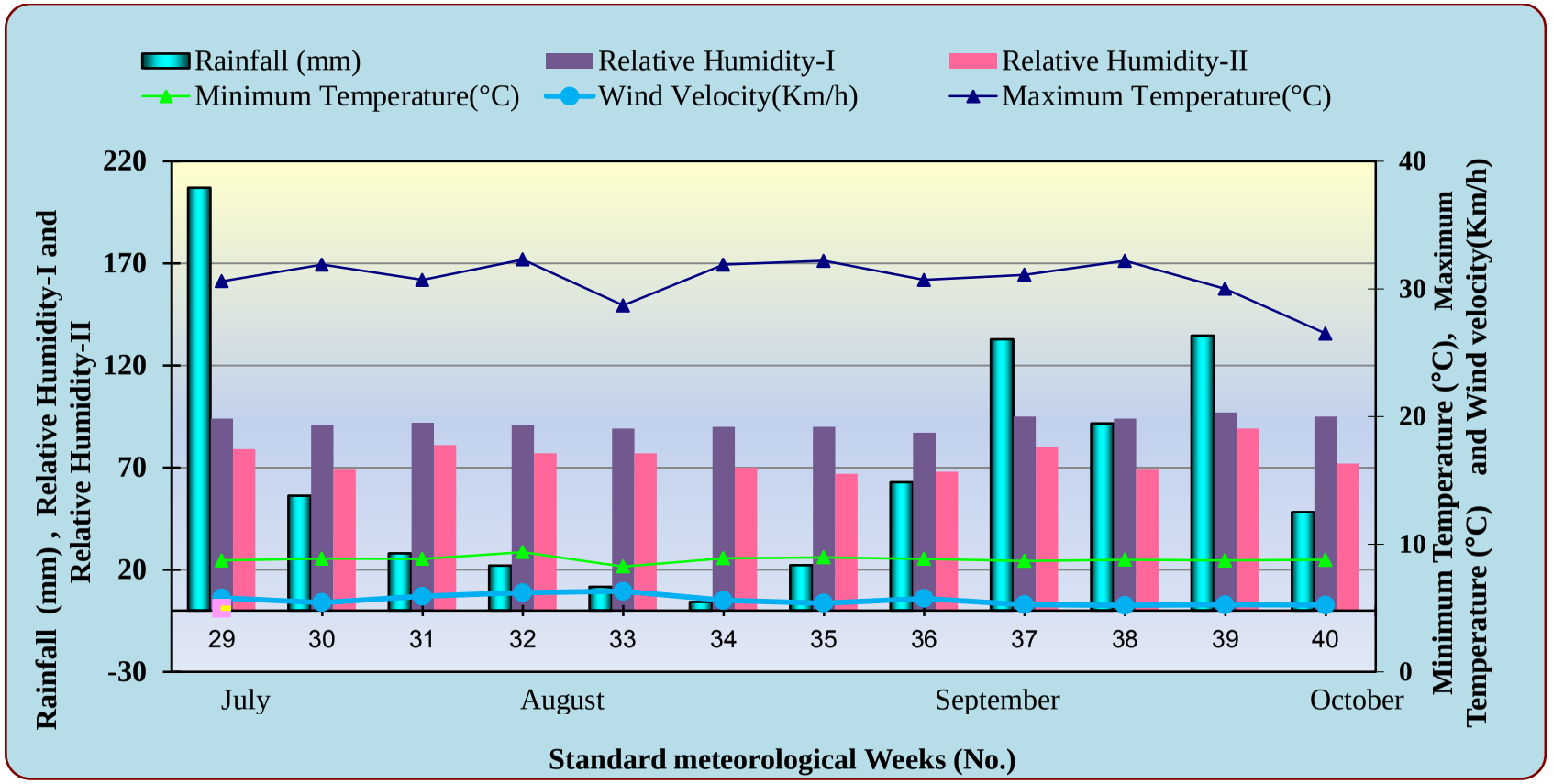

Fig.3.1: Weekly meteorological data during crop growth period (from 16 July, 2016 to 7 Oct, 2016)

3.4 Cultural Operation:

3.4.1 Field preparation

The subject has obtained good tilt and growth in the crop by preparing fields through the methods of cross ploughing with the help of tractor just after the first monsoon rain followed by harrowing and planking. In addition to that removal of weed and crop residues were done to get weed and stubble-free seed bed.

To obtain fine tilt and good crop growth, the field was prepared by cross ploughing with tractor drawn cultivator after the first shower of monsoon followed by harrowing and planking. The weed and crop residues were removed to get weed and stubble-free seed bed.

3.4.2 Sowing

Seeds were drilled in rows 30 cm apart and 10 cm between plants.

3.4.3 Fertilizer

Recommended dose of fertilizer 20:80:20 kg N, P, K per hectare has been applied to the crop. The N, P and K were applied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively, as basal dose applied in furrows at the time of sowing.

3.4.4 Weed control

One manual hand weeding at 35 DAS was done to keep the experimental plots weed-free.

3.4.5 Harvesting

Harvesting was done, when the leaves turned yellow and finally dried out as well as seeds became hard enough, on 23th October 2016, with the help of sickle at 3-

4 cm above the ground level. A net area was harvested manually and the crop was left in the field for sun drying.

3.4.6 Threshing

The plot-wise harvested produce was separately stocked and scattered on threshing floor for proper drying. When the produce was dried completely, then it was threshed plot wise. After threshing, seed yield was recorded plot-wise.

3.5 Experimental details

Researcher has done Experiments to study the seasonal incidence of major insect pests of soybean and their biocontrol agents, influence of ambient weather on the incidence of major insect pests and their bioagents, to find out the performance of genotype, bioefficacy evaluation of plant products as against major insect pests, and assessment of benefit cost ratio.

Table 3.2: Cultural schedule followed in different experiments.

S. No.	Cultural operation	Implements/ Methods used	Date
1.	Ploughing and harrowing	Tractor-drawn cultivator and disc harrow	June 25, 2016
2.	Planking and leveling	Tractor drawn planking	June 28, 2016
3.	Layout and channel preparation	Steel tap and manually	June 29, 2016
4.	Sowing and fertilizer application	Manually	June 30, 2016
5.	Weeding	Manually	August 04, 2016
6.	Harvesting	Manually	October 23, 2016
7.	Threshing	Manually	October 26, 2016

3.5.1 Seasonal incidence of major insect-pests and their bio-control agents:

Seasonal incidence of major insect-pests infesting soybean were recorded at weekly intervals, from field during *Kharif* season 2016. Soybean variety JS- 97-52 was sown 28 June 2016. The plot size was 100 sq. meter. All the recommended agronomic practices were followed to grow the crop except the measures for insect pest control. Observations on major insect-pests of soybean were taken at an interval of 7 days; using suitable techniques for different insects as explained below:

a. Defoliator pests

Observation for defoliators was recorded by counting the number of larvae or caterpillars found in one meter row length by shaking the plants. Such observation were recorded at weekly interval at randomly selected 10 places (leaving border rows) and thereafter mean number of larvae per meter row was calculated.

b. Sucking pests

Observations on number of plants infested by sucking pests *i.e.* whiteflies, and thrips from randomly selected ten plants and insect count were recorded from three leaves, (upper, middle and bottom part of the plant). Later, mean number of sucking pests per plant was calculated.

c. Natural Enemies

Natural enemies (particularly coccinellids, spiders and predatory bug) population was recorded from randomly selected ten plants.

3.5.1.1 Influence of ambient weather on the incidence of major insect pests and their bio-agents.

Weekly meteorological data on temperature, relative humidity, rainfall and wind velocity were recorded during the cropping season. The incidence of major insect pests of soybean and their natural enemies was correlated with ambient weather,

to find out the effect of weather on the density of insect pests and their natural enemies.

3.5.2 To find out the performance of soybean genotypes against major insect pests.

The performance of soybean genotype was done under two categories, the initial varietal trial (IVT) and advanced varietal trial (AVT). In initial varietal trial thirty nine entries of soybean were screened against caterpiller and sucking pests of soybean in which each entry was sown in two rows, each of 5 meter length with a row to row spacing of 30 cm. Entries from 1-35 were coded. There were four checks entries - RKS-18, Bragg, JS335, and JS-97-52 and these entries were replicated twice.

In advanced varietal trial, twenty four entries of soybean were screened against caterpiller and sucking pests of soybean under randomized block design in which each entry was sown in three rows of 3 meter length with a row to row spacing of 30 cm. This trial comprised of 20 test entries and four checks (RKS-18, Bragg, JS 335 and JS-97-52). The entries were sown in two replications.

The crop was sown on 28th june 2016 (IVT) and (AVT) to evaluate the incidence of major insect pests of soybean during *kharif* season. All the recommended packages and practices were followed in establishing the plants except the insect pests control measures. In IVT entry nos. 1-35 were coded and denoted as V1 to V35. The variety name of entry no.36 to39 is listed in table 3.3 and layout of the experiment is given in fig 3.2 and fig. 3.3.

Table 3.3: Name of check entries against major insect-pests of soybean.

Sl. No.	Entry No.	Name
1.	V 36	RKS – 18
2.	V 37	Bragg
3.	V 38	JS-335
4.	V 39	JS-97-52

3.5.2.1 Observations Recorded

The observations were taken during cropping period by counting number of caterpillar pests from five randomly selected places of one meter row length from each plot at maximum infestation by insect pests. Similarly, for sucking pests; from each plot, five plants were selected randomly and insect count was recorded from three leaves; (upper, middle and bottom part of the plant).

3.5.3 To study the relative bio-efficacy of plant products against major insect pests.

A field experiment was laid out in randomized block design with nine treatments including untreated control replicated three times. The crop was sown on 1st July, 2016 in plot size of 5 m × 4m. In this experiment,observations were recorded the efficacy of treatments one day before the spray and one day after, 3, 7, and 15 days of first and second spraying of plant products.

Defoliator pests: Tobacco caterpillar and green semilooper were observed as the major defoliator pests. The observation of these pests was recorded by counting the no. of larvae per meter row length.

Sucking pests: The observations on sucking pests, whiteflies and thrips were taken from three leaves, (upper, middle and bottom part of the plant) and whole plant was taken for thrips and whiteflies population in randomly selected ten plants.

3.5.3.1 To study the relative bio-efficacy of plant products against major insect pests.

Experimental details:

Design : Randomized Block Design

Treatment : 10

Replication : 3

Spacing : 30 cm row length

Plot size : 5mx4m.

Variety : JS 97-52

Table 3.4: Details of of plant products for bioefficacy evaluation against insect pests of soybean:

Sl. No.	Insecticides	Dose	Quantity Per Hectare
1.	Neem oil	2%	10 lt
2.	Karanj oil	2%	10 lt
3.	NSKE	5%	25 lt
4.	Karanj seed extract	2.5%	12.5 lt
5.	Garlic+green chilli (0.5 kg + 3 kg)	8.75 kg/ha	8.75 kg
6.	Green chilli	10 kg/ha	10 kg
7.	Red chilli	2 kg/ha	2 kg
8.	Mahua oil	2%	10 lt
9.	Triazophos 40 EC	1.5 ml/lit	750 ml
10.	Control	-	-

3.5.4 Assessment of benefit cost ratio

For benefit cost analysis, record of costs incurred in each treatment and that of control were maintained. It was to be noted here that expenses incurred referred to

those only on pest management *i.e.* cost of insecticides and labour charges for insecticide spraying. The price and expences of the harvested crop of each treatment and that of control were also calculated at the then existing market rate. Thereafter, Benefit cost ratio (B:C ratio) was calculated by the estimation of different pest management cost by adjusting with the control condition *i.e.*

B**:** C ratio = Adjusted net return (Rs/ha)/Cost of pest management (Rs/ha).

Where,

Adjusted net return (Rs/ha)

= [Net return from individual treated plot (Rs/ha) –Net return from untreated control plot (Rs/ha)].

Cost of pest management (Rs/ha)

= Cost of insecticide + Labour charges per hectare.

3.5.5 Statistical analysis

The researcher has mentioned all the above three experiments in Randomized Block Design. The data obtained were transformed using square root transformation, by the formula (+ 0.5). This transformed data was then analyzed by the method of analysis of variance as described by Gomez and Gomez (1984). The "F" test was used at 5 per cent level of significance. Critical difference (CD) values were analyzed at 5 per cent level of significance. The skeleton of analysis of variance and formula used for various estimations are given in table 3.4

Table 3.5: Skeleton of analysis of variance for bioefficacy evaluation trials.

Source of variation	d.f.	SS	MSS	Fcal	Ftab	S.Em±	CD (5%)
Replication (R)	(R – 1)						
Treatment (T)	(T – 1)						
Error (E)	(R – 1) (T – 1)						
Total	RT – 1						

The following formulae were used for the estimation of standard error, critical difference and coefficient of variance:

a. S.Em ± = $\sqrt{\frac{EMS}{R}}$ b. C.D. = $\sqrt{\frac{2EMS}{R}} \times {}_{or\ d.f.(5\%)}$

c. C.V.(%) = $\frac{\sqrt{EMS}}{GM} \times 100$

Where,

R = Number of replications, D.F = Degree of freedom

T = Number of treatments, S.S. = Sum of square

C.D. = Critical difference, C.V. = Coefficient of variance

M.S.S = Mean sum of squares, E.M.S. = Error mean square

S.Em ± = Standard error of mean, G.M. = Grand mean

CHAPTER- IV

RESULTS AND DISCUSSION

The researcher has conducted the experiments on various aspects of present study entitled "Studies on seasonal incidence of major insect pests of soybean and its bio-rational management" during *Kharif* season of 2016 at research area of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The results are presented under following heads:

4.1 To study the seasonal incidence of major insect-pests of soybean and their bio-control agents.

4.2 To find out the performance of soybean genotypes against major insect pests.

4.3 To study the relative bio-efficacy of plant products against major insect pests.

4.4 To work out the benefit cost ratio of plant products.

4.1 To Study the Seasonal Incidence of Major Insect-Pests of Soybean and their Bio-Control Agents.

According to the studies on the seasonal incidence of insect-pests of soybean crop on variety JS- 97-52, the occurrence of insect-pests complex began from 21 days after sowing. Observations on pests incidence were recorded from last week of July to second week of October. During this period population of each insect was recorded on soybean crop as per the procedure mentioned under "Materials and Methods".

During the study it has been observed that four species of insect-pests *viz*., tobacco caterpillar, *Spodoptera litura* Fabricius; green semilooper, *Chrysodeixis acuta* Walker; white fly, *Bemisia tabaci* Gennadius; and thrips, *Thrips tabaci* attacked on soybean crop causing damage at various growth stages. Among the bio-control agents, two predators, namely lady bird beetle, *Menochilus sexmaculata* and *Coccinella septumpunctata*; spiders - *Oxyopes* sp. and *Neoscona* sp., and a predatory pentatomid bug- *Eocanthecona furcellata*, were mainly observed preying on them. The

observations were recorded on seasonal incidence of major insect-pests and their bio-control agents, *i.e. Kharif*, 2016 have been presented in table 4.1 and fig.4.1.

4.1.1 Pests Succession Studies

(A) Insect-pests Fauna

(i) Defoliators

Two major defoliators *viz.*, tobacco caterpillar, *S. litura* and green semilooper, *C. acuta* feeding on the foliage of the crop were observed.

(a)Tobacco caterpillar- *S. litura* (Lepidoptera: Noctuidae)

It made its first appearance on last week of July with mean population of 0.5 larva per meter row length. The pest density increased gradually and attained the peak in the second week of September with 1.9 larvae with a seasonal mean of 0.50 larva per meter row. There was a gradual decline in the population, which disappeared completely after the first week of October.

(b) Green semilooper- *C. acuta* (Lepidoptera: Noctuidae)

The attack of *C. acuta* was first recorded on the crop in first week of August with mean population of 0.1 larva per meter row length. The pest density increased gradually and attained the peak in the first week of September with 2.1 larvae with a seasonal mean of 0.67 larva per meter row. Thereafter the population of the pest decreased gradually and disappeared due to senescence of the crop after the sec week of October.

(ii) Sucking Pests:

(a) White fly - *B. tabaci* (Hemiptera: Aleyrodidae)

Of the two sucking pest, white fly was the major pest. Its population ranged from 1.3 to 9.1nymphs and adults/ three leaves/ plant with seasonal mean of 4.89 flies. It was first appeared on the crop in the third week of July with a mean population of 1.3 flies. Thereafter, the density of whitefly increased gradually with a peak of 9.1 flies in the last week of September 2016.

Table 4.1: Seasonal incidence of major insect pests and predators on soybean variety JS- 97-52 during *kharif*, 2016.

Date of observation	SMW	No. of sucking pest / three leaves			No. of predators per plant					
		No. of Caterpillar			*Bemisia tabaci*	Thrips	Total	C. Beetle	Pentatomid bug	Spider
		S.litura	*C. acuta*	Total						
21.07.16	29	0.0	0.0	0.0	1.3	0.1	1.4	0.0	0.0	0.1
28.07.16	30	0.5	0.0	0.5	1.8	0.7	2.5	0.0	0.1	0.3
04.08.16	31	0.0	0.1	0.1	1.6	0.6	2.2	0.0	0.0	0.6
11.08.16	32	0.5	0.1	0.6	4.7	1.5	6.2	0.5	0.0	0.8
18.08.16	33	0.8	0.8	1.6	6.4	1.6	8.0	0.5	0.6	1.1
25.08.16	34	0.6	0.8	1.4	8.8	3.2	12	0.5	0.7	0.7
01.09.16	35	0.2	1.8	2.0	7.5	4.1	11.6	0.4	0.0	2.7
08.09.16	36	0.7	2.1	2.8	4.3	0.0	4.3	0.2	0.1	0.5
15.09.16	37	1.9	1.6	3.5	7.0	3.1	10.1	0.9	0.3	2.3
23.09.16	38	0.6	0.4	1	9.1	3.4	12.5	1.0	0.5	1.4
01.10.16	39	0.3	0.4	0.7	6.2	3.4	9.6	0.7	0.1	1.0
07.10.16	40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Seasonal mean	-	0.50	0.675	1.183	4.89	1.808	6.7	0.39	0.20	0.975

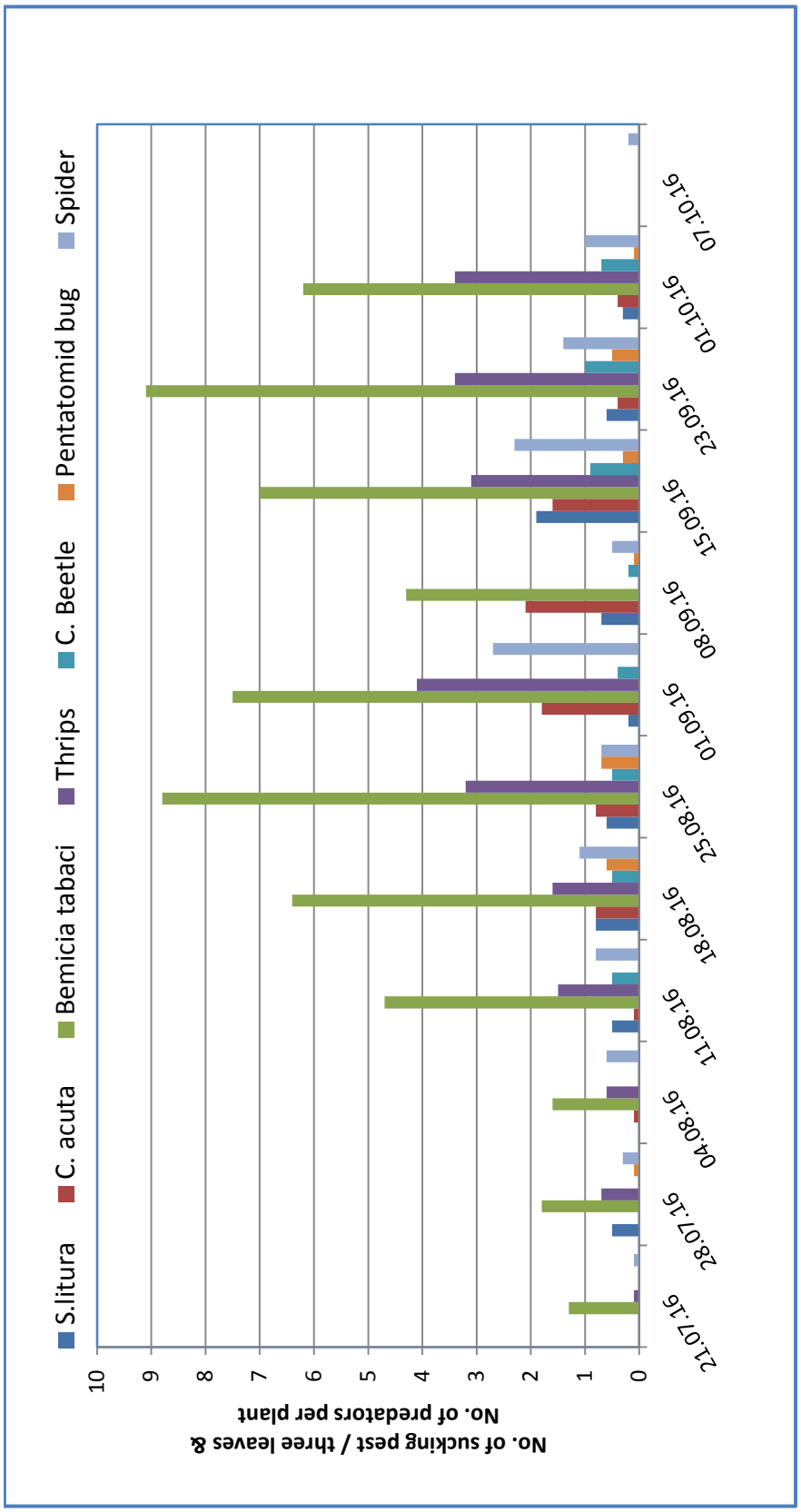

Fig 4.1 : Seasonal incidence of major insect-pests and predators on soybean variety JS-92-57 during *Kharif* 2016

Table 4.2: Insect-pests fauna observed on Soybean variety JS- 97-52 during *Kharif*, 2016.

S.No.	Common Name	Systemic Position	Damaging Stage	Range of Incidence	Status of Peak activity
1.	Tobacco caterpillar	*Spodoptera litura* (Lepidoptera : Noctuidae)	Caterpillar	0 to 1.9 (Caterpillars/ m. row)	Third week of September
2.	Green semilooper	*Chrysodecxis acuta* (Lepidoptera : Noctuidae)	Caterpillar	0 to 2.1 (Caterpillars/ m. row)	First week of September
3.	White fly	*Bemisia tabaci* (Hemiptera : Aleyrodidae)	Nymph and Adult	0 to 9.1 (flies /three leaves)	Last week of September
4.	Thrips	*Thrips tabaci* (Hemiptera : Thripidae)	Nymph and Adult	0 to 3.4 (thrips/ plant)	Last week of September to first week of October

(b) Thrips - *Thrips tabaci* (Thysanoptera: Thripidae)

The infestation of thrips started in the last week of July with a mean population of 0.1 and its population ranged from 0.1 to 4.1 nymphs and adults per plant with seasonal mean of 1.80. Thereafter, the density of thrips decreased gradually after third week of August.

Singh (1996) reported a severe infestation of green semilooper, feeding on buds, flowers and pods of soybean in Raisen, Hoshangabad and Narsinghpur districts of MP .

Kumar *et al.* (1998) estimated the population density of some insects associated with soybean and they also reported that the population densities of *Spilosoma oblique* (Walker) and *Spodoptera litura* (Feb.) during the crop growth period were maximum around the second half of October. However, densities of *Empoasca* sp and thrips were maximum during the later part of September or early October.

Similar observations were also recorded by Ahirwar (2013), Kujur (2011) and Netam (2010). Thus, these observations are in conformity with the present findings.

(B) Predatory fauna of soybean pests

Soybean is mainly attacked by girdle tobacco caterpillar, green semilooper, whitefly, and thrips at different growth stages of the crop. To assess the potential of biological control of these insect pests on soybean, study was undertaken during *Kharif*, 2016. It revealed the following predatory fauna on these insects.

(a) Lady bird beetle

Two species of lady bird beetle, *M. sexmuculata* and *C. septumpunctata* were recorded as the major bioagents of the sucking pests. They made their first appearance on the crop in the second week of August with 0.5 grub and adult per plant. They were observed feeding on nymphs and adults of thrips and whiteflies. Their activity continued till the first week of October and peak activity was observed in last week of September with 1.0 grub and adult per plant.

Table 4.3: Predatory fauna observed on Soybean variety JS- 97-52 during *Kharif*, 2016

S.No.	Common name	Systemic position	Insect pests preyed	Range of incidence	Status of peak activity
1.	Lady bird beetle	a) *Menochilus sexmaculata*	Whiteflies,and Thrips	0 to 1.0 (beetles/plant)	Lasts week of September
		b) *Coccinella septumpunctata* (Coleopteran :Coccinellidae)	Whiteflies,and Thrips		
2.	Pentatomid bug	*Eocanthecona furcellata* (Hemiptera: Pentatomidae)	Lepidopterous caterpillars	0 to 0.7 (bugs/meter row)	Last week of August
3.	Spiders – (a) Lynx spider	*Oxyopes satticus* (Araneae: Oxyopidae)	Lepidopterous caterpillars	0.1 to 2.7 (Spiders/meter row)	first week of September
	(b) Orb weaver spider	*Neoscona sp.* (Araneae: Araneidae)	Whitefliesand thrips		

(b) Predatory Pentatomid bug

The Pentatomid bug, *Eocanthecona furcellata* was observed to suck the body sap of caterpillar pests. It made its first appearance on the crop in the last week of July with 0.1 bug per plant. Its density increased gradually with the peak population of 0.7 bug in the last week of August and a seasonal mean of 0.39 bug. It coincide with the peak activity of caterpillar pests on the crop.

(c) Spiders

Besides the lady bird beetle and pentatomid bug, two predatory spiders, namely, lynx spider and orb weaver spider were found preying upon lepidopterous caterpillars and sucking pests, respectively. *Oxyopes* sp. is a hunting spider, whereas, *Neoscona* sp. is a web building spider.

The spiders made their first appearance on the crop in the last week of July with mean population of 0.1 spider per plant. It coincided with the appearance of host insects on the crop. They were active throughout the growth period of the crop, till the second week of October. Their population ranged from 0.1 to 2.3 spiders with a seasonal mean of 0.97 spider per plant. The spiders disappeared from the crop with the disappearance of their host insects.

To observe the effect of predatory population on the activity of the insect pests, the population of predators *i.e.* coccinellid beetles, pentatomid bugs and spiders was co-related with the population of lepidopterous caterpillars and sucking pests.

Correlation between coccinelid beetles and total sucking pests (*B. tabaci,* and *T. tabaci)* was found to be positive and significant at 5 per cent level with ‘r’ value 0.867. Similarly, the correlation coefficient between spiders and total sucking pests was found to be positive and significant at 5 per cent level with ‘r’ value 0.740.

Correlation between lepidopterous pests (*S. litura, and C. acuta)* and spiders was also found to be positive and significant at 5 percent level with ‘r’ values 0.652. Further correlation between predatory pentatomid bug and lepidopterous pests was also found to be positive but non significant at 5 percent with ‘r’ values 0.327.

Table 4.4: Influence of natural predatory fauna on the incidence of caterpillars and sucking pests infesting soybean during, *Kharif*, 2016.

S.No.	Date of Observation	No. of predators per plant			Incidence of insect pests	
		Coccinellid beetle	Eocanthecona bug	Spiders	No of caterpillar per meter row	No of sucking pest/ three leaves
1.	21-07-2016	0.0	0.0	0.1	0.0	1.4
2.	28-07-2016	0.0	0.1	0.3	0.5	2.5
3.	04-08-2016	0.0	0.0	0.6	0.1	2.2
4.	11-08-2016	0.5	0.0	0.8	0.6	6.2
5.	18-08-2016	0.5	0.6	1.1	1.6	8.0
6.	25-08-2016	0.5	0.7	0.7	1.4	12.0
7.	01-09-2016	0.4	0.0	2.7	2.0	11.06
8.	08-09-2016	0.2	0.1	0.5	2.8	4.3
9.	15-09-2016	0.9	0.3	2.3	3.5	10.1
10.	23-09-2016	1.0	0.5	1.4	1.0	12.5
11.	01-09-2016	0.7	0.1	1.0	0.7	9.6
12.	07-10-2016	0.0	0.0	0.2	0.0	0.0
			Coccinellid beetle per plant		-	0.867*
	Correlation coefficient (r) =		Pentatomid bug per plant		0.327	-
			Spiders per plant		0.652*	0.740*

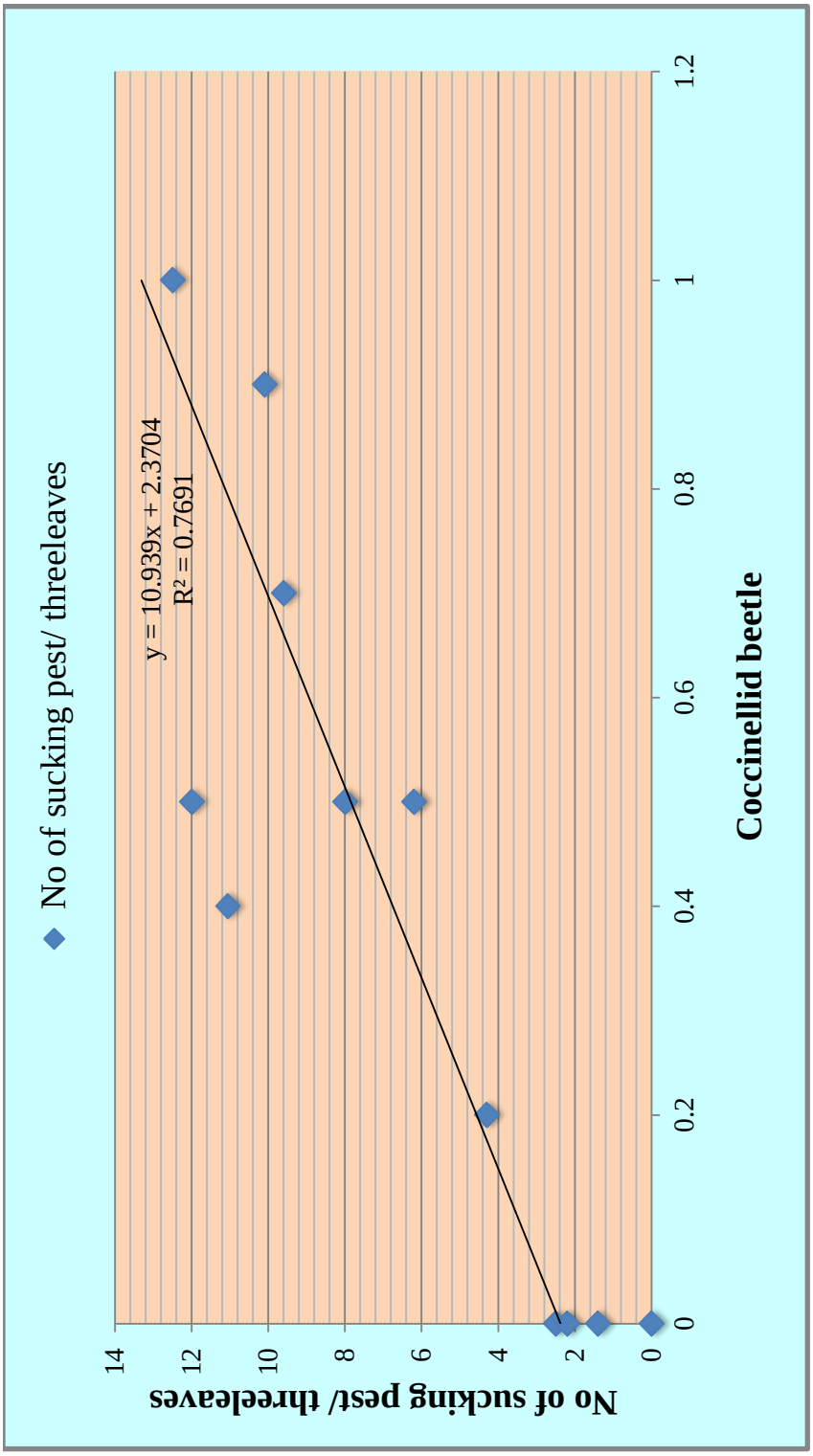

Fig. 4.2 : Regression of total sucking pest per plant on Coccinellid beetle.

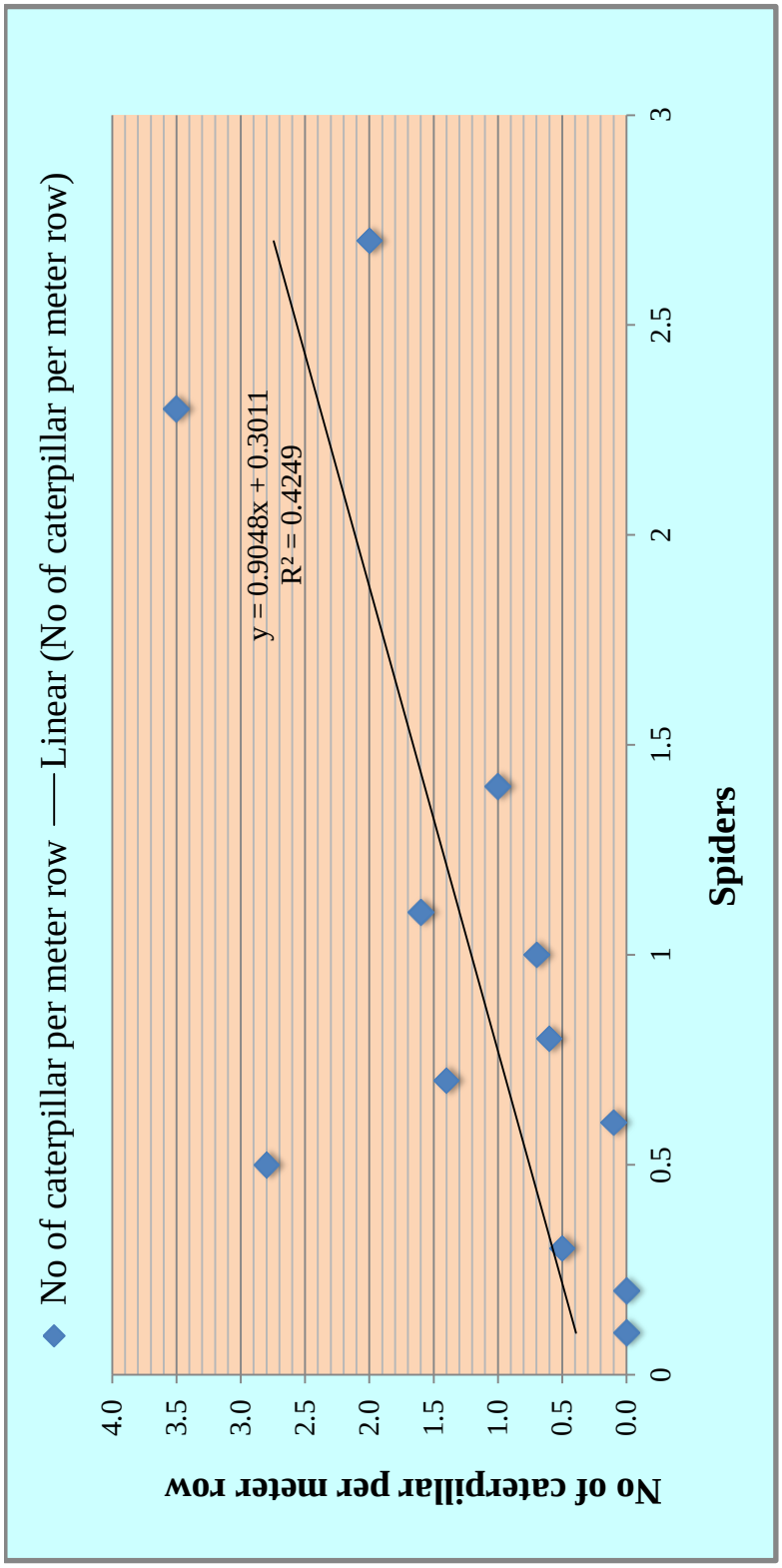

Fig. 4.3 : Regression of total caterpillar per metre row length on spider.

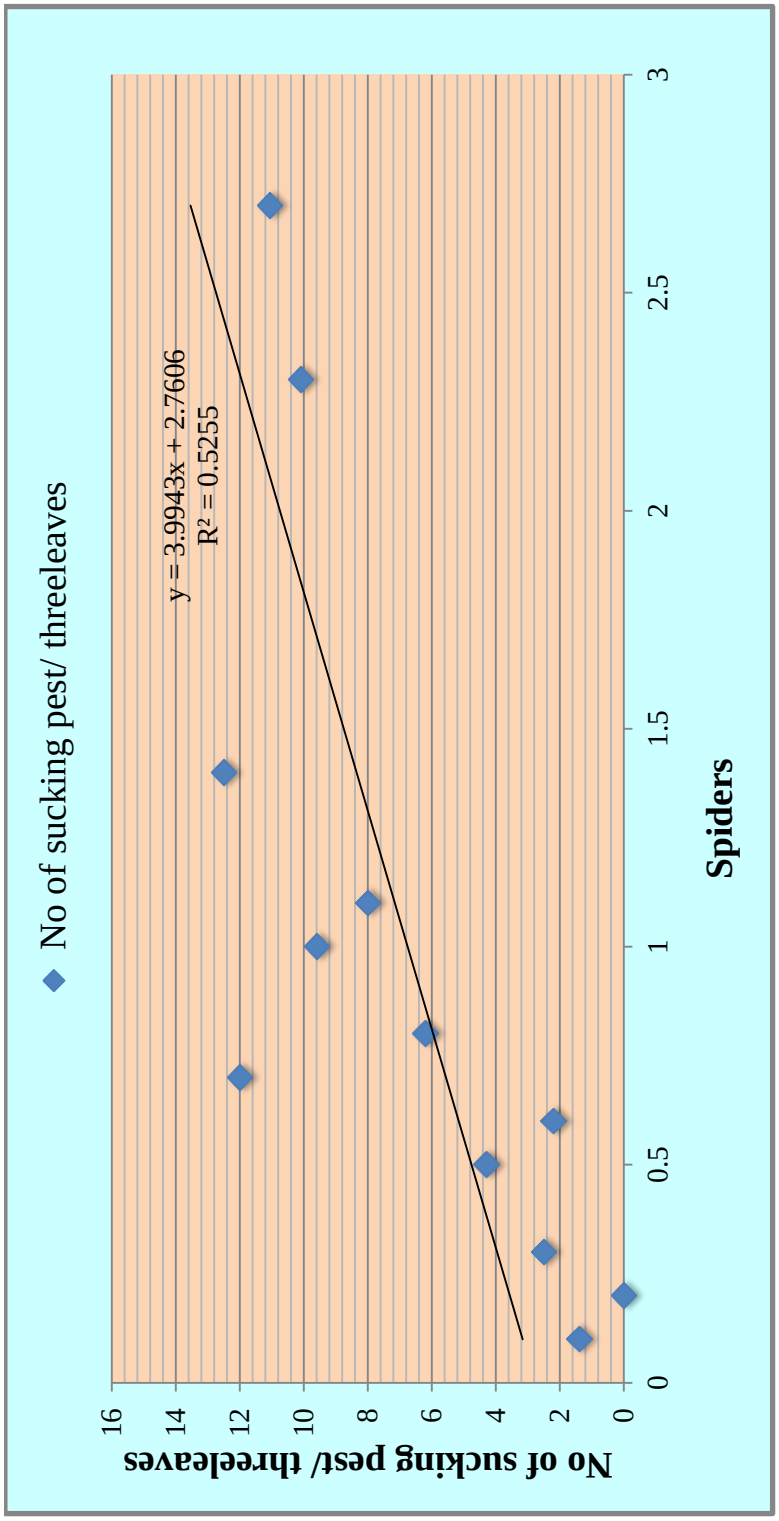

Fig. 4.4 : Regression of total sucking pest per plant on spider.

Similar results were reported by Van den berg and Shepard Nasikin (1998) during their studies the natural enemy population increased with increase in host density, although, there was no evidence of density dependence.

Netam (2010) and Kujur (2011) also observed positive but non-significant correlations between predatory fauna and incidence of soybean insect-pests *i.e.* lepidopterous caterpillars and sucking pests, during the course of his investigation.

Gardiner *et al.* (2011) observed that in Michigan, the exotic coccinellids *Coccinella septempunctata* and *Harmonia axyridis* were the most abundant predators found in soybean fields.

The present results are also confirmed with the findings of Ahirwar (2013) who observed positive and significant correlation between predatory population of spider and lepidopterous pests and similarly, a positive and significant correlation between predatory population of pentatomid bugs and lepidopterous pests and correlation between coccinellid beetles and total sucking pests was found to be positive and significant.

The correlation coefficient between spiders and total sucking pests was found to be positive but non-significant during the course of his investigation.

4.1.2 Influence of ambient weather on the incidence of major insect pests and their bio-agents:

The influence of different weather parameters *viz.* maximum and minimum temperature, morning and evening relative humidity, rainfall and wind velocity on the seasonal incidence of caterpillars, and sucking pests *viz.* white fly, and thrips were observed. Population of caterpillars was recorded on 10 randomly selected one meter row length. However, sucking pest population per plant was recorded on 10 randomly selected plants. It was statistically correlated by working out correlation coefficient (r) and regression equation, $Y = a + bx$.

(a) Caterpillar pests as influenced by different weather parameters.

(i) Maximum Temperature

Correlation between number of lepidopterous larvae per meter row length and maximum temperature was found to be positive but non-significant at 5% level with "r" value (r = (0.235). The peak activity of the caterpillar pests was associated with mean maximum temperature of 31.1°C.

(ii) Minimum Temperature

Correlation between number of defoliator larvae per meter row length and minimum temperature was found to be negative but non-significant at 5% level with "r" value (r =(-) 0.165). The maximum activity of the defoliator pests was associated with mean minimum temperature of 24.3°C.

(iii) Morning Relative Humidity

Number of defoliator larvae per meter row length was negative but non significantly correlated with mean relative humidity of morning at 5% level with "r" value =(-) 0.327. The peak density of sucking pests was associated with 95 % mean relative humidity.

(iv) Evening Relative Humidity

The correlation coefficient between number of defoliator larvae per meter row length and mean relative humidity of evening was found to be negatively correlated "r" =(-) 0.203 but non-significant at 5% level. The peak density of sucking pests was associated with 80 % mean evening relative humidity.

(v) Rainfall

The correlation coefficient between the number of defoliator larvae per meter row length and total rainfall was found to be negative but non-significant at 5% level with "r" value (-) 0.042. The maximum activity of the defoliator pests was recorded with 132.8 mm rainfall.

Table 4.5: Influence of different weather parameters on defoliator pests (*S. litura* & *C. acuta*) of soybean during *Kharif*, 2016.

SMW	Date	No. of total caterpillar pests per meter row.	Temperature (°C)		Relative humidity (%)		Rain fall (mm)	Wind Velocity (Km/h)
			Max.	Min.	Morning	Evening		
29	21-07-2016	0.0	30.6	24.5	94	79	207.0	6.1
30	28-07-2016	0.5	31.9	25.4	91	69	56.2	3.9
31	05-08-2016	0.1	30.7	25.3	92	81	28.0	7.0
32	11-08-2016	0.6	32.3	28.6	91	77	22.0	8.7
33	18-08-2016	1.6	28.7	21.6	89	77	11.6	9.4
34	25-08-2016	1.4	31.9	25.6	90	70	4.2	5.0
35	02-09-2016	2.0	32.2	26.0	90	67	22.2	3.6
36	08-09-2016	2.8	30.7	25.3	87	68	62.8	5.9
37	15-09-2016	3.5	31.1	24.3	95	80	132.8	2.9
38	23-09-2016	1.0	32.2	24.9	94	69	91.6	2.5
39	01-10-2016	0.7	30.0	24.5	97	89	134.6	2.8
40	07-10-2016	0.0	26.5	24.8	95	72	48.2	2.7
	Correlation coefficient (r) =		0.235	-0.165	0.327	-203	-0.042	-0.113

(vi) Wind velocity

The correlation coefficient between number of defoliator larvae per meter row length and wind velocity was found to be negatively correlated r = (-) 0.113 but non-significant at 5% level. The peak larval activity of the pests was was associated with 2.9 km per h.

(b) Sucking pests as influenced by different weather parameters.

(i) Maximum Temperature

The association between number of sucking pests per plant and maximum temperature was worked out. It was found to be positive but non significant at 5% level with "r" value 0.494. The peak activity of sucking pests was associated with 32.2^{0C} maximum temperature.

(ii) Minimum Temperature

The association between number of sucking pests per plant and minimum temperature was worked out. The two variables were found to be negatively correlated with "r" value (r =(-) 0.295) and non significant at 5% level. The peak activity of sucking pests was recorded in the last week of August which was associated with 24.9°C.

(iii) Morning Relative Humidity

The population of sucking pests per plant was negatively but non-significantly correlated with mean relative humidity of morning at 5% level with "r" value =(-) 0.014. The peak density of sucking pests was associated with 94 % mean relative humidity.

(iv) Evening Relative Humidity

The correlation coefficient between number of sucking pests per plant and mean relative humidity of evening was found to be negatively correlated "r" =(-) 0.082 but non significant at 5% level. The peak density of sucking pests was associated with 69 % mean evening relative humidity.

Table 4.6: Influence of different weather parameters on sucking pests (*B. tabaci, and T. tabaci)* of soybean during *Kharif*, 2016.

SMW	Date	No. of sucking pests per plant	Temperature (^{0}c)		Relative humidity (%)		Rain fall (mm)	Wind Velocity (Km/h)
			Max.	Min.	Morning	Evening		
29	21-07-2016	1.4	30.6	24.5	94	79	207.0	6.1
30	28-07-2016	2.5	31.9	25.4	91	69	56.2	3.9
31	05-08-2016	2.2	30.7	25.3	92	81	28.0	7.0
32	11-08-2016	6.2	32.3	28.6	91	77	22.0	8.7
33	18-08-2016	8.0	28.7	21.6	89	77	11.6	9.4
34	25-08-2016	12.0	31.9	25.6	90	70	4.2	5.0
35	01-09-2016	11.6	32.2	26.0	90	67	22.2	3.6
36	08-09-2016	4.3	30.7	25.3	87	68	62.8	5.9
37	15-09-2016	10.1	31.1	24.3	95	80	132.8	2.9
38	23-09-2016	12.5	32.2	24.9	94	69	91.6	2.5
39	01-10-2016	9.6	30.0	24.5	97	89	134.6	2.8
40	07-10-2016	0.0	26.5	24.8	95	72	48.2	2.7
	Correlation coefficient (r) =		0.494	-0.029	-0.014	-0.082	-0.138	-0.235

(v) Rainfall

The correlation coefficient between number of sucking pests per plant and total rainfall was worked out and was found to be negative but non-significant with "r" value(r = (-) 0.138). The peak density of sucking pests was associated with 91.6 mm mean rainfall.

(vi) Wind velocity

The correlation coefficient between number of sucking pests per plant and wind velocity was worked out and was negative correlated with "r" value =(-) 0.235 but non-significant at 5% level. The peak density of sucking pests was associated with 2 .5 km per h wind velocity.

Sutaria *et al.* (2010) studied the correlation matrix indicated that none of the weather parameters was found significantly correlated with population of jassid on soybean during *Kharif* season of 2007.

(a) Bioagents as influenced by different weather parameters.

The correlation coefficient between the predatory population and different weather parameters *viz.*, maximum and minimum temperatures, morning and evening R.H., rainfall and wind velocity was worked out and found to be non significant.

Sharma *et al.* (1997) reported that the correlations of weather parameters with the population build-up of green semilooper, *Thysanoplusia orichalcea* (Fab.) and Bihar hairy caterpillar, *Spilosoma obliqua* (Walker) were non-significant.

El-Khouly *et al*. (1998) studied the combined effect of the weekly mean of predator populations, daily mean temperature, relative humidity and wind speed. It was responsible for 84.76, 73.9, 68.70 and 58% of changes in the populations of jassids, thrips, whitefly and aphids, respectively, in the first season, and for 79.40, 54.80, 66.30 and 45.8%, respectively, in the second season. Joshi and Patel (2010) observed non significant relationship between the insect pest population and the ambient weather on soybean.

Sutaria *et al.* (2010) also studied the correlation matrix indicated that none of the weather parameters was found significantly correlated with population of jassid on soybean during *Kharif* season of 2007.

Although, positive correlation existed between population of jassid and minimum temperature, morning and evening R.H. and sunshine hrs. While other factors *viz*., maximum temperature, rainfall and rainy days were negatively correlated.

Gaur *et al.* (2012) also reported that all the weather parameters were nonsignificantly related to incidence of *S.litura* and *O.brevis.*

Ahirwar (2013) observed a significantly positive correlation between total sucking pests and minimum temperature, evening relative humidity which confirm the present finding. A non significant correlation of tobacco caterpillar was found with minimum temperature, relative humidity (afternoon) and evaporation by Patil *et al.* (2013).

4.2 To find out the performance of soybean genotypes against major insect pests.

The screening trial was conducted during *kharif*, 2016 under two categories, the initial varietal trial (IVT) and advanced varietal trial (AVT). The entries were screened as per the methodologies explained in "Material and Methods". The results on the response of the genotypes in the screening trials are presented in the following paragraphs.

4.2.1 IVT screening trial:

The data of the insect-pests infestation recorded in entry no. 1 to 35, along with the checks entries viz., RKS-18, Bragg, JS-335, and JS-97-52 have been presented in Table 4.8a and the results are as follows:

The thirty nine genotypes were screened for resistance against major caterpillar pests, i.e. tobacco caterpillar (*S. litura*), and semilooper (*C. acuta*) . Among the different genotypes, JS-21-05 with the mean value of 0.1 larvae per meter row was least preferred by S. litura. It was followed by RSC-10-71 with 0.2 larvae per meter row and also by PS-1589, RVS-2009-9, KDS-921, MAUS-771 and TS-70 each with 0.3 larvae per meter row and DSB-32, MACS-1520.

PS-1587, KDS-921, NRC-25, PS-1086, VLS-93, NRC-25, and RSC-10-52, each with 0.4 larvae per meter row. Among the test entries, genotype VLS-92 1.10 larvae per meter row was most attacked by tobacco caterpillar, as against 0.4 to 0.9 larvae per meter row in check varieties.

Table 4.7: Bioagents (C. beetle, Pentatomid bug and Spider) on soybean crop as influenced by different weather parameters during *Kharif*, 2016.

SMW	Date	No. of predators per plant			Temperature (°C)		Relative humidity (%)		Rain fall (mm)	Wind velocity (km/h)
		c. beetle	Penta.bug	spider	Max.	Min.	Morning	Evening		
29	21-07-2016	0.0	0.0	0.1	30.6	24.5	94	79	207.0	6.1
30	28-07-2016	0.0	0.1	0.3	31.9	25.4	91	69	56.2	3.9
31	05-08-2016	0.0	0.0	0.6	30.7	25.3	92	81	28.0	7.0
32	11-08-2016	0.5	0.0	0.8	32.3	28.6	91	77	22.0	8.7
33	18-08-2016	0.5	0.6	1.1	28.7	21.6	89	77	11.6	9.4
34	25-08-2016	0.5	0.7	0.7	31.9	25.6	90	70	4.2	5.0
35	02-09-2016	0.4	0.0	2.7	32.2	26.0	90	67	22.2	3.6
36	08-09-2016	0.2	0.1	0.5	30.7	25.3	87	68	62.8	5.9
37	15-09-2016	0.9	0.3	2.3	31.1	24.3	95	80	132.8	2.9
38	23-09-2016	1.0	0.5	1.4	32.2	24.9	94	69	91.6	2.5
39	01-10-2016	0.7	0.1	1.0	30.0	24.5	97	89	134.6	2.8
40	07-10-2016	0	0.0	0.2	26.5	24.8	95	72	48.2	2.7
			c. beetle		0.328	0.086	0.260	0.150	0.099	0.261
Correlation coefficient (r) =			Penta.bug		0.098	0.450	0.191	0.172	0.245	0.062
				spider	0.355	0.029	-0.032	0.069	0.079	0.0.283

Table 4.8a: Field screening of IVT entries for resistance to major insect pests of Soybean during *Kharif* 2016.

S.No	Name of entries	Incidence per meter row length			No. of sucking pests per three leaves per plant			Grain Yield (gm/plot)
		Mean of Larvae/two rep.			*Bemisia tabaci*	*Thrips tabaci*	Total	
		S.litura	*C.acuta*	Total				
1	TS-80	0.60	1.0	1.6	4.4	4.2	8.6	215
2	JS21-08	0.80	1.1	1.9	4.2	3.8	8.0	415
3	VLS-92	1.10	1.4	2.5	4.0	4.0	8.0	175
4	PS-1589	0.30	0.7	1.0	2.1	4.2	6.3	225
5	MACS-1543	0.80	1.5	2.3	4.6	4.2	8.8	525
6	DS-3105	0.60	1.4	2.0	4.5	4.2	8.7	475
7	SL-1104	0.60	1.3	1.9	5.1	4.8	9.9	325
8	KDS-1045	0.70	1.2	1.9	4.3	6.0	10.3	490
9	DSb -32	0.40	0.9	1.3	4.7	4.2	8.9	590
10	RVS-2009-9	0.30	0.9	1.2	5.0	4.0	9.0	500
11	MACS-1520	0.4	0.8	1.2	3.9	5.0	8.9	570
12	PS-1587	0.4	0.8	1.2	4.7	3.4	8.1	415
13	NRC-126	0.5	0.8	1.3	3.9	3.2	7.1	675
14	RSC-10-70	0.7	1.5	2.2	4.7	4.2	8.9	490
15	KDS-921	0.3	1.3	1.6	4.1	3.2	7.3	375
16	Himso-1687	0.7	1.5	2.2	4.6	3.4	8.0	475
17	MAUS 711	0.3	0.9	1.2	3.9	3.2	7.1	490
18	NSO-626	0.8	0.8	1.6	3.2	2.8	6.0	550
19	AMS-MB 5-19	0.5	1.1	1.6	3.9	3.6	7.5	375
20	NRC-125	0.4	0.9	1.3	3.7	2.4	6.1	650

S.No	Name of entries	Incidence per meter row length			No. of sucking pests per three leaves per plant			Grain Yield (gm/plot)
		Mean of Larvae/two rep.			*Bemisia tabaci*	*Thrips tabaci*	Total	
		S.litura	*C.acuta*	Total				
21	RSC-10-71	0.2	0.9	1.1	4.8	4.0	8.8	637
22	PS-1086	0.4	1.0	1.4	5.5	5.60	11.1	175
23	TS-70	0.3	1.0	1.4	5.0	4.6	9.6	165
24	VLS-93	0.4	1.5	1.9	5.5	5.6	11.1	175
25	NRC-127	0.4	1.4	1.8	4.8	4.0	8.8	515
26	SL-1113	0.5	1.8	2.3	5.8	5.8	11.6	450
27	DS-3106	0.9	1.6	2.5	5.1	4.4	9.5	390
28	BAU-100	0.6	1.3	1.9	4.9	3.6	8.5	375
29	RSC-10-52	0.4	1.1	1.5	4.3	4.6	8.9	400
30	NRC-124	0.7	0.9	1.6	4.7	4.6	9.3	525
31	AMS-MB-5-18	0.6	1.1	1.7	5.3	4.8	10.3	500
32	MACS-1505	0.6	0.8	1.4	5.7	5.4	11.1	415
33	KDS-980	0.6	1.1	1.7	5.2	4.8	10.0	560
34	DSb-31	0.7	1.1	1.8	4.6	4.8	9.4	475
35	JS-21-05	0.1	0.6	1.7	4.8	4.8	9.6	440
36	RKS 18	0.7	0.9	1.6	5.6	5.6	11.2	350
37	Bragg	0.5	0.9	1.4	4.9	5.4	10.3	560
38	JS335	0.9	1.0	1.9	4.7	5.6	10.3	390
39	JS-97-52	0.8	1.0	1.8	4.9	4.8	9.7	365

Among the different genotypes, JS-21-05 with the mean value of 0.6 larvae per meter row was least preferred by semilooper. It was followed by PS-1589 with 0.7 larvae per meter row and also by MACS-1520, PS-1587, NRC-126, NSO-626, and MACS-1505 each with 0.8 larvae per meter row and DSB-32, RVS-2002-9, MAUS-771, NRC-125, RSC-10-71, and NRC-124 each with 0.9 larvae per meter row. Among the test entries, genotype SL-1113 with 1.8 larvae per meter row was most attacked by semilooper, as against 0.9 to 1.4 larvae per meter row in check varieties.

Based on total lepidopterous larval infestation, genotype PS-1589 with 1.0 larvae per meter row was least attacked by the lepidopterous pests. It was followed by RVS-2009-9, MACS-1520, PS-1587, HIMSO-1687, and MAUS-771, each with 1.2 larvae per meter row. Whereas, genotype DS-3106 and VLS-92 with 2.5, and SL-1113 with 2.4 larvae per meter row was most attacked by caterpillar pests as against 1.4 to 1.9 larvae per meter row in check entries.

Among the sucking pests, the incidence of whiteflies was mostly equal to that of thrips. The incidence of whiteflies ranged from 2.1 to 5.8 whiteflies per plant. Genotype PS-1589 was least attacked by whiteflies with 2.1 whiteflies per plant followed by genotype NSO-626 with 3.2 whiteflies per plant and MACS-1520, NRC-126, MAUS-711, and AMS-MB 5-19, each with 3.9 whiteflies per plant.

The highest incidence of whiteflies was on genotype SL-1113 with 5.8 whiteflies per plant as against 4.7 to 5.6 whiteflies per plant in check entries.

Based on total sucking pests population per plant, genotype NSO-626 with 6.0 sucking pests per plant was least preferred by sucking pests. It was followed by genotypes NRC-125 with 6.1 and PS-1589 each with 6.3 sucking pests per plant. Genotype VLS-93 and PS-1086 each with 11.1 sucking pests per plant was most preferred by the sucking pests as against 9.7 to 11.2 sucking pests per plant on the check entries.

Based on overall pests incidence, genotype PS-1589 with 1.0 larvae per meter row was least attacked by the lepidopterous pests. It was followed by RVS-2009-9, MACS-1520, PS-1587, HIMSO-1687, and MAUS-771, each with 1.2 larvae per meter

row, and genotype NSO-126 with 6.0 sucking pests per plant was least preferred by sucking pests. It was followed by genotypes NRC-125 with 6.1 and PS-1589 with 6.3 sucking pests per plant, respectively showed least preference by these insect pests.

The grain yield among different test genotypes ranged from 165 to 675gm/plot as against 350 to 560 gm/plot yield in check varieties. The highest yield was recorded with genotypes DSB-32 (590 gm/plot) as against 350, 560, 390, and 365 gm/plot grain yields from check varieties.

4.2.2 **AVT screening trial:**

Under AVT, twenty four soybean genotypes including four checks – RKS-18, BRAGG, JS- 335 and JS-97-52 were screened against major insect-pests of soybean during *kharif*, 2016. The results on the response of the genotypes in the screening trials are presented in the following paragraphs and table 4.8b

The 24 genotypes were screened for resistance against caterpiller pests, i,e. tobacco caterpillar, and semilooper. Among the different genotypes, JS-20-96 and RVS-2010-1 each with 0.1 larvae per meter row was least preferred by *S.litura*. It was followed by RVS-2006-7, RSC-10-46, and JS-20-87 each with 0.2 larvae per meter row and PS-1572, SL-1074, PS-1569, JS-20-116, JS-20-94, NRS-117, PS-1556, RVS-2008-24, DSB-28-3, and KDS-869 each with 0.3 larvae per meter row. Among the test entries, genotype DS-1301,VLS-89, SL-1028, MACS-1407 and KDS-753 each with 0.4 larvae per meter row was most attacked by tobacco caterpillar, as against 0.2 to 0.8 larvae per meter row in check varieties.

Table 4.8b: Field screening of AVT entries for resistance to major insect pests of Soybean during *Kharif*, 2016.

S.No	Name of entries	Incidence per meter row length			No. of sucking pests per three leaves per plant			Grain Yield (gm/plot)
		Mean of Larvae/two rep.			*Bemisia tabaci*	*Thrips tabaci*	Total	
		S.litura	*C.acuta*	Total				
1	PS – 1572	0.30	0.6	0.9	9.40	6.30	15.7	0.976
2	SL – 1074	0.30	0.7	1.0	8.50	5.10	13.6	0.650
3	PS – 1569	0.30	0.5	0.8	8.40	4.80	13.2	0.600
4	JS – 20-116	0.30	0.7	1.0	8.30	4.70	13.0	0.850
5	RVS – 2010-1	0.10	0.6	0.7	7.70	4.60	12.3	0.800
6	JS – 20-94	0.30	0.5	0.8	8.50	4.70	13.2	0.250
7	NRS – 117	0.30	0.8	1.1	9.70	4.70	14.4	0.750
8	PS – 1556	0.30	0.7	1.0	8.30	4.20	12.5	0.425
9	DS – 1301	0.40	0.7	1.1	7.80	4.30	12.1	0.600
10	VLS – 89	0.40	0.4	0.8	7.70	4.40	12.1	0.550
11	SL – 1028	0.40	0.5	0.9	8.90	5.50	14.4	0.250
12	MACS – 1407	0.40	0.6	1.0	9.20	5.20	1.4.4	0.950
13	RSC – 10 –46	0.20	0.8	1.0	9.60	5.30	14.9	0.725
14	KDS – 753	0.40	0.6	1.0	8.50	4.60	13.1	0.325
15	RVS – 2006-7	0.20	0.6	0.8	9.90	5.30	15.2	0.900
16	JS – 20-87	0.20	0.6	0.8	9.30	5.20	14.5	0.250
17	RVS – 2008-24	0.30	0.4	0.7	9.90	5.80	15.7	0.550
18	JS – 20-96	0.10	0.8	0.9	9. 20	4.90	14.1	0.800
19	DSB-28-3	0.30	0.7	1.0	7.10	3.90	11.0	0.350
20	KDS- 869	0.30	0.5	0.8	7.50	4.20	11.7	0.675
21	RKS-18 (Check)	0.30	0.6	0.9	8.90	4.80	13.7	0.475
22	BRAGG (Check)	0.20	0.8	1.0	9.10	5.00	14.1	0.900
23	JS- 335 (Check)	0.20	0.4	0.6	8.60	4.60	13.2	0.275
24	JS - 97-52 (Check)	0.20	0.5	0.7	9.4	4.50	13.9	0.900

Genotypes VLS-89, and RVS-2008-24 each with 0.4 larvae per meter row were least attacked by *C. acuta*; followed by genotype PS-1569, SL-1028 and KDS-869 each with 0.5 larvae per meter row. And also genotype NRS-117, RSC-10-46, and JS-20-96 each with 0.8 larvae per meter row was most attacked by the semilooper; as against 0.4 to 0.8 larvae per meter row in check varieties.

Based on total lepidopterous larval infestation, genotype RVS-2010-1, and RVS-2008-24 each with 0.7 larvae per meter row was least attacked by the lepidopterous pests. It was followed by PS-1569, JS-20-94, VLS-89, RVS-2006-7, JS-20-87 and KDS-869 each with 0.8 larvae per meter row. Whereas, genotype NRS-117 and DS-1301 each with 1.1 larvae per meter row was most attacked by caterpillar pests as against 0.6 to 0.9 larvae per meter row in check entries.

Among the sucking pests, the incidence of whiteflies was comparatively higher than that of thrips. The incidence of whiteflies ranged from 7.10 to 9.90 whiteflies per plant. Genotype DSB-28-3 was least attacked by whiteflies with 7.10 whiteflies per plant followed by genotype KDS-869 with 7.50 and RVS-2010-1 and VLS-89 each with 7.70 whiteflies per plant and DS-1301 with 7.80 whiteflies per plant. The highest incidence of whiteflies was on genotype RVS-2008-24 and RVS-2006-7 with 9.90 whiteflies per plant as against 8.60 to 9.40 whiteflies per plant in check entries.

Similarly, the thrips incidence ranged from 3.90 to 6.30 thrips per plant on the test entries. Genotype DSB-28-3 with 3.90 thrips per plant was least preferred by the thrips and followed by PS-1556 and KDS-869 with 4.20 thrips per plant and DS-1301 with 4.30 thrips per plant. Whereas, maximum incidence of thrips was observed on genotype PS-1572 with 6.30 thrips per plant; as against 4.60 to 5.0 thrips per plant on the check entries.

Based on total sucking pests (whiteflies and thrips) population per plant, genotype DSB-28-3 with 11.0 sucking pests per plant was least preferred by sucking pests. It was followed by genotypes KDS-869 with 11.7 and DS-1301 and VLS-89 with 12.1 sucking pests per plant. Genotype PS-1572 and RVS-2008-24 with 15.7

sucking pests per plant was most preferred by the sucking pests as against 13.2 to13.9 sucking pests per plant on the check entries.

Based on overall pests incidence, genotype RVS-2010-1, and RVS-2008-24 each with 0.7 larvae per meter row was least attacked by the lepidopterous pests. It was followed by PS-1569, JS-20-94, VLS-89, RVS-2006-7, JS-20-87 and KDS-869 each with 0.8 larvae per meter row, and genotype DSB-25-3 with 11.0 sucking pests (whiteflies and thrips) per plant and followed by KDS-869 with 11.7 and DS-1301 and VLS-89 with 12.1 sucking pests per plant was least preferred by these insect pests.

The grain yield among different test genotypes ranged from 0.25 to 0.976gm/plot as against 0.27 to 0.900 gm/plot yield in check varieties. The highest yield was recorded with genotypes PS-1572 (0.976 gm/plot) as against 0.27 to 0.976 gm/plot grain yields from check varieties.

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

Sandhya (1999) reported that among the 20 cultivars screened for girdle beetle and stem fly incidence, six varieties showed moderate resistance to these pests. Varieties with higher total phenol content showed low incidence of stem fly and girdle beetle.

Sinha (2009) recorded reaction of twelve advanced varieties of soybean (AVT) against girdle beetle (*Obereopsis brevis)* in the form of percentage of girdle beetle infested plants. Based on seasonal mean of girdle beetle infestation the percent plant damage ranged from 1.57 to 7.91 percent. The variety NRC – 37 with 1.57 percent damaged plant was least infested by girdle beetle followed by Bragg, JS -20-06 and NRC-77 with 1.73, 2.73 and 2.74 percent infested plants, respectively. Variety RKS-54 with 7.91 percent infested plants was most damaged by girdle beetle. The grain yield from different varieties ranged from 1720 to 2220 kg/ha. Highest yield was

recorded in NRC- 77 which was almost similar to that obtained yield of Bragg and NRC-37 with 2210 and 2200 kg/ha, respectively.

Netam (2010) worked on evaluation of key insect pest management components on soybean at I.G.K.V. during *kharif*, 2010 and reported that genotype

L129, with least number of girdle beetle damaged plants and lepidopterous larvae per meter row and minimum density of sucking pests per plant, was most tolerant to these insects recording 31.1q/ha grain yield.

Kujur (2011) worked on population dynamics of major insect-pests of soybean and management of defoliators and girdle beetle at I.G.K.V. during *kharif*, 2011 and reported that among the soybean genotypes screened for resistance against major insect-pests of soybean, MACS 1336 was identified as resistant against girdle beetle. MACS 1039 showed resistance against lepidopterous defoliators, whereas, DSb 63 was identified as resistant against both sucking pests and lepidopterous defoliators. With respect to yield, DSb 63 recorded highest grain yield (21.4 q/ha) compared to all the other genotypes.

4.3 To study the relative bio-efficacy evaluation of plant products and insecticides against major insect pests.

4.3.1 Bio-efficacy evaluation of plant products against major insect pests of soybean crop.

An experiment for evaluating the bio-efficacy of Neem oil, Karanj oil, NSKE, Karanj seed extract, garlic+green chilli, green chilli, red chilli, Mahua oil, triazophos against major insect pests *viz.*, tobacco caterpillar, *Spodoptera litura*, green semilooper, *Chrysodeixis acuta*, white fly *B. tabaci* and thrips, *thrips tabaci* on soybean crop was carried out during *Kharif,* 2016.

4.3.1.1 Bio-efficacy of plant product against defoliator pests on soybean crop.

Defoliator pests: The population of tobacco caterpillar and green semilooper was recorded separately. The average larval population per meter row length was recorded

from randomly selected one meter row length from each plot, one day before application of plant products as pre-treatment observation and after one day, three days, seven days and fifteen days of spray as post treatment observations. Second spray was given after twenty days of the first spray. Grain yield was recorded from each plot separately and converted into q/ha.

(a) Tobacco caterpillar; *Spodoptera litura*

Effect of plant products *S. litura* after first spray

Pre treatment observation

In the pre-treatment observation, the larval population ranged from 1.73 to 1.90 larva per one meter row length and was non significant among different treatments.

Post treatment observation

Larval population at one day after first spray

After one day of first spray, the larval population on soybean crop ranged in different treatments from 0.43 to 2.23 larvae/mrl. Plot treated with standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.43 larva/mrl.

Among the plant products, garlic+green chilli @ 8.75 kg/ha was found to be most effective which recorded with 0.49 larva/mrl. It was at par with Karanj seed extract @ 2.5% (0.5), red chilli @ 2kg/ha (0.56) but differed significantly from Karanj oil @ 2% (0.63), green chilli @ 10kg/ha (0.63), mahua oil @2%(0.66), Neem oil @ 2% (0.76 larva/mrl), NSKE @ 5% (0.73), and maximum population was recorded in Neem oil @ 2% 0.76 larva/mrl as against 2.23 larvae/meter row in untreated control.

Larval population at three days after first spray

After three days the larval population on soybean crop ranged in different treatments from 0.23 to 2.26 larvae per meter row length. Plot treated with standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.23 larva/mrl.

Among the plant products, garlic+green chilli @ 8.75 kg/ha recorded minimum population of 0.26 larva/mrl. It was at par with Karanj seed extract @ 2.5% (0.3) but differed significantly from NSKE @ 5% (0.4), mahua oil @ 2% (0.43), green chilli @ 10kg/ha (0.46), red chilli @ 2kg/ha (0.5) Karanj oil @ 2% (0.56), and maximum population was recorded in Neem oil @ 2% 0.6 larva/mrl as against 2.26 larvae/meter row in untreated control.

Larval population at seven days after first spray

After seven days of first spray, the average larval population ranged in different treatments from 0.18 to 3 larvae per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.18 larva/mrl.

Among the plant products again, garlic+green chilli @ 8.75 kg/ha recorded minimum population of 0.2 larva/mrl and was at par with followed by Karanj seed extract @ 2.5% (0.2), followed by green chilli @ 10kg/ha (0.4 larva/mrl) , but differed significantly from NSKE @ 5% (0.43), Karanj oil @ 2% (0.43), red chilli @ 10kg/ha having 0.43 larva/mrl Neem oil @ 2% (0.5), and mahua oil @ 2% (0.53) as against 3 larvae/meter row in untreated control.

Larval population at fifteen days after first spray

After fifteen days of first spray, the larval population ranged in different treatments from 0.25 to 3.36 larvae per meter row length. Plot treated with standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.25 larva per meter row length.

Among the plant products, minimum population of 0.2 larva/mrl was recorded in garlic+green chilli @ 8.75 kg/ha continued to exhibit its superiority over other treatments in controlling the defoliator pests. It was at par with Karanj seed extract @ 2.5% (0.4), but differed significantly from NSKE @ 5% (0.5), Neem oil @ 2% (0.56), green chilli @ 10kg/ha (0.45) and red chilli @ 10kg/ha (0.53 larva per meter row), and mahua oil @ 2% (0.53) as against 3.36 larvae/meter row in untreated control.

Table 4.9 : Efficacy of plant products against Tobacco caterpillar *(S.litura*) in Soybean during *Kharif*, 2016 after first spray

				Mean Population of Tobacco caterpillar per mrl						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of insect population over control
T1	Neem oil	2%	10 lt	1.86 (1.693)#	0.76 (1.328)	0.6 (1.264)	0.5 (1.224)	0.56 (1.251)	0.61	77.49
T2	Karanj oil	2%	10 lt	1.76 (1.663)	0.63 (1.278)	0.56 (1.251)	0.43 (1.197)	0.53 (1.238)	0.54	80.07
T3	NSKE	5%	25 lt	1.86 (1.693)	0.73 (1.316)	0.4 (1.183)	0.43 (1.197)	0.5 (1.224)	0.52	80.81
T4	Karanj seed extract	2.5%	12.5 lt	1.83 (1.683)	0.5 (1.224)	0.3 (1.140)	0.2 (1.095)	0.4 (1.183)	0.34	87.45
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	1.76 (1.663)	0.49 (1.222)	0.26 (1.125)	0.2 (1.095)	0.2 (1.096)	0.29	89.29
T6	Green chilli	10 kg/ha	10 kg	1.8 (1.673)	0.63 (1.278)	0.46 (1.211)	0.4 (1.183)	0.45 (1.204)	0.49	81.91
T7	Red chilli	2 kg/ha	2 kg	1.8 (1.673)	0.56 (1.252)	0.5 (1.224)	0.43 (1.197)	0.53 (1.237)	0.51	81.18
T8	Mahua oil	2%	10 lt	1.9 (1.702)	0.66 (1.291)	0.43 (1.197)	0.53 (1.238)	0.63 (1.277)	0.56	79.33
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	1.73 (1.653)	0.43 (1.197)	0.23 (1.110)	0.18 (1.088)	0.4 (1.183)	0.27	90.03
T10	Control	-	-	1.76 (1.662)	2.23 (1.798)	2.26 (1.807)	3 (2.002)	3.36 (2.090)	2.71	-
C.D. at 5%				NS	0.062	0.058	0.041	0.066	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

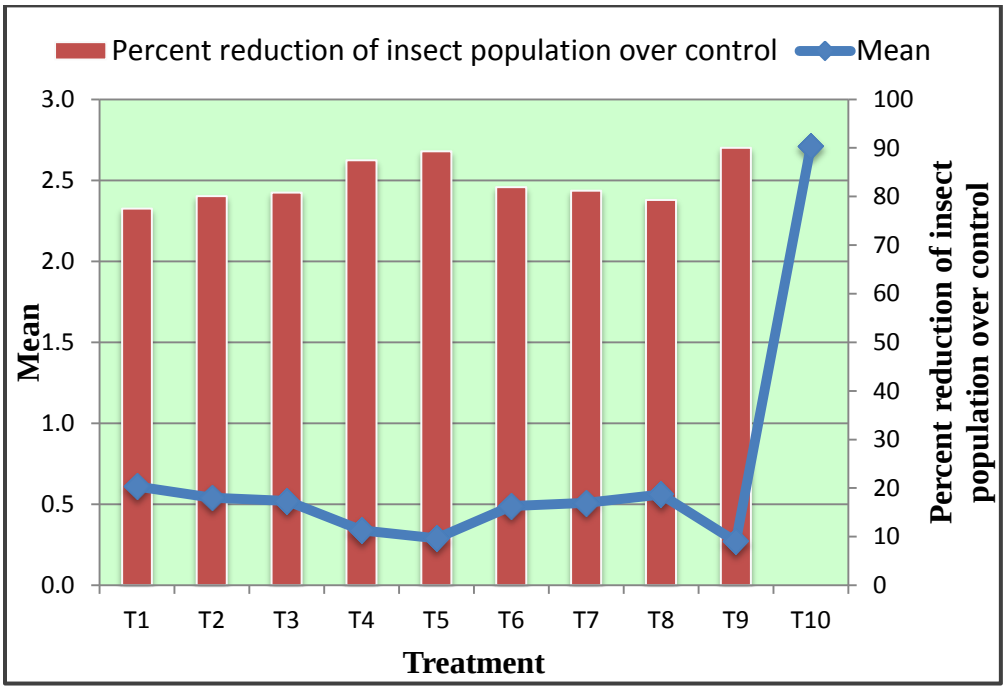

Fig. 4.5: Over all mean population and percent reduction of *S.litura* after first spray

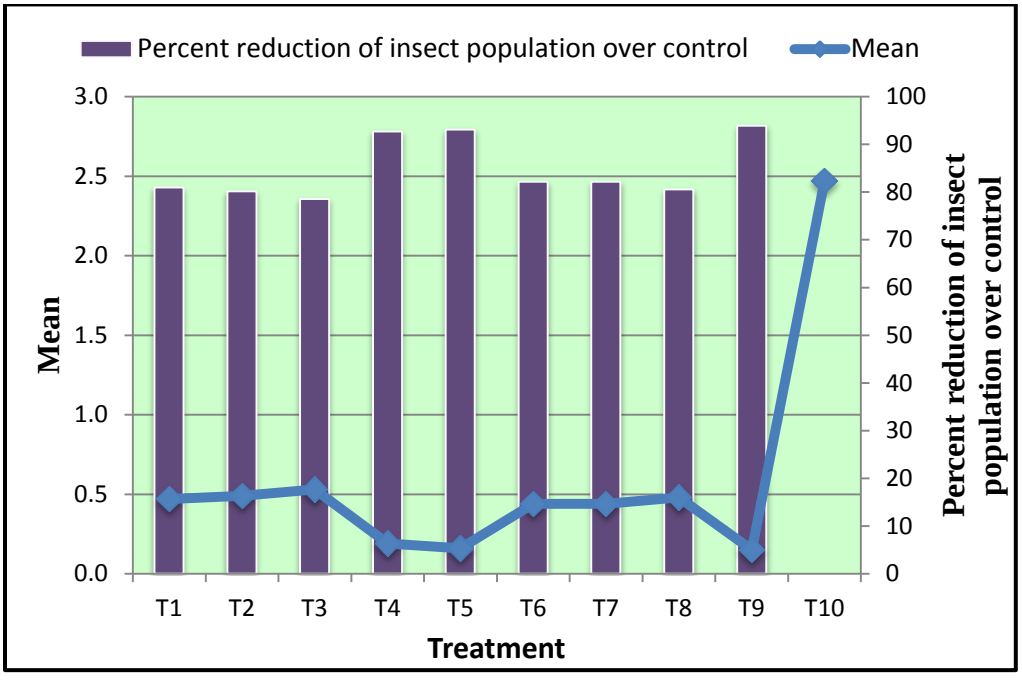

Fig.4.6 : Over all mean population and percent reduction of *S.litura* after second spray

Table 4.10 : Efficacy of plant products against Tobacco caterpillar *(S.litura*) in Soybean during *Kharif*, 2016 after second spray

	Treatments	Dose	Quantity Per Hectare	Mean Population of Tobacco caterpillar per mrl Post treatment observation						Percent reduction of insect population over control
				Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	
T1	Neem oil	2%	10 lt	1.96 (1.722)	0.53 (1.237)	0.4 (1.183)	0.4 (1.183)	0.53 (1.238)	0.47	80.97
T2	Karanj oil	2%	10 lt	1.8 (1.673)	0.56 (1.252)	0.46 (1.210)	0.4 (1.183)	0.53 (1.238)	0.49	80.16
T3	NSKE	5%	25 lt	1.78 (1.669)	0.63 (1.278)	0.53 (1.238)	0.4 (1.183)	0.56 (1.252)	0.53	78.54
T4	Karanj seed extract	2.5%	12.5 lt	1.82 (1.679)	0.3 (1.125)	0.2 (1.095)	0.13 (1.064)	0.16 (1.079)	0.19	92.71
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	1.84 (1.685)	0.23 (1.110)	0.16 (1.080)	0.1 (1.049)	0.13 (1.064)	0.16	93.11
T6	Green chilli	10 kg/ha	10 kg	1.82 (1.679)	0.6 (1.263)	0.5 (1.223)	0.26 (1.125)	0.4 (1.183)	0.44	82.18
T7	Red chilli	2 kg/ha	2 kg	1.83 (1.683)	0.53 (1.237)	0.43 (1.197)	0.33 (1.155)	0.46 (1.210)	0.44	82.18
T8	Mahua oil	2%	10 lt	1.82 (1.679)	0.5 (1.224)	0.5 (1.224)	0.4 (1.183)	0.5 (1.223)	0.48	80.56
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	1.81 (1.676)	0.2 (1.097)	0.15 (1.074)	0.1 (1.052)	0.15 (1.074)	0.15	93.92
T10	Control	-	-	1.84 (1.685)	1.9 (1.703)	2 (1.732)	2.43 (1.853)	3.56 (2.137)	2.47	-
C.D. at 5%				NS	0.071	0.065	0.036	0.052	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

Overall mean population of *S.litura*

Mean larval population during first spray indicated that chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.27 larva per meter row length and among the different plant products, garlic+green chilli @ 8.75 kg/ha recorded minimum larval population with 0.29 larva/mrl, followed by Karanj seed extract @ 2.5% (0.34), green chilli@10kg/ha(0.49), red chilli@2kg/ha (0.51), NSKE@ 5% (0.52), karanj oil @ 2% (0.54), mahua oil 2%(0.56) and it was maximum in neem oil2% (0.61) larva/mrl.

Percent reduction of *S.litura* population over control

Percent reduction of *S.litura* population was higher in triazophos @ 750 ml/ha (90.03%) treated crop and among the plant products, it was maximum in garlic+green chilli @ 8.75 kg/ha (89.29%) treated crop which was followed by Karanj seed extract @ 2.5% (87.45%), green chilli@10kg/ha(81.91%), red chilli@2kg/ha (81.18%), NSKE@ 5% (80.81%), karanj oil @ 2% (80.07%), mahua oil 2%(79.33%) and lowest in neem oil 2% treated crop and was recorded only 77.49 percent reduction in insect population.

Effect of plant products on *S. litura* after second spray

Pre treatment observation

In the pretreatment observation, the larval population ranged from 1.78 to 1.96 larva per one meter row length among different treatments and it was statistically non significant.

Post treatment observation

Larval population at one day after second spray

After one day of second spray, the larval population on soybean crop recorded. The population varied from 0.2 to 1.9 larvae per meter row. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.2 larva per meter row length Among the plant products, most of the all plant product were equally effective. Garlic+green chilli @ 8.75 kg/ha recorded with 0.23 larva/mrl and at par with Karanj seed extract @ 2.5% (0.3), but differ significantly from mahua oil @

2% (0.5), Neem oil @ 2% (0.53), red chilli @ 2kg/ha (0.53), green chilli @ 10kg/ha (0.6), NSKE @ 5% (0.63).The larval population of 0.63/mrl was maximum in NSKE @5% treated plot as against 1.9 larvae/meter row in untreated control.

Larval population at three days after second spray

After three days the larval population on soybean crop ranged in different treatments from 0.15 to 2 larvae per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the larval population of 0.15 larva per meter row length.

Among the plant products, garlic+green chilli @ 8.75 kg/ha recorded minimum larval population of 0.16 larva/mrl. It was at par with Karanj seed extract @ 2.5% (0.2) but differed significantly from Neem oil @ 2% (0.4 larva/mrl) red chilli @ 2kg/ha having 0.43 larvae per meter row Karanj oil @ 2% having (0.46), green chilli @ 10kg/ha (0.5), Mahua oil @ 2% (0.5) and NSKE @ 5% (0.53), as against 2 larvae/meter row in untreated control.

Larval population at seven days after second spray

Seven days after spray, larval population varied in different treatments from 0.1 to 2.43 larvae per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.1 larva per meter row length.

Among the plant products, garlic+green chilli @ 8.75 kg/ha recorded minimum larval population of 0.1 larva/mrl. It was at par with Karanj seed extract @ 2.5% (0.13) but differed significantly from green chilli @ 10kg/ha (0.26), red chilli @ 2kg/ha having 0.33 larvae per meter row, Neem oil @ 2% (0.4 larva/mrl), Karanj oil @ 2% having (0.4), Mahua oil @ 2% (0.4) and NSKE @ 5% (0.4), as against 2.43 larvae/meter row in untreated control.

Larval population at fifteen days after second spray

After fifteen days of first spray, the larval population ranged in different treatments from 0.15 to 3.56 larvae per meter row length. Standard chemical

insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.15 larva/mrl.

Among the plant products, the plot treated with garlic+green chilli @ 8.75 kg/ha recorded minimum population of 0.13 larva/mrl. It was statistically similar with Karanj seed extract @ 2.5% (0.16 larva/mrl), but differed significantly from green chilli @ 10kg/ha (0.4), red chilli @ 2kg/ha (0..46 larva/mrl) , Mahua oil @ 2% (0.5), Neem oil @ 2% (0.53), Karanj oil @ 2% and (0.53), NSKE @ 5% (0.56), as against 3.56 larvae/mrl in untreated control.

Over all mean population of *S.litura*

Mean larval population during second spray indicated that chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.15 larva per meter row length and among the different plant products, garlic+green chilli @ 8.75 kg/ha recorded minimum larval population with 0.17 larva/mrl, followed by Karanj seed extract @ 2.5% (0.18), green chilli @ 10kg/ha (0.44), red chilli @ 2kg/ha (0.44larva/mrl), Neem oil @ 2% (0.47), Mahua oil @ 2% (0.48), Karanj oil @ 2% (0.49) and maximum population in NSKE @ 5% (0.53).

Percent reduction of *S.litura* population over control

Percent reduction was higher in triazophos @ 750 ml/ha (93.92%) treated crop. Among the plant products, garlic+green chilli 8.75 kg/ha (93.11%) followed by Karanj seed extract @ 2.5% (92.71%), green chilli @ 10kg/ha (82.18%), red chilli @ 2kg/ha(82.18), Neem oil @ 2% (80.97%), Mahua Oil @ 2% (80.56%), Karanj oil @ 2% (80.16%), It was lowest in NSKE @ 5% treated plots and recorded only 78.54 percent reduction in insect population.

(b) Green semilooper; *Chrysodeixis acuta*

Effect of plant products on *C. acuta* after first spray

Pre treatment observation

In the pretreatment observation, the larval population varied from 1.4 to 1.5 larvae per one meter row length and it was non significant among different treatments.

Post treatment observation

Larval population at one day after first spray

After one day of first spray, the larval population on soybean crop ranged in different treatments from 0.7 to 1.8 larva per meter row length. Plot treated with standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the larval population of 0.7larva/mrl.

Among the various plant products, garlic+green chilli @ 8.75 kg/h recorded the minimum population of 0.8 larva/mrl and found to be most effective in reducing the larval population of green semilopper as compared to untreated control (1.8larva/mrl). It was at par with Karanj seed extract @ 2.5% (0.86) but differed significantly from and green chilli @ 10kg/ha (1.06 larva/mrl), NSKE @ 5% (1.06), Neem oil @ 2% (1.1), Karanj oil @ 2% (1.16), red chilli @ 2kg/ha having (1.36 larva/mrl) and Mahua oil @ 2% (1.4) as against 1.8 larva/meter row in untreated control.

Larval population at three days after first spray

After three days the larval population on soybean crop varied in different treatments from 0.5 to 1.93 larvae per meter row length. Plot treated with standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded population of 0.5 larva/mrl.

Among the various plant products, garlic+green chilli @ 8.75 kg/ha recorded the minimum population of 0.56 larva/mrl and found to be most effective in reducing the larval population of green semilopper as compared to untreated control (1.93larva/mrl). It was at par with Karanj seed extract @ 2.5% (0.63) but differed significantly from and NSKE @ 5% (0.83), Karanj oil @ 2% (0.91), green chilli @ 10kg/ha (0.97larva/mrl), Neem oil @ 2% (1.02), red chilli @ 2kg/ha having (1.1 larva/mrl) and Mahua Oil @ 2% (1.11) as against 1.93 larva/meter row in untreated control.

Table 4.11 : Efficacy of plant products against Semilooper (*C. acuta*) in Soybean during *Kharif*, 2016 after first spray

	Treatments	Dose	Quantity Per Hectare	Mean Population of Semilooper per mrl Post treatment observation						Percent reduction of insect population over control
				Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	
T1	Neem oil	2%	10 lt	1.5 (1.580)	1.1 (1.449)	1.02 (1.424)	0.97 (1.405)	1.26 (1.505)	1.09	48.09
T2	Karanj oil	2%	10 lt	1.5 (1.580)	1.16 (1.471)	0.91 (1.382)	0.83 (1.353)	1.16 (1.472)	1.02	51.42
T3	NSKE	5%	25 lt	1.46 (1.570)	1.06 (1.437)	0.83 (1.353)	0.66 (1.289)	0.96 (1.400)	0.88	58.09
T4	Karanj seed extract	2.5%	12.5 lt	1.44 (1.561)	0.86 (1.365)	0.63 (1.276)	0.6 (1.266)	0.8 (1.340)	0.72	65.71
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	1.45 (1.565)	0.8 (1.340)	0.56 (1.250)	0.4 (1.182)	0.53 (1.236)	0.57	72.85
T6	Green chilli	10 kg/ha	10 kg	1.4 (1.548)	1.06 (1.437)	0.97 (1.403)	0.9 (1.378)	1.13 (1.460)	1.02	51.42
T7	Red chilli	2 kg/ha	2 kg	1.42 (1.553)	1.36 (1.537)	1.1 (1.449)	0.94 (1.394)	1.23 (1.494)	1.16	44.76
T8	Mahua oil	2%	10 lt	1.44 (1.561)	1.4 (1.549)	1.11 (1.451)	1.04 (1.429)	1.26 (1.505)	1.20	42.85
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	1.43 (1.559)	0.7 (1.305)	0.5 (1.223)	0.5 (1.223)	0.56 (1.250)	0.56	73.33
T10	Control	-	-	1.5 (1.581)	1.8 (1.673)	1.93 (1.712)	2.05 (1.745)	2.63 (1.906)	2.10	-
C.D. at 5%				NS	0.083	0.098	0.100	0.094	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

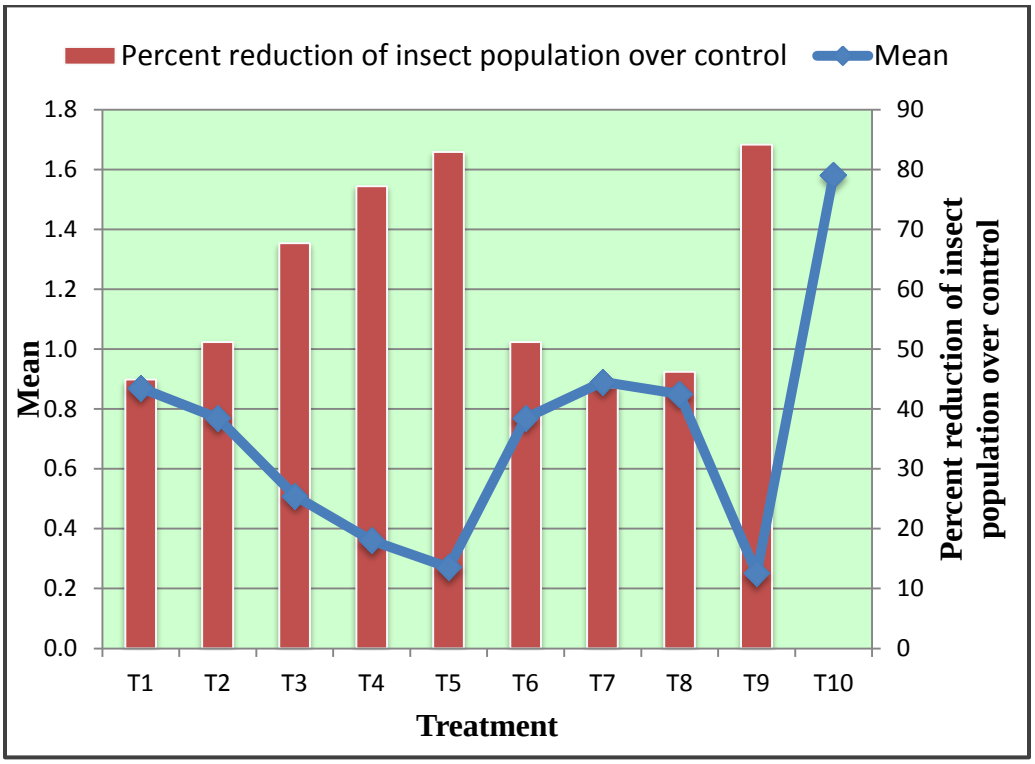

Fig. 4 .7 : Over all mean population and percent reduction of *C.acuta* after first spray

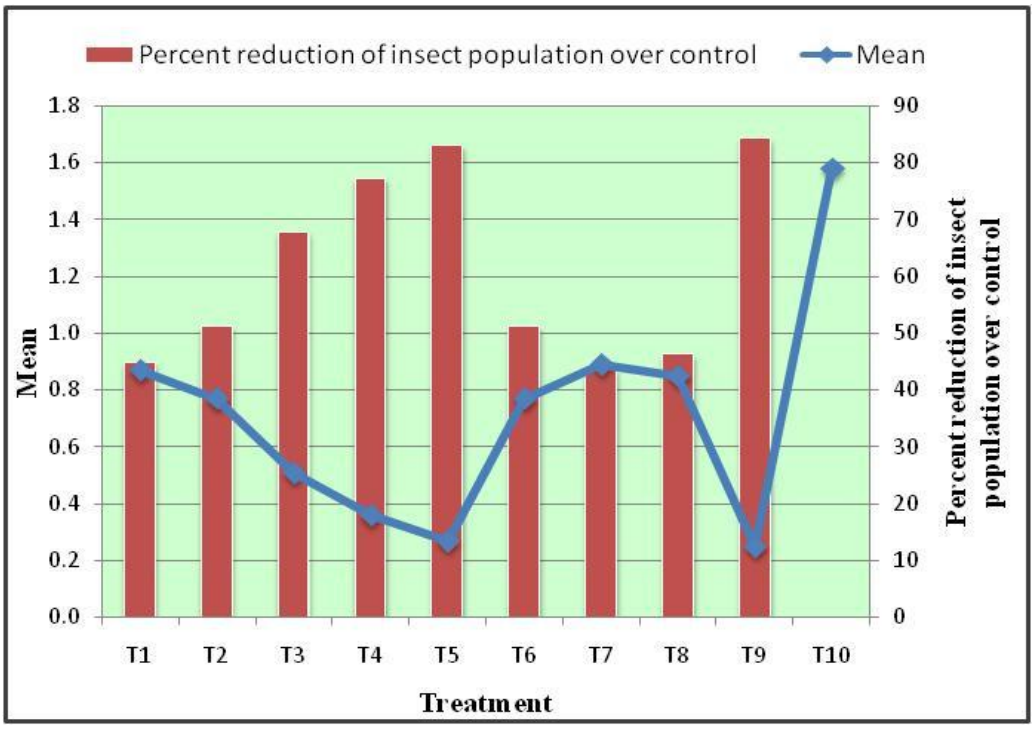

Fig. 4.8 : Over all mean population and percent reduction of *C.acuta* after second spray

Table 4.12 : Efficacy of plant products against semilooper(*C. acuta*) in Soybean during *Kharif*, 2016 after second spray

				Mean Population of Semilooper per mrl						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of insect population over control
T1	Neem oil	2%	10 lt	1.5 (1.580)#	1.16 (1.472)	0.96 (1.402)	0.83 (1.354)	0.53 (1.238)	0.87	44.9
T2	Karanj oil	2%	10 lt	1.48 (1.577)	1.1 (1.449)	0.86 (1.366)	0.6 (1.264)	0.55 (1.246)	0.77	51.2
T3	NSKE	5%	25 lt	1.47 (1.573)	0.83 (1.351)	0.6 (1.262)	0.36 (1.168)	0.26 (1.122)	0.51	67.7
T4	Karanj seed extract	2.5%	12.5 lt	1.46 (1.570)	0.45 (1.202)	0.36 (1.168)	0.26 (1.125)	0.4 (1.182)	0.36	77.21
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	1.44 (1.561)	0.45 (1.202)	0.33 (1.155)	0.2 (1.095)	0.11 (1.054)	0.27	82.91
T6	Green chilli	10 kg/ha	10 kg	1.43 (1.559)	1.03 (1.426)	0.83 (1.353)	0.63 (1.277)	0.6 (1.264)	0.77	51.2
T7	Red chilli	2 kg/ha	2 kg	1.42 (1.553)	1.12 (1.455)	1 (1.414)	0.76 (1.329)	0.7 (1.303)	0.89	43.6
T8	Mahua oil	2%	10 lt	1.49 (1.565)	1.13 (1.461)	0.9 (1.378)	0.7 (1.303)	0.68 (1.295)	0.85	46.2
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	1.45 (1.565)	0.4 (1.181)	0.3 (1.140)	0.2 (1.096)	0.1 (1.052)	0.25	84.17
T10	Control	-	-	1.47 (1.573)	1.53 (1.591)	1.46 (1.569)	1.33 (1.526)	2.03 (1.622)	1.58	-
C.D. at 5%				NS	0.105	0.101	0.094	0.090	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

Larval population at seven days after first spray

After seven days of first spray, the average larval population on soybean crop ranged in different treatments from 0.5 to 2.05 larvae per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.5 larva per meter row length. Similar to previous observations, again garlic+green chilli @ 8.75 kg/ha showed its effectivity over other treatments which was recorded 0.4 larva/mrl and at par with Karanj seed extract @ 2.5% (0.6), and followed by NSKE @ 5% (0.66) but differed significantly from Karanj oil @ 2% (0.83 larva/mrl), green chilli @ 10kg/ha (0.9) and red chilli @ 2kg/ha with 0.94 larva/mrl, Neem oil @ 2% (0.97) and Mahua Oil @ 2% (1.04) as against 2.05 larvae/meter row in untreated control.

Larval population at fifteen days after first spray

After fifteen days of first spray, clearly indicated that the larval population on soybean crop varied from 0.56 to 2.63 larvae per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.56 larva/mrl.

Among the plant products, minimum population was recorded in garlic+green chilli @ 8.75 kg/ha 0.53 larva/mrl, and it was at par with Karanj seed extract @ 2.5% (0.8) but differed significantly from NSKE @ 5% (0.96), green chilli @ 10kg/ha (1.13 larva/mrl), Karanj oil @ 2% (1.16), red chilli 2kg/ha 1.23 larva/mrl, Neem oil @ 2% (1.26) and Mahua oil @ 2% (1.26) as against 2.63 larvae/meter row in untreated control.

Overall mean population of *C. acuta*

Mean larval population during first spray indicated that chemical insecticide *i.e* triazophos 40 EC @ 750 ml/ha recorded the minimum population of 0.56 larva/mrl and among the different plant products, garlic+green chilli @ 8.75 kg/ha recorded minimum larval population with 0.57 larva/mrl, followed by Karanj seed extract @ 2.5% (0.72), NSKE @ 5% (0.88), Karanj oil @ 2% (1.02), green chilli @ 10kg/ha

(1.02 larva/mrl), Neem oil @ 2% (1.09), and red chilli @ 2kg/ha (1.16) and it was maximum in mahua oil @2% having 1.20 larva/mrl.

Percent reduction of *C. acuta* population over control

Percent reduction was higher in triazophos @ 750 ml/ha (73.33%) treated crop and among the plant products, it was maximum in garlic+green chilli @ 8.75 kg/ha (72.85%) treated crop followed by followed by Karanj seed extract @ 2.5% (65.71%), NSKE @ 5% (58.09%), Karanj oil @ 2% (51.42%), green chilli @ 10kg/ha (51.42%), Neem oil @ 2% (48.09%), and red chilli @ 2kg/ha (44.76%) and minimum of 42.85% percent recorded in mahua oil @2% .

Effect of plant products on *C.acuta* after second spray

Pre treatment observation

In the pretreatment observation, the mean of larval population varied between 1.42 to 1.5 larvae/ meter row length and it was non significant among different treatments.

Post treatment observation

Larval population at one day after second spray

After one day of second spray, the larval population of green semilooper on soybean crop recorded population in the range of 0.4 to 1.53 larvae per meter row. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.3 larva per meter row length.

Among the plant products, garlic+green chilli @ 8.75 kg/ha was continued to exhibit its effective as compared to other treatments in controlling defoliator pests with 0.45 larva per meter row length. It was at par with Karanj seed extract @ 2.5% (0.45 larva/mrl) but differed significantly from NSKE @ 5% (0.83), green chilli @ 10kg/ha (1.03), Karanj oil @ 2% (1.1), red chilli @ 2kg/ha (1.12 larva/mrl), mahua oil @2% (1.13), and Neem oil @ 2% (1.16) as against 1.53 larvae/meter row in untreated control.

Larval population at three days after second spray

After three days of second spray the larval population on soybean crop varied in different treatments from 0.3 to 1.46 larvae per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the larval population of 0.3 larva per meter row length. Similar to the above plots treated with garlic+green chilli @ 8.75 kg/ha recorded minimum infestation of 0.33 larvae per meter row length. It was at par with Karanj seed extract @ 2.5% (0.36) but differed significantly from NSKE @ 5% (0.6), Karanj oil @ 2% (0.86), green chilli @ 10kg/ha (0.83 larva/mrl), Neem oil @ 2% (0.96), mahua oil @2% (1.13), and red chilli @ 2kg/ha (1.0 larva/mrl) as against 1.46 larvae/meter row in untreated control.

Larval population at seven days after second spray

Seven days after second spray, larval population on soybean crop varied in different treatments from 0.20 to 1.33 larva per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.20 larva /mrl.

Among the plant products, plots treated with garlic+green chilli @ 8.75 kg/ha recorded minimum infestation of 0.2 larvae per meter row length. It was at par with Karanj seed extract @ 2.5% (0.26) but differed significantly from NSKE @ 5% (0.83), Karanj oil @ 2% (0.6), green chilli @ 10kg/ha (0.63 larva/mrl), mahua oil @2% (0.7), Neem oil @ 2% (0.83) and red chilli @ 2kg/ha (0.76 larva/mrl) and Neem oil @ 2% (0.83) as against 1.33 larvae/meter row in untreated control.

Larval population at fifteen days after second spray

After fifteen days of first spray, the larval population on soybean crop ranged in different treatments from 0.1 to 2.03 larvae per meter row length. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.1 larva/mrl.

Among the plant products, plots treated with garlic+green chilli @ 8.75 kg/ha recorded minimum infestation of 0.11 larvae per meter row length. It was at par with

NSKE @ 5% (0.26) but differed significantly from Karanj seed extract @ 2.5% (0.4), Neem oil @ 2% (0.53), Karanj oil @ 2% (0.55), green chilli @ 10kg/ha (0.6 larva/mrl), mahua oil @2% (0.68), and red chilli @ 2kg/ha (0.7 larva/mrl) as against 2.03 larvae/meter row in untreated control.

Over all mean population of *C. acuta*

Mean larval population during second spray indicated that chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.25 larva/mrl and among the different plant products, garlic+green chilli @ 8.75 kg/ha recorded minimum larval population with 0.27 larva/mrl followed by Karanj seed extract @ 2.5% (0.36), NSKE @ 5% (0.51), Karanj oil @ 2% (0.77), green chilli @ 10kg/ha (0.77), mahua oil @2% (0.85), Neem oil @ 2% (0.87), and it was maximum in red chilli @ 2kg/ha having 0.89 larva/mrl.

Percent reduction of *C. acuta* population over control

Percent reduction was higher in triazophos @ 750 ml/ha (84.17%) treated crop and among the plant products, it was maximum in garlic+green chilli @ 8.75 kg/ha (82.91%) treated crop followed by followed by Karanj seed extract @ 2.5% (77.21%), NSKE @ 5% (67.7%), Karanj oil @ 2% (51.2%), green chilli @ 10kg/ha (51.2%), mahua oil @2% (46.2%), Neem oil @ 2% (44.9%), and minimum of 43.6% percent recorded in red chilli @ 2kg/ha.

The results are in conformity with the findings of Vijayalakshmi *et al.* (1997) who reported that ginger extract as natural pesticide, alone and in combination with other plant products like chilli, garlic and cow urine as effective plant products against *H. armigera.*

Lakshmanan (2001) also reported that the garlic bulb extract alone or in combination with other plant extracts were effective in managing the several lepidopteran pests *viz*., *Earias vitella, Chilo partellus* (Swinhoe), *Corcyra cephalonica* Staint., *Helicoverpa armigera* and *Spodoptera litura.*

Table 4.13 : Efficacy of plant products against white fly (*B. tabaci*) in Soybean during *Kharif*, 2016 after first spray

				Mean Population of white fly per three leaves / plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of insect population over control
T1	Neem oil	2%	10 lt	6.86 (2.085)#	5.03 (2.413)	4.8 (2.408)	4.66 (2.380)	5.76 (2.601)	5.06	32.71
T2	Karanj oil	2%	10 lt	6.9 (2.811)	4.7 (2.387)	4.56 (2.359)	4.46 (2.338)	4.6 (2.366)	4.58	39.09
T3	NSKE	5%	25 lt	7.1 (2.846)	4.56 (2.359)	3.96 (2.228)	3.86 (2.206)	4.73 (2.394)	4.27	43.21
T4	Karanj seed extract	2.5%	12.5 lt	6.96 (2.822)	3.6 (2.145)	3.73 (2.175)	3.53 (2.129)	4.56 (2.359)	3.85	48.80
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	7.03 (2.834)	4.03 (2.243)	3.96 (2.228)	3.63 (2.150)	4.66 (2.380)	4.07	45.87
T6	Green chilli	10 kg/ha	10 kg	7.13 (2.852)	4.03 (2.243)	3.96 (2.227)	4.6 (2.364)	5.23 (2.497)	4.45	40.82
T7	Red chilli	2 kg/ha	2 kg	6.93 (2.816)	4.26 (2.295)	4.06 (2.25)	3.93 (2.221)	5.29 (2.508)	4.38	41.75
T8	Mahua oil	2%	10 lt	6.93 (2.817)	4.1 (2.258)	4.36 (2.316)	4.2 (2.280)	5.43 (2.536)	4.52	39.89
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	6.76 (2.787)	3.6 (2.145)	3.4 (2.098)	3.3 (2.074)	4.26 (2.294)	3.64	51.59
T10	Control	-	-	7.03 (2.834)	7.53 (2.921)	7.39 (2.897)	7.16 (2.858)	8.03 (3.005)	7.52	-
C.D. at 5%				NS	0.310	0.089	0.103	0.059	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

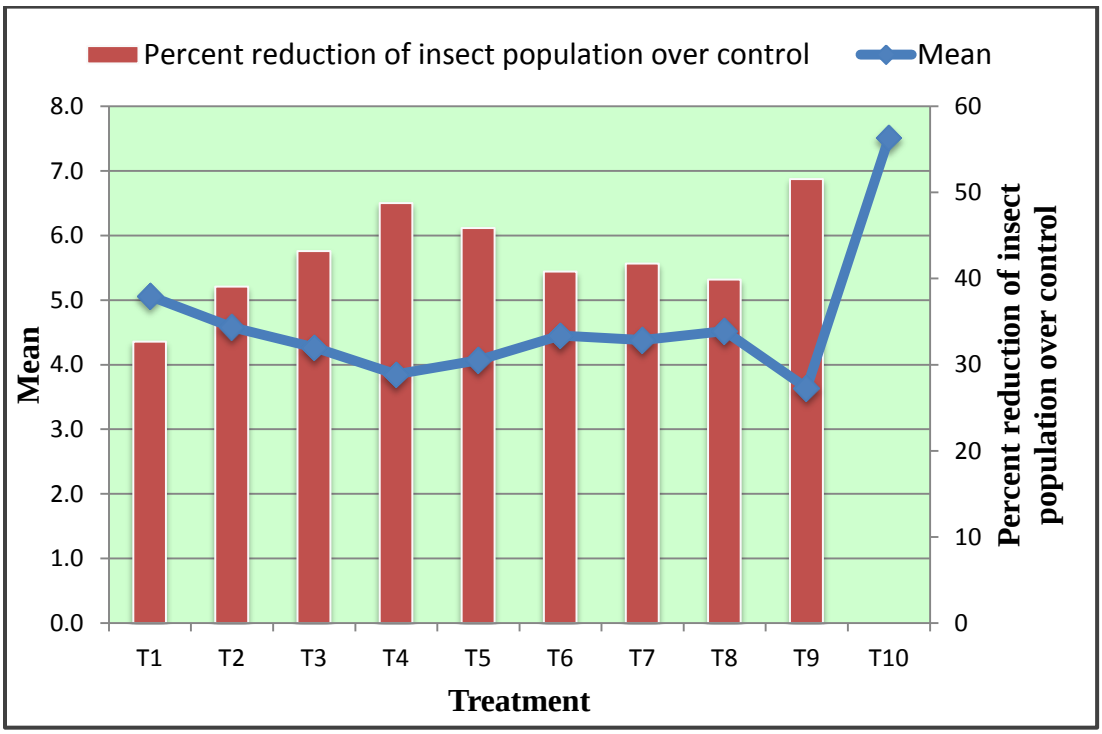

Fig. 4.9 : Over all mean population and percent reduction of *B. tabaci* after first spray

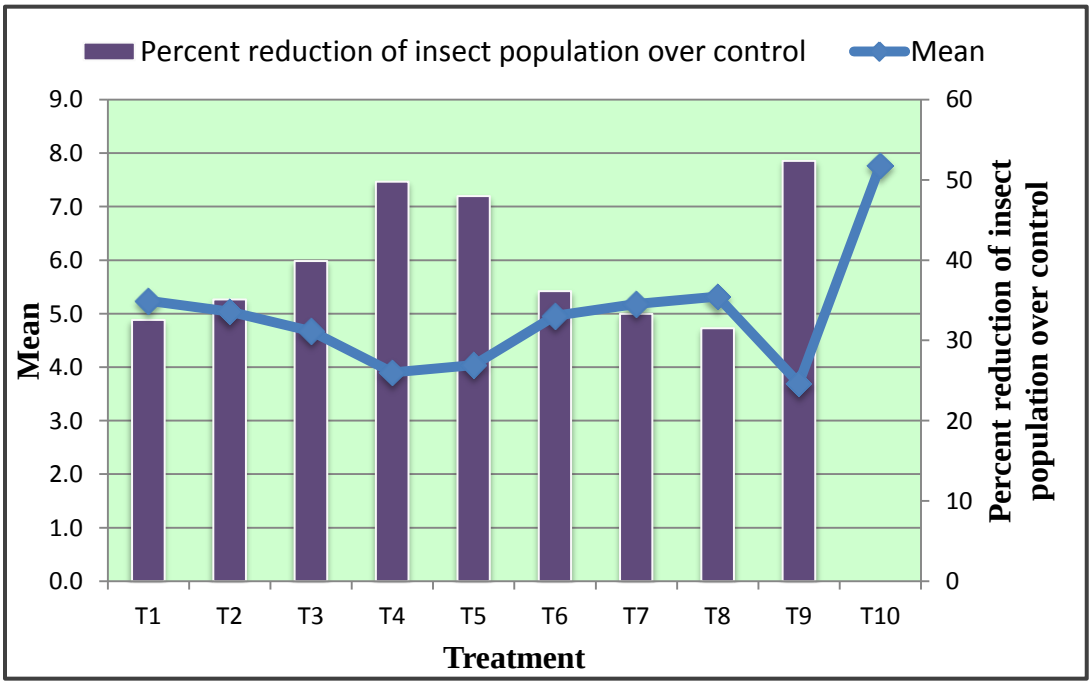

Fig. 4.10:Over all mean population and percent reduction of *B. tabaci* after second spray

Table 4.14 : Efficacy of plant products against white fly (*B. tabaci*) in Soybean during *Kharif*, 2016 after second spray

				Mean Population of white fly per three leaves / plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of insect population over control
T1	Neem oil	2%	10 lt	6.3 (2.702)	6.43 (2.726)	4.83 (2.413)	4.46 (2.337)	5.23 (2.497)	5.24	32.56
T2	Karanj oil	2%	10 lt	6.2 (2.683)	5.2 (2.490)	4.3 (2.302)	4.33 (2.309)	6.33 (2.708)	5.04	35.13
T3	NSKE	5%	25 lt	6.3 (2.702)	5.5 (2.549)	4.2 (2.280)	3.9 (2.213)	5.06 (2.463)	4.67	39.89
T4	Karanj seed extract	2.5%	12.5 lt	6.26 (2.696)	4.23 (2.287)	3.36 (2.089)	3.33 (2.074)	4.66 (2.380)	3.90	49.80
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	6.16 (2.677)	4.43 (2.331)	3.56 (2.137)	3.53 (2.129)	4.63 (2.373)	4.04	48.01
T6	Green chilli	10 kg/ha	10 kg	6.2 (2.683)	5.4 (2.530)	4.66 (2.380)	4.4 (2.323)	5.36 (2.523)	4.96	36.16
T7	Red chilli	2 kg/ha	2 kg	6.2 (2.683)	5.6 (2.569)	4.9 (2.429)	4.6 (2.366)	5.63 (2.575)	5.18	33.33
T8	Mahua oil	2%	10 lt	6.4 (2.720)	6.2 (2.683)	4.73 (2.394)	4.7 (2.387)	5.66 (2.581)	5.32	31.53
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	6.23 (2.689)	4 (2.236)	3.2 (2.051)	3.3 (2.074)	4.3 (2.302)	3.7	52.38
T10	Control	-	-	6.26 (2.696)	7.5 (2.915)	7.36 (2.892)	7.8 (2.967)	8.43 (3.071)	7.77	-
C.D. at 5%				NS	0.051	0.110	0.089	0.065	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

Choudhary and Shrivastava (2007) reported that application of neem seed kernel extract (NSKE) at 5% + neem leaf extract (NLE) at 10% reduced the maximum larval population.

4.3.1.2 Efficacy of plant products against sucking pests on soybean crop

Different plant products were evaluated against the sucking pests on soybean crop. Observations were taken from the upper, middle and bottom leaves of randomly selected five plants in each plot. The population of white flies and thrips was recorded separately and it was noticed that the population of white flies was higher than that of thrips in the experimental field.

White fly; *B. tabaci*

Effect of plant products on *B. tabaci* after first spray

Pre treatment observation

In the pre-treatment observation, the white fly population ranged from 6.76 to 7.1 white flies per plant in different treatments and it differed non significantly among different treatments.

Post treatment observation

White fly population at one day after first spray

After one day of first spray, the mean population of white fly varied between different treatments from 3.6 to7.53 white flies per plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3.6 white flies per plant.

Among the plant products, green chilli @10kg/ha (4.0) white flies per plant was most effective as compared to other treatments. it was at par with Karanj seed extract @ 2.5% (4.03), garlic+green chilli @ 8.75 kg/ha with (4.03), mahua oil@2% (4.1), red chilli @ 2kg/ha (4.26white flies/plant), but differed significantly from NSKE 5% (4.56) white flies per plant, Karanj oil @ 2% (4.7), and Neem oil @ 2% (5.03), as against 7.53 white flies per plant in untreated control.

White fly population at three days after first spray

After three days of first spray, the mean population of white fly varied between different treatments from 3.4 to 7.39 white flies per plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3.4 white flies per plant.

Among the plant products, Karanj seed extract @ 2.5% 3.73 white flies per plant was most effective as compared to other treatments.it was at par with garlic+green chilli @ 8.75 kg/ha with 3.96 but differed significantly from NSKE 5% (3.96) white flies per plant, green chilli @10kg/ha (3.96), and red chilli @ 2kg/ha (4.06white flies/plant), mahua oil@2% (4.3), Karanj oil @ 2% (4.56), and Neem oil @ 2% (4.8), as against 7.39 white flies per plant in untreated control.

Whitefly population at seven days after first spray

After seven days of first spray, the mean population of white fly varied between different treatments from 3.3 to 7.16 white flies per plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3.3 white flies per plant. Similar to previous observations Karanj seed extract @ 2.5% 3.53 white flies per plant was most effective as compared to other treatment it was at par with green chilli @10kg/ha (3.63), but differed significantly from garlic+green chilli @ 8.75 kg/ha with 4.67, NSKE 5% (3.86) white flies per plant, and red chilli @ 2kg/ha (3.93white flies/plant), mahua oil@2% (4.2), Karanj oil @ 2% (4.46), and Neem oil @ 2% (4.66), as against 7.16 white flies per plant in untreated control.

White fly population at fifteen days after first spray

After fifteen days of first spray, the mean population of white fly varied between different treatments from 4.26 to 8.03 white flies per plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 4.26 white flies per plant.

Among the plant products, garlic+green chilli @ 8.75 kg/ha with (4.56), white flies per plant was most effective as compared to other treatment but differed

significantly from Karanj oil @ 2% (4.6), Karanj seed extract @ 2.5% (4.66) , NSKE 5% (4.73) white flies per plant, green chilli @10kg/ha (5.23), and red chilli @ 2kg/ha (5.29white flies/plant), mahua oil@2% (5.43), and Neem oil @ 2% (5.76), as against 8.03 white flies per plant in untreated control.

Over all mean population of *B. tabaci*

Mean white fly population during first spraying indicated that chemical insecticide *i.e* triazophos 40 EC @ 750 ml/ha recorded the minimum population of 3.64 white flies per plant and among the plant products, Karanj seed extract @ 2.5% (3.98) recorded lowest population of white fly, and followed by green chilli @ 10kg/ha (4.205), garlic+green chilli @ 8.75 kg/ha (4.305 whiteflies per plant), NSKE 5% (4.27), red chilli @ 2kg/ha having 4.38 white flies per plant, Karanj oil @ 2% (4.58), and maximum in Neem oil @ 2% (5.06).

Percent reduction of *B. tabaci* population over control

Percent reduction was higher in triazophos @ 750 ml/ha (51.59%) treated crop, and among the plant products, it was maximum in Karanj seed extract @ 2.5% (47.04%), which was followed by garlic+green chilli @ 8.75 kg/ha (42.81%) treated crop Neem oil @ 2% (32.71%), NSKE @ 5% (43.21%), Karanj oil @ 2% (39.09%), green chilli @ 10kg/ha (44.14%) and 41.75 percent reduction in insect population was recorded in red chilli 2kg/ha treated crop.

Effect of plant products *B. tabaci* after second spray

Pre treatment observation

Pre-treatment observations recorded ranged in different treatments varied from 6.16 to 6.4 white flies per plant and was non significant differences among different treatments.

Post treatment observation

White fly population at one day after second spray

After one day of second spray, white fly population on soybean crop ranged from 4.0 to 7.5 white flies/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 4.0 white flies per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% 4.23 white flies per plant was most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha with 4.43 but differed significantly from Karanj oil @ 2% (5.2), , green chilli @10kg/ha (5.4), NSKE 5% (5.5) white flies per plant and red chilli @ 2kg/ha (5.6white flies/plant), mahua oil@2% (6.2), and Neem oil @ 2% (6.43), as against 7.5 white flies per plant in untreated control.

White fly population at three days after second spray

After three day of second spray, white fly population on soybean crop ranged from 3.2 to 7.36 white flies/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3.2 white flies per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% (3.36) white flies per plant was most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha with 3.56 but differed significantly from NSKE 5% (4.2) white flies per plant, Karanj oil @ 2% (4.3), green chilli @10kg/ha (4.66), mahua oil @ 2% (4.73), and Neem oil @ 2% (4.83), and red chilli @ 2kg/ha (4.9white flies/plant) as against 7.36 white flies per plant in untreated control.

White fly population at seven days after second spray

After seven day of second spray, white fly population on soybean crop ranged from 3.3 to 7.8 white flies/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3.3 white flies per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% (3.33) white flies per plant was most effective as compared to other treatment it was at par

with garlic+green chilli @ 8.75 kg/ha with 3.53 but differed significantly from NSKE 5% (3.9) white flies per plant, Karanj oil @ 2% (4.33), green chilli @10kg/ha (4.4), Neem oil @ 2% (4.46), red chilli @ 2kg/ha (4.6white flies/plant), mahua oil@2% (4.7), and as against 7.8 white flies per plant in untreated control.

Whitefly population at fifteen days after second spray

After fifteen days of second spray, standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 4.3 white flies per plant.

Among the plant products, plot treated with garlic+green chilli @ 8.75 kg/ha with 4.63white flies per plant was most effective as compared to other treatment it was at par with Karanj seed extract @ 2.5% 4.66 but differed significantly from NSKE 5% (5.06), Neem oil @ 2% (5.23), green chilli @10kg/ha (5.36), red chilli @ 2kg/ha (5.63white flies/plant), mahua oil@2% (5.66), and Karanj oil @ 2% (6.33) white flies per plant as against 8.43 white flies per plant in untreated control.

Over all mean population of *B. tabaci*

Mean population of white fly during second spray indicated that chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3.7 white flies per plant and among the different plant products, Karanj seed extract @ 2.5% recorded minimum white fly population with 3.90 white flies per plant followed by garlic+green chilli 8.75 kg/ha (4.04), NSKE @ 5% (4.67), green chilli @ 10kg/ha (4.96), Karanj oil @ 2% (5.04), red chilli @ 2kg/ha (5.18), Neem oil @ 2% (5.24), and maximum in mahua oil@2% (5.32)white flies per plant.

Percent reduction of *B. tabaci* population over control

Percent reduction was higher in triazophos 40 EC @ 750 ml/ha (52.38%) treated crop, and among the plant products, it was maximum in Karanj seed extract @ 2.5% (49.80%), treated scrop followed by garlic+green chilli 8.75 kg/ha (48.01%), Neem oil @ 2% (32.56%), NSKE @ 5% (39.89%), Karanj oil @ 2% (35.13%), green chilli @ 10kg/ha (36.16%) and lowest in red chilli @ 2kg/ha treated plots was recorded only 5.18, mahua oil@2% (5.32) percent reduction in insect population.

(B) Thrips: *T. tabaci*

Effect of plant products on *T. tabaci* after first spray

Pre treatment observation

The thrips population in the pre-treatment observation varied from 3.2 to 3.56 thrips per plant. There were non significant difference among different treatments before spraying of plant products on the crop.

Post treatment observation

Thrips population at one day after first spray

After one day of second spray, Thrips population on soybean crop ranged from 1.2 to 3.8 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1.2 Thrips per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% 1.3 thrips per plant was most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha with 1.33 but differed significantly from green chilli @10kg/ha (1.43), mahua oil@2% (1.5), and Neem oil @ 2% (1.53), NSKE 5% (1.6) thrips per plant and red chilli @ 2kg/ha (1.6thrips/plant), and Karanj oil @ 2% (1.66) as against 3.8 thrips per plant in untreated control.

Thrips population at three day after first spray

After one day of second spray, Thrips population on soybean crop ranged from 0.7 to 4.83 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.7 Thrips per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% 0.96 thrips per plant was most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha with 1.1 but differed significantly from green chilli @10kg/ha (1.26), red chilli @ 2kg/ha (1.3thrips/plant), mahua oil @ 2% (1.36), and Neem oil @ 2% (1.36), NSKE 5% (1.46) thrips per plant and Karanj oil @ 2% (1.5) as against 4.83 thrips per plant in untreated control.

Table 4.15 : : Efficacy of plant products against Thrips (*Thrips tabaci*) in Soybean during Kharif, 2016 after first spray

				Mean Population of Thrips per three leaves/ plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of insect population over control
T1	Neem oil	2%	10 lt	3.3 (2.073)#	1.53 (1.591)	1.36 (1.537)	1.26 (1.505)	2.1 (1.758)	1.56	68.92
T2	Karanj oil	2%	10 lt	3.26 (2.065)	1.66 (1.633)	1.5 (1.580)	1.26 (1.505)	2.06 (1.750)	1.62	67.72
T3	NSKE	5%	25 lt	3.2 (2.049)	1.6 (1.612)	1.46 (1.570)	1.33 (1.527)	2.63 (1.903)	1.76	64.94
T4	Karanj seed extract	2.5%	12.5 lt	3.2 (2.049)	1.3 (1.516)	0.96 (1.402)	0.86 (1.366)	1.5 (1.581)	1.16	76.89
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	3.3 (2.073)	1.33 (1.527)	1.1 (1.449)	1.06 (1.437)	1.46 (1.569)	1.24	75.29
T6	Green chilli	10 kg/ha	10 kg	3.26 (2.065)	1.43 (1.560)	1.26 (1.505)	1.2 (1.483)	2.86 (1.965)	1.69	66.33
T7	Red chilli	2 kg/ha	2 kg	3.26 (2.065)	1.6 (1.612)	1.3 (1.516)	1.23 (1.494)	2.9 (1.971)	1.76	64.94
T8	Mahua oil	2%	10 lt	3.3 (2.073)	1.5 (1.581)	1.36 (1.538)	1.36 (1.538)	2.93 (1.983)	1.79	64.34
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	3.3 (2.081)	1.2 (1.484)	0.7 (1.303)	0.66 (1.288)	1.1 (1.447)	0.91	81.77
T10	Control	-	-	3.56 (2.137)	3.8 (2.191)	4.83 (2.415)	4.89 (2.428)	6.56 (2.751)	5.02	-
C.D. at 5%				NS	0.059	.065	0.050	0.171	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

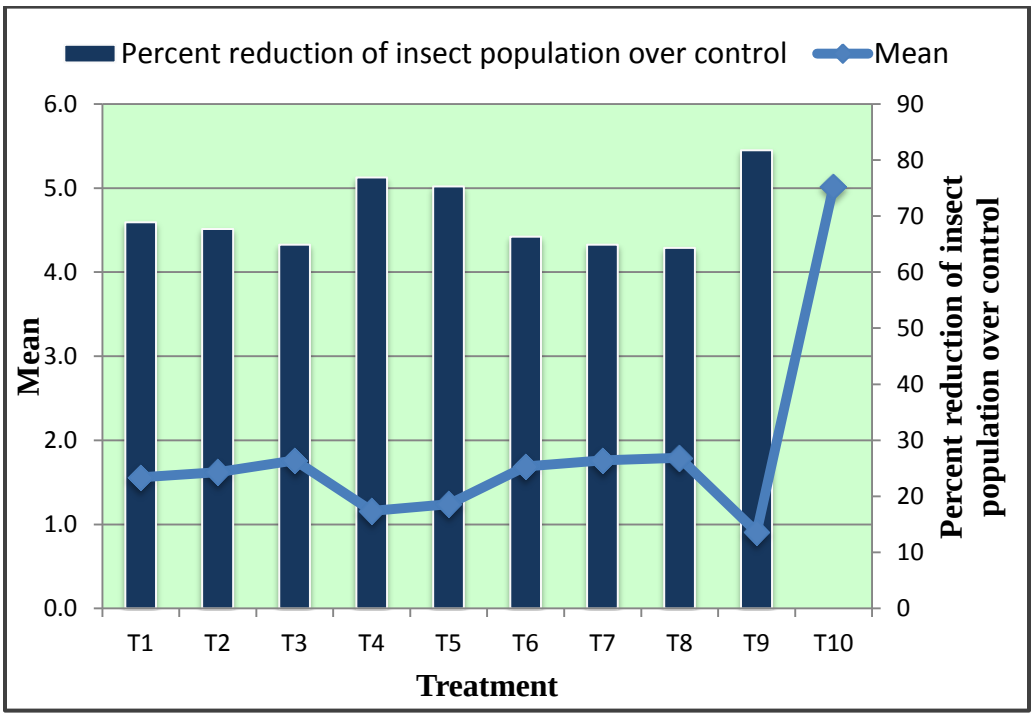

Fig. 4.11 : Over all mean population and percent reduction of *T. tabaci* after first spray

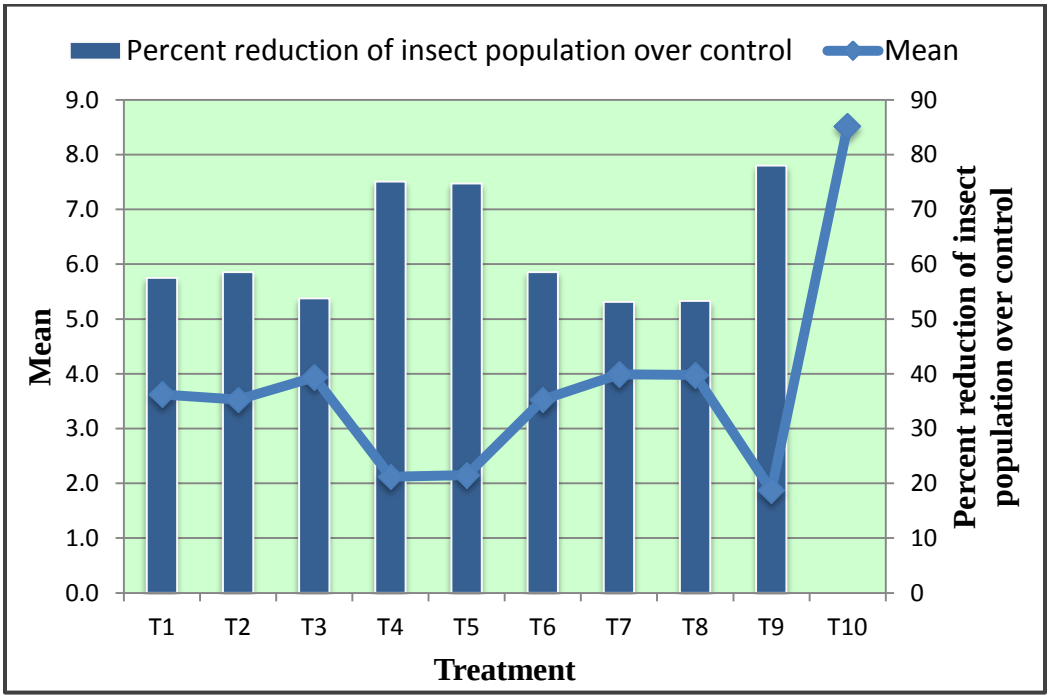

Fig. 4.12:Over all mean population and percent reduction of *T. tabaci* after second spray

Table 4.16 : : Efficacy of plant products against Thrips (*Thrips tabaci*) in Soybean during *Kharif*, 2016 after second spray

				Mean Population of Thrips per three leaves/ plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of insect population over control
T1	Neem oil	2%	10 lt	5.13	3.66	3.6	3.4	3.8	3.62	57.51
				(2.476)#	(2.159)	(2.142)	(2.096)	(2.191)		
T2	Karanj oil	2%	10 lt	5.03	3.73	3.53	3.33	3.53	3.53	58.56
				(2.456)	(2.175)	(2.127)	(2.080)	(2.129)		
T3	NSKE	5%	25 lt	5.23	4.43	4.06	3.4	3.86	3.94	53.75
				(2.497)	(2.330)	(2.250)	(2.097)	(2.206)		
T4	Karanj seed extract	2.5%	12.5 lt	5.23	3.3	2	1.83	1.36	2.12	75.11
				(2.510)	(2.073)	(2.732)	(1.683)	(2.537)		
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	5.3	3.16	2.06	1.96	1.43	2.15	74.76
				(2.497)	(2.041)	(2.751)	(1.722)	(2.559)		
T6	Green chilli	10 kg/ha	10 kg	5.23	4.53	3.3	3.13	3.16	3.53	58.56
				(2.483)	(2.352)	(2.073)	(2.032)	(2.041)		
T7	Red chilli	2 kg/ha	2 kg	5.16	4.63	3.83	3.63	3.86	3.99	53.16
				(2.483)	(2.373)	(2.197)	(2.151)	(2.205)		
T8	Mahua oil	2%	10 lt	5.4	4.6	4.03	3.66	3.63	3.98	53.28
				(2.530)	(2.366)	(2.242)	(2.159)	(2.152)		
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	5.36	3	2	1.5	1	1.87	77.99
				(2.523)	(1.999)	(1.731)	(1.582)	(1.413)		
T10	Control	-	-	5.4	7.4	8.23	9.03	9.4	8.52	-
				(2.530)	(2.898)	(3.039)	(3.167)	(3.225)		
C.D. at 5%				NS	.112	0.141	0.132	0.087		

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

Thrips population at seven day after first spray

After one day of second spray, Thrips population on soybean crop ranged from 0.66 to 4.89 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.66 Thrips per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% 0.86 thrips per plant was most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha with 1.06 but differed significantly from green chilli @10kg/ha (1.2), red chilli @ 2kg/ha (1.23thrips/plant), Karanj oil @ 2% (1.26), and Neem oil @ 2% (1.26), NSKE 5% (1.33) thrips per plant and mahua oil@2% (1.36) as against 4.89 thrips per plant in untreated control.

Thrips population at fifteen day after first spray

After one day of second spray, Thrips population on soybean crop ranged from 1.1 to 6.56 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1.1 Thrips per plant.

Among the plant products, plot treated with was most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha with 1.46 but differed significantly from Karanj oil @ 2% (2.06), and Neem oil @ 2% (2.1), NSKE 5% (2.63) thrips per plant, green chilli @10kg/ha (2.86), red chilli @ 2kg/ha (2.9thrips/plant), and mahua oil@2% (2.93) as against 6.56 thrips per plant in untreated control.

Over all mean population of *T. tabaci*

Mean thrips population during first spraying indicated that chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.91 thrips/plant but among the plant products Karanj seed extract @ 2.5% 1.16 thrips per plant which was followed by garlic+green chilli @ 8.75 kg/ha recorded minimum population of 1.24 thrips/plant Neem oil @ 2% (1.56), Karanj oil @ 2% (1.62), green chilli @ 10kg/ha (1.69), NSKE @ 5% (1.76), red chilli @ 2kg/ha having 1.76 thrips/plant, and maximum population was recorded in mahua oil@2% (1.79).

Percent reduction of *T. tabaci* population over control

Percent reduction of insect population over control was found higher in triazophos @ 750 ml/ha (81.77%) treated crop and among the plant products, it was maximum in Karanj seed extract @ 2.5% (76.89%) followed by garlic+green chilli @ 8.75 kg/ha (75.29%) treated crop, Neem oil @ 2% (68.92%), Karanj oil @ 2% (67.72%), green chilli @ 10kg/ha (66.33%), NSKE @ 5% (64.94%), red chilli @ 2kg/ha (64.94%), and lowest in mahua oil @2% treated plots having only 64.34 percent reduction in insect population.

Effect of plant products on T. *tabaci* after second spray

Pre treatment observation

Pre-treatment observations was recorded ranged in different treatments from 5.03 to 5.4 thrips per plant with non significant differences among different treatments.

Thrips population at first day after second spray

After one day of second spray, Thrips population on soybean crop ranged from 3.0 to 7.4 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3 Thrips per plant.

Among the plant products, plot treated with garlic+green chilli @ 8.75 kg/ha 3.16 was most effective as compared to other treatment it was at par with Karanj seed extract @ 2.5%3.3 thrips per plant but differed significantly from Neem oil @ 2% (3.66), Karanj oil @ 2% (3.73), NSKE 5% (4.43) thrips per plant, green chilli @10kg/ha (4.53), red chilli @ 2kg/ha (4.63thrips/plant), and and mahua oil@2% (4.6) as against 7.4 thrips per plant in untreated control.

Thrips population at three day after second spray

After one day of second spray, Thrips population on soybean crop ranged from 2.0 to 8.23 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 3 Thrips per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% (2.0) thrips per plantwas most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha (2.06) but differed significantly from green chilli @10kg/ha (3.3), Neem oil @ 2% (3.6), Karanj oil @ 2% (3.6), red chilli @ 2kg/ha (3.83thrips/plant), NSKE 5% (4.06) thrips per plant, and mahua oil@2% (4.03) as against 8.23 thrips per plant in untreated control.

Thrips population at seven day after second spray

After one day of second spray, Thrips population on soybean crop ranged from 1.5 to 9.03 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1.5 Thrips per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% 1.83 thrips per plantwas most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha 1.96 but differed significantly from green chilli @10kg/ha (3.13), Karanj oil @ 2% (3.33), Neem oil @ 2% (3.4), NSKE 5% (3.4) thrips per plant, red chilli @ 2kg/ha (3.63thrips/plant), and mahua oil @2% (3.66) as against 9.03 thrips per plant in untreated control.

Thrips population at fifteen day after second spray

After one day of second spray, Thrips population on soybean crop ranged from 1.0 to 9.4 Thrips/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1.0 Thrips per plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% 1.36 thrips per plant was most effective as compared to other treatment it was at par with garlic+green chilli @ 8.75 kg/ha 1.43 but differed significantly from green chilli @10kg/ha (3.16), Karanj oil @ 2% (3.53), mahua oil@2% (3.63), Neem oil @ 2% (3.8), NSKE 5% (3.86) thrips per plant, and red chilli @ 2kg/ha (3.86thrips/plant) as against 9.4 thrips per plant in untreated control.

Over all mean population of *T. tabaci*

Mean thrips population during second spray indicated that chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1.87 thrips/plant and among the different plant products, Karanj seed extract @ 2.5% recorded minimum thrips population with 2.12 thrips/plant followed by garlic+green chilli @ 8.75 kg/ha (2.15), Karanj oil @ 2% (3.53), green chilli @ 10kg/ha (3.53), Neem oil @ 2% (3.62), NSKE @ 5% (3.94), mahua oil @2% (3.98), and maximum population in red chilli @ 2kg/ha (3.99 thrips/plant).

Percent reduction of *T. tabaci* population over control

Percent reduction of insect population over control was found higher in triazophos 40 EC @ 750 ml/ha (77.99%) treated crop and among the plant products, it was maximum in Karanj seed extract @ 2.5% (75.11%), garlic+green chilli @ 8.75 kg/ha (74.76%) treated crop, followed by Karanj oil @ 2% (58.56%), green chilli @ 10kg/ha (58.56%), Neem oil 2% (57.51%), NSKE 5% (53.75%), mahua oil @2% (53.28%) and lowest in red chilli @ 2kg/ha treated plots recorded only 53.16 percent reduction in insect population.

The results are in conformity with the findings of Vijayalakshmi *et al.* (1996) and (1997) garlic extract alone and in combination with other plant extracts *viz.*, chilli, ginger, neem, tobacco and even cow urine was found effective against sucking pests like aphids, whiteflies, thrips and mites.

Lakshmanan (2001) reported that garlic bulb extract alone or in combination with kerosene, neem oil, chilli and other extracts effectively managed sucking pests like aphids, whiteflies, thrips.

4.3.1.3 Effect of plant products on natural enemies on soybean crop

(a) Lady bird beetle

Effect of plant products on lady bird beetle after first spray

Pre treatment observation

In pre-treatment observation, of lady bird beetle population was recorded between 0.2 to 0.80 and was non significant differences among different plots.

Post treatment observation

Lady bird beetle population at one day after first spray

After one day spray among the population of coccinellids on soybean crop ranged from 0.46 to 1.86 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.46 coccinellid/plant.

Among different plant products, plot treated with garlic+green chilli @ 8.75 kg/ha with 1.7 coccinellid/plant showed the maximum population as against 1.86 coccinellids/plant in untreated control. It was followed by red chilli 2kg/ha having 1.6, Karanj seed extract @ 2.5% (1.56), Neem oil @ 2% (1.56), NSKE @ 5% (1.5), green chilli @ 10kg/ha (1.36), Karanj oil @ 2% (1.13), and minimum population was recorded in mahua oil@ 2% (1.1) coccinellid/plant.

Lady bird beetle population at three days after first spray

After three days of first spray, population of coccinellids on soybean crop ranged from 0.3 to 1.83 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.3 coccinellid/plant.

Among plant products, different treatments followed more or less similar to first day odservation of garlic+green chilli @ 8.75 kg/ha with 1.56 coccinellid/plant showed the maximum population as against 1.83 coccinellids/plant in untreated control. It was followed by Karanj seed extract @ 2.5% (1.53), red chilli @ kg/ha (1.5), Neem oil @ 2% (1.46), NSKE @ 5% (1.4), green chilli @ 10kg/ha (1.3), Karanj oil @ 2% (1.06), and minimum population was recorded in mahua oil@ 2% (0.96) coccinellid/plant.

Lady bird beetle population at seven days after first spray

After seven days of first day, the population of coccinellids on soybean crop ranged from 0.2 to 1.76 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @750ml/ha recorded the minimum population of 0.2 coccinellid/plant.

Among plant products, different treatments followed more or less similar to first day odservation of Karanj seed extract @ 2.5% (1.43) with coccinellid/plant

showed the maximum population as against 1.76 coccinellids/plant in untreated control. It was followed by, garlic+green chilli @ 8.75 kg/ha(1.4), red chilli @ kg/ha (1.3), Neem oil @ 2% (1.3), NSKE @ 5% (1.2), green chilli @ 10kg/ha (1.13), mahua oil@ 2% (1.0) and minimum population was recorded in Karanj oil @ 2% (0.9) coccinellid/plant.

Lady bird beetle population at fifteen days after first spray

After fifteen days of first spray, population of coccinellids on soybean crop ranged from 0.09 to 1.86 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.09 coccinellid/plant.

Among plant products, different treatments showed more or less similar to first day odservation of red chilli @ kg/ha (1.73) coccinellid/plant showed the maximum population as against 1.86 coccinellids/plant in untreated control. It was followed by Karanj seed extract @ 2.5% (1.7), garlic+green chilli @ 8.75 kg/ha with 1.6 , NSKE @ 5% (1.53), Neem oil @ 2% (1.5), green chilli @ 10kg/ha (1.43), mahua oil@ 2% (1.23) and minimum population was recorded in Karanj oil @ 2% (1.2) coccinellid/plant.

Over all mean population of coccinellids

Mean of coccinellids population during first spray indicated that Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.26 coccinellid/ plant and among the different plant products, garlic+green chilli @ 8.75 kg/ha recorded maximum population with 1.57 coccinellid/plant followed by Karanj seed extract @ 2.5% (1.56) red chilli @ 2kg/ha (1.53), Neem oil @ 2% (1.46), NSKE @ 5% (1.41), green chilli @ 10kg/ha (1.31), and minimum in Karanj oil @ 2% (1.07), mahua oil@ 2% (1.07) coccinellid/plant.

Table 4.17 : Effect of plant products on Coccinellid beetle population in Soybean during *Kharif*, 2016 after first spray

				Mean Population of Coccinellid per plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of C. beetle population over control
T1	Neem oil	2%	10 lt	0.6 (1.263)#	1.56 (1.602)	1.46 (1.570)	1.3 (1.517)	1.5 (1.581)	1.46	20.21
T2	Karanj oil	2%	10 lt	0.63 (1.276)	1.1 (1.449)	0.96 (1.402)	1.0 (1.414)	1.23 (1.494)	1.07	41.53
T3	NSKE	5%	25 lt	0.6 (1.263)	1.5 (1.580)	1.4 (1.548)	1.2 (1.481)	1.53 (1.591)	1.41	22.95
T4	Karanj seed extract	2.5%	12.5 lt	0.53 (1.225)	1.56 (1.600)	1.53 (1.590)	1.43 (1.559)	1.7 (1.643)	1.56	14.75
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	0.46 (1.210)	1.7 (1.643)	1.56 (1.602)	1.4 (1.549)	1.6 (1.612)	1.57	14.20
T6	Green chilli	10 kg/ha	10 kg	0.6 (1.265)	1.36 (1.538)	1.3 (1.516)	1.13 (1.459)	1.43 (1.560)	1.31	28.41
T7	Red chilli	2 kg/ha	2 kg	0.53 (1.236)	1.6 (1.612)	1.5 (1.581)	1.3 (1.516)	1.73 (1.653)	1.53	16.39
T8	Mahua oil	2%	10 lt	0.2 (1.095)	1.13 (1.461)	1.06 (1.437)	0.9 (1.378)	1.2 (1.483)	1.07	41.53
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	0.46 (1.210)	0.46 (1.202)	0.3 (1.140)	0.2 (1.095)	0.09 (1.045)	0.26	85.79
T10	Control			0.8 (1.338)	1.86 (1.693)	1.83 (1.683)	1.76 (1.663)	1.86 (1.693)	1.83	-
	C.D. at 5%			NS	0.118	0.070	0.073	0.059	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

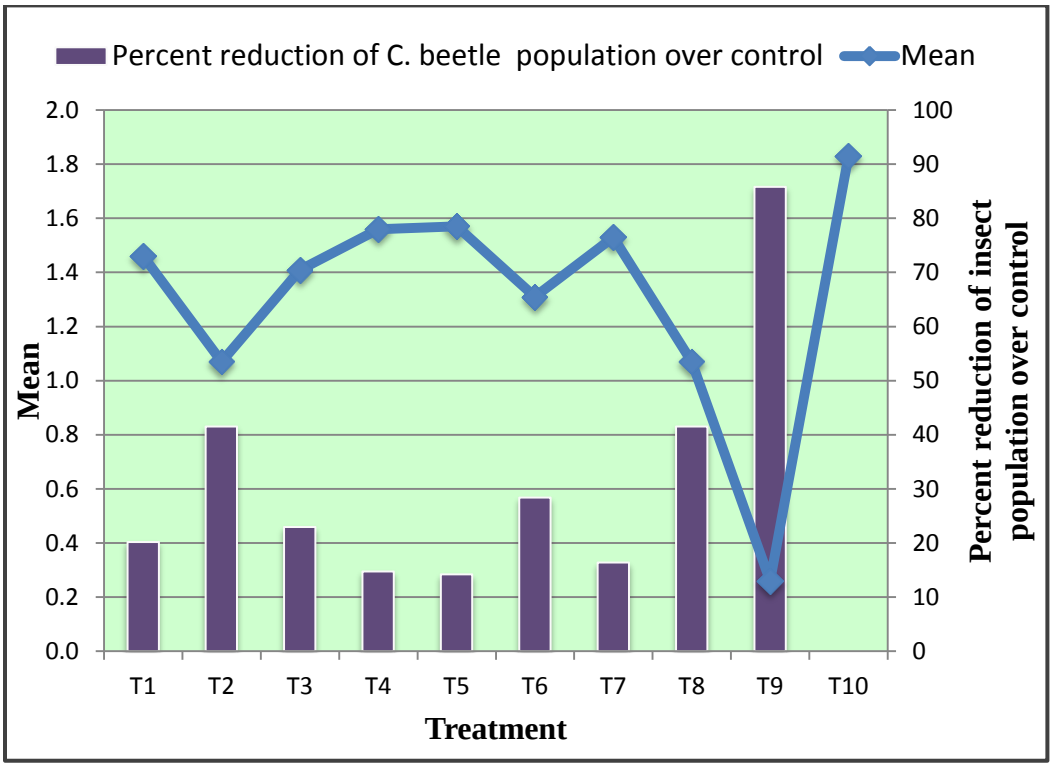

Fig. 4.13 : Over all mean population and percent reduction of C. beetle after first spray

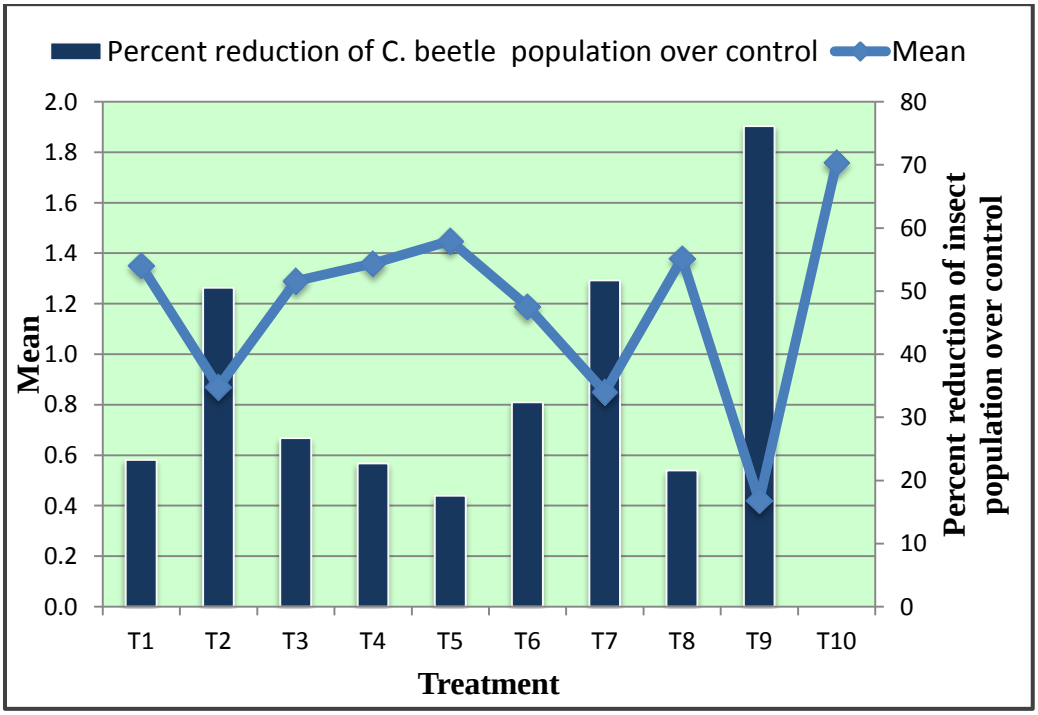

Fig.4.14:Over all mean population and percent reduction of C. beetle after second spray

Table 4.18 : Effect of plant products on Coccinellid beetle population in Soybean during *Kharif*, 2016 after second spray

				Mean Population of Coccinellid beetle per plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	Percent reduction of C. beetle population over control
T1	Neem oil	2%	10 lt	0.8	1.46	1.3	1.16	1.46	1.35	23.29
				(1.342)#	(1.570)	(1.516)	(1.472)	(1.570)		
T2	Karanj oil	2%	10 lt	1	1.1	0.8	0.7	0.86	0.87	50.56
				(1.413)	(1.449)	(1.340)	(1.302)	(1.366)		
T3	NSKE	5%	25 lt	1.06	1.4	1.16	1.13	1.46	1.29	26.70
				(1.437)	(1.549)	(1.472)	(1.460)	(1.570)		
T4	Karanj seed extract	2.5%	12.5 lt	1	1.43	1.3	1.2	1.5	1.36	22.72
				(1.413)	(1.560)	(1.505)	(1.483)	(1.581)		
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	1.26	1.56	1.4	1.23	1.6	1.45	17.61
				(1.503)	(1.602)	(1.548)	(1.494)	(1.612)		
T6	Green chilli	10 kg/ha	10 kg	1.13	1.23	1.13	1.06	1.33	1.19	32.38
				(1.460)	(1.494)	(1.460)	(1.437)	(1.527)		
T7	Red chilli	2 kg/ha	2 kg	1.2	1.03	0.86	0.73	0.76	0.85	51.70
				(1.480)	(1.426)	(1.364)	(1.315)	(1.329)		
T8	Mahua oil	2%	10 lt	1.35	1.43	1.26	1.3	1.53	1.38	21.59
				(1.529)	(1.559)	(1.505)	(1.515)	(1.591)		
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	0.93	0.5	0.4	0.23	0.53	0.42	76.13
				(1.390)	(1.224)	(1.183)	(1.110)	(1.238)		
T10	Control	-	-	0.8	1.73	1.7	1.76	1.83	1.76	-
				(1.332)	(1.653)	(1.643)	(1.663)	(1.683)		
C.D. at 5%				NS	0.070	0.097	0.085	0.074	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

Percent reduction of coccinellids population over control

Percent reduction of coccinellids population over control was found higher in triazophos @ 750 ml/ha (85.79%) and among the plant products, reduction higher in Karanj oil @ 2% (41.53%), mahua oil@ 2% (41.53%) followed by green chilli @ 10kg/ha (28.41%), NSKE @ 5% (22.95%), Neem oil @ 2% (20.21%), red chilli @ 2kg/ha (16.39%) Karanj seed extract @ 2.5% (14.75%), and lowest in garlic+green chilli 8.75 kg/ha (14.20%).

Effect of plant products on lady bird beetle after second spray

Pre treatment observation

Pre-treatment observations was recorded ranged in different treatments from 0.8 to 1.35 coccinellids/plant, with non significant differences among different treatments.

Post treatment observation

Lady bird beetle population at one day after second spray

After one day of second spray, population of coccinellids on soybean crop ranged from 0.5 to 1.73 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.5 coccinellid/plant.

Among the plant products, garlic+green chilli @ 8.75 kg/ha with 1.56 coccinellids/plant, showed the maximum population as against 1.73 coccinellids/plant in untreated control. It was followed by Neem oil @ 2% (1.46), Karanj seed extract @ 2.5% (1.43), NSKE @ 5% (1.4), Karanj oil @ 2% (1.43), green chilli @ 10kg/ha (1.23), mahua oil@ 2% (1.1), and minimum population was recorded in red chilli @ 2kg/ha having (1.03) coccinellid/plant.

Lady bird beetle population at three days after second spray

After three day of second spray, population of coccinellids on soybean crop ranged from 0.4 to 1.7 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @ 750ml/ha recorded the minimum population of 0.4 coccinellid/plant.

Among the plant products, garlic+green chilli @ 8.75 kg/ha with 1.4 coccinellids/plant, showed the maximum population as against 1.7 coccinellids/plant in untreated control. It was followed by Neem oil @ 2% (1.3), Karanj oil @ 2% (1.3), Karanj seed extract @ 2.5% (1.26), NSKE @ 5% (1.16), green chilli @ 10kg/ha (1.13), red chilli @ 2kg/ha having (0.86), and minimum population was recorded in mahua oil@ 2% (0.8) coccinellid/plant.

Lady bird beetle population at seven days after second spray

After seven days of second spray, population of coccinellids on soybean crop ranged from 0.23 to 1.76 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.23 coccinellid/plant.

Among the plant products, Karanj seed extract @ 2.5% (1.3), garlic+green chilli @ 8.75 kg/ha with 1.23 coccinellids/plant, showed the maximum population as against 1.76 coccinellids/plant in untreated control. It was followed by Neem oil @ 2% (1.3), Karanj oil @ 2% (1.2), NSKE @ 5% (1.13), green chilli @ 10kg/ha (1.06), red chilli @ 2kg/ha having (0.73), and minimum population was recorded in mahua oil@ 2% (0.7) coccinellid/plant.

Lady bird beetle population at fifteen days after second spray

After fifteen days of second spray, population of coccinellids on soybean crop ranged from 0.53 to 1.83 coccinellids/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.53 coccinellid/plant.

Among the plant products, plot treated with garlic+green chilli @ 8.75 kg/ha with 1.6 coccinellid/plant of maximum population as against 1.83 coccinellids/plant in untreated control. It was followed by Karanj seed extract @ 2.5% (1.53), Karanj oil @ 2% (1.5), Neem oil @ 2% (1.46), NSKE @ 5% (1.46), green chilli @ 10kg/ha (1.33), red chilli @ 2kg/ha having 0.76 and minimum population was recorded in mahua oil@ 2% (0.7) coccinellid/plant.

Over all mean population of coccinellids

Mean of coccinellids population during second spray indicated that chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.42 coccinellids/plant and among the different plant products garlic+green chilli @ 8.75 kg/ha recorded maximum population with 1.45 coccinellid per plant followed by Karanj seed extract @ 2.5% (1.38) Karanj oil @ 2% (1.36), Neem oil @ 2% (1.35), NSKE @ 5% (1.29), green chilli 10kg/ha (1.19), mahua oil@ 2% (0.87) and minimum in red chilli @ 2kg/ha 0.85.

Percent reduction of coccinellids population over control

(a) Percent reduction of coccinellids population over control was found higher in red chilli @ 2kg/ha (51.70%) followed by green chilli @ 10kg/ha (32.38%), NSKE @ 5% (26.70%), Neem oil @ 2% (23.29%), Karanj oil @ 2% (22.72%), Karanj seed extract @ 2.5% (21.59%), and lowest (21.59%) in garlic+green chilli @ 8.75 kg/ha.

(b) Spider

(c) Effect of plant products on Spider after first spray

Pre treatment observation

Pre-treatment observations was recorded ranged in different treatments from 0.4 to 0.8 spiders/plant with non significant differences among different treatments

Post treatment observation

Spider population at one day after first spray

After one day of first spray, population of spider on soybean crop ranged from 0.46 to 1.63 spidesr/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.46 spider/plant.

Among the plant products, plots treated with red chilli @ 2kg/ha recorded the maximum population of 1.43 spiders/plant as against 1.63 spiders/plant in untreated control. It was followed by Neem oil @ 2% (1.4), garlic+green chilli @ 8.75 kg/ha

(1.33), Karanj seed extract 2.5% (1.36), NSKE @ 5% (1.3), Karanj oil @ 2% (1.2), green chilli 10kg/ha (1.26) and minimum population was recorded in mahua oil @2%1.16.

Spider population at three days after first spray

After three days of first spray, population of spider on soybean crop ranged from 0.36 to 1.73 spiders/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.36 spider/plant.

Among the different plant products, garlic+green chilli @ 8.75 kg/ha recorded maximum population with 1.3 spiders/plant as against 1.73 spiders/plant in untreated control. It was followed by Karanj seed extract @ 2.5% (1.3 spider/plant), Neem oil @ 2% (1.26), red chilli @ 2kg/ha having (1.26) spider/plant. NSKE @ 5% (1.23), green chilli @ 10kg/ha (1.2), Karanj oil @ 2% (1.06), green chilli @ 10kg/ha (1.2), where as minimum population was recorded in mahua oil @2%(1.0)

Spider population at seven days after first spray

After seven days of first day, population of spider on soybean crop ranged from 0.26 to 1.83 spiders/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.26 spider/plant. Like the previous observations to continued to be recorded the maximum population in garlic+green chilli @ 8.75 kg/ha with 1.36 spiders/plant, as against 1.83 spiders/plant in untreated control. It was followed by Neem oil @ 2% (1.2), red chilli @ 2kg/ha having 1.2 spider/plant, Karanj seed extract @ 2.5% (1.16), NSKE @ 5% (1.06), green chilli @ 10kg/ha (0.93), Karanj oil @ 2% (0.86), and minimum population was recorded in mahua oil @ 2%(0.76)

Spider population at fifteen days after first spray

After fifteen days of first spray, population of spider on soybean crop ranged from 0.36 to 1.93 spiders/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.36 spider/plant.

Among the plant products, plot treated with Karanj seed extract @ 2.5% continued to exhibit its consistency of maximum population with 1.46 spider/plant as against 1.93 spiders/plant in untreated control. It was followed by Neem oil @ 2% (1.43), garlic+green chilli @ 8.75 kg/ha(1.36), NSKE @ 5% (1.23), red chilli @ 2kg/ha having(1.2), green chilli @ 10kg/ha (1.1), Karanj oil @ 2% (1.03), and minimum population was recorded in mahua oil @ 2%(0.96).

Over all mean population of spider

Mean of spider population during first spray indicated that triazophos 40 EC @ 750 ml/ha recorded the minimum population of 0.36 spider/plant and among the different plant products, garlic+green chilli @ 8.75 kg/ha recorded maximum population with (1.32 spider/plant) followed by Karanj seed extract @ 2.5% (1.32), Neem oil @ 2% (1.32), red chilli @ 2kg/ha (1.27), NSKE @ 5% (1.21), green chilli @ 10kg/ha (1.12), Karanj oil @ 2% (1.04), and mahua oil@2%(0.97).

Percent reduction of spider population over control

Percent reduction of spider population over control found higher in triazophos 40 EC @ 750 ml/ha (79.77%) and among the plant products, it was maximum in mahua oil@ 2% (45.50%), followed by Karanj oil @ 2% (41.57%), NSKE @ 5% (32.02%), green chilli @ 10kg/ha (37.07%), red chilli @ 2kg/ha (28.65%), Neem oil @ 2% (25.84%), Karanj seed extract @ 2.5% (25.84%), and lowest in garlic+green chilli @ 8.75 kg/ha (24.71%).

Effect of plant products on Spider after second spray

In pre-treatment observations the mean of spider population varied from 0.86 to 1.26 spiders per plant, with non significant differences among different treatments.

Spider population at one day after second spray

After one day of second spray, population of spider on soybean crop ranged from 1 to 1.76 spiders/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1 spider/plant.

Table 4.19 : Effect of plant products on Spider population in Soybean during *Kharif*, 2016 after first spray

				Mean Population of Spider per plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	% reduction of spider population over control
T1	Neem oil	2%	10 lt	0.46	1.4	1.26	1.2	1.43	1.32	25.84
				(1.265)	(1.549)	(1.505)	(1.482)	(1.559)		
T2	Karanj oil	2%	10 lt	0.73	1.2	1.06	0.86	1.03	1.04	41.57
				(1.316)	(1.483)	(1.437)	(1.366)	(1.426)		
T3	NSKE	5%	25 lt	0.4	1.3	1.23	1.06	1.23	1.21	32.02
				(1.181)	(1.516)	(1.494)	(1.437)	(1.494)		
T4	Karanj seed extract	2.5%	12.5 lt	0.66	1.36	1.3	1.16	1.46	1.32	25.84
				(1.276)	(1.538)	(1.517)	(1.472)	(1.570)		
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	0.66	1.33	1.3	1.36	1.36	1.34	24.71
				(1.287)	(1.527)	(1.516)	(1.538)	(1.538)		
T6	Green chilli	10 kg/ha	10 kg	0.66	1.26	1.2	0.93	1.1	1.12	37.07
				(1.290)	(1.505)	(1.483)	(1.390)	(1.449)		
T7	Red chilli	2 kg/ha	2 kg	0.46	1.43	1.26	1.2	1.2	1.27	28.65
				(1.210)	(1.560)	(1.505)	(1.483)	(1.482)		
T8	Mahua oil	2%	10 lt	0.8	1.16	1	0.76	0.96	0.97	45.50
				(1.340)	(1.472)	(1.414)	(1.329)	(1.402)		
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	0.66	0.46	0.36	0.26	0.36	0.36	79.77
				(1.289)	(1.210)	(1.168)	(1.125)	(1.169)		
T10	Control	-	-	0.4	1.63	1.73	1.83	1.93	1.78	-
				(1.181)	(1.622)	(1.653)	(1.683)	(1.713)		
C.D. at 5%				NS	0.067	0.064	0.049	0.055	-	-

- Figure in parantheses are square root transformed values

DAS -Days after spraying of insecticide, mrl - meter row length

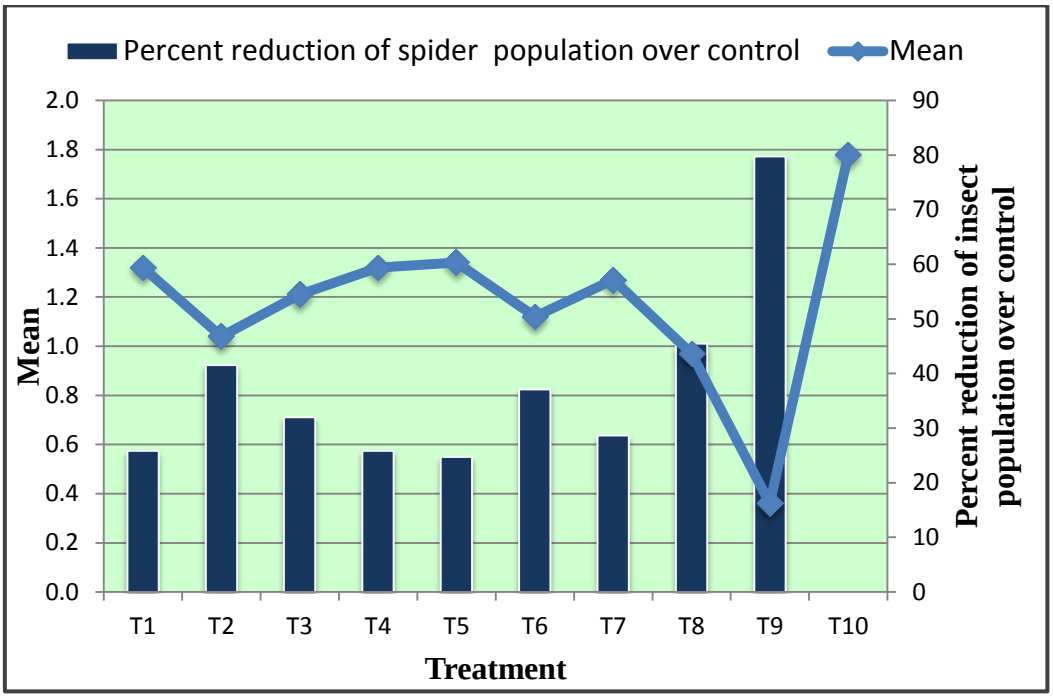

Fig. 4. 15: Overall mean population and percent reduction of spider after first spray

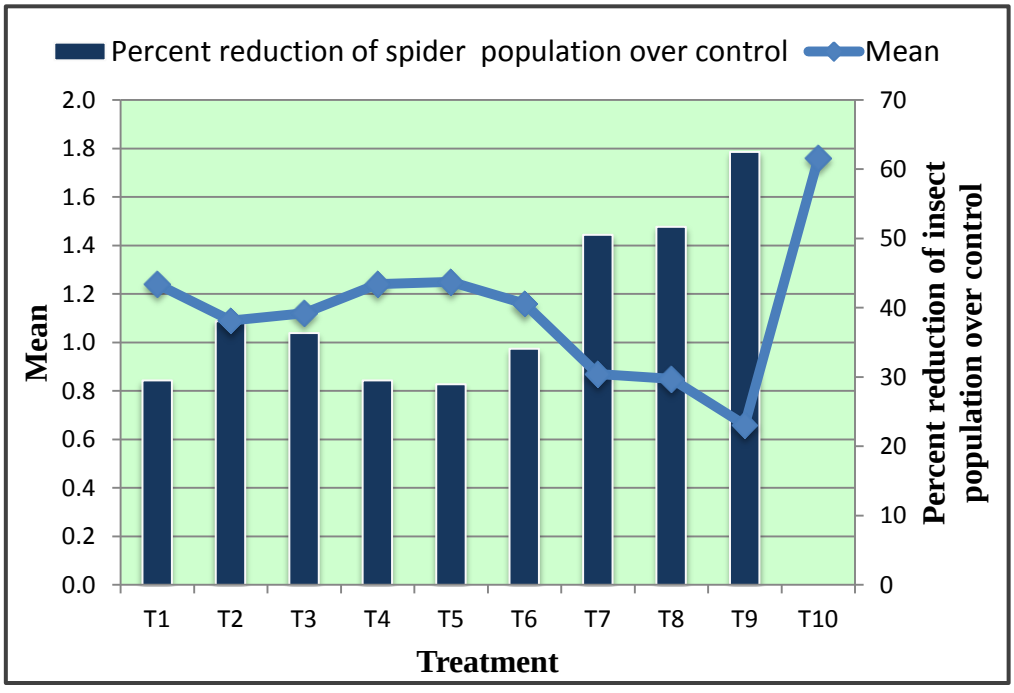

Fig. 4.16 : Overall mean population and percent reduction of spider after second spray

Table 4.20 : Effect of plant products on Spider population in Soybean during *Kharif*, 2016 after second spray

				Mean Population of Spider per plant						
					Post treatment observation					
	Treatments	Dose	Quantity Per Hectare	Pre treat. Obs.	1 DAS	3 DAS	7DAS	15DAS	Mean	% reduction of spider population over control
T1	Neem oil	2%	10 lt	1.06	1.3	1.2	1.1	1.36	1.24	29.54
				(1.435)	(1.516)	(1.483)	(1.449)	(1.538)		
T2	Karanj oil	2%	10 lt	1.13	1.13	1.06	0.93	1.23	1.09	38.06
				(1.454)	(1.460)	(1.437)	(1.390)	(1.494)		
T3	NSKE	5%	25 lt	1.26	1.2	1.06	0.9	1.3	1.12	36.36
				(1.499)	(1.483)	(1.437)	(1.378)	(1.514)		
T4	Karanj seed extract	2.5%	12.5 lt	0.93	1.3	1.23	1.06	1.36	1.24	29.54
				(1.390)	(1.516)	(1.494)	(1.437)	(1.538)		
T5	Garlic+green chilli	8.75 kg/ha	8.75 kg	0.93	1.2	1.23	1.16	1.4	1.25	28.97
				(1.382)	(1.483)	(1.494)	(1.472)	(1.548)		
T6	Green chilli	10 kg/ha	10 kg	1	1.11	1.16	1.13	1.26	1.16	34.09
				(1.409)	(1.449)	(1.471)	(1.460)	(1.505)		
T7	Red chilli	2 kg/ha	2 kg	1.13	1	0.8	0.63	1.06	0.87	50.56
				(1.432)	(1.414)	(1.341)	(1.278)	(1.436)		
T8	Mahua oil	2%	10 lt	0.86	0.93	0.76	0.66	1.03	0.85	51.70
				(1.354)	(1.390)	(1.329)	(1.291)	(1.425)		
T9	Triazophos 40 EC	1.5 ml/lit	750 ml	1.13 (1.452)	1	0.73	0.56	0.36	0.66	62.50
					(1.415)	(1.316)	(1.250)	(1.168)		
T10	Control	-	-	0.93 (1.413)	1.76	1.7	1.73	1.83	1.76	-
					(1.663)	(1.643)	(1.653)	(1.683)		
C.D. at 5%				NS	0.059	0.066	0.066	0.076	-	-

- Figure in parantheses are square root transformed values , DAS -Days after spraying of insecticide, mrl - meter row length

Among the plant products, maximum population was recorded in Karanj seed extract @ 2.5% (1.3) spiders/plant, as against 1.76 spiders/plant in untreated control. It was followed by Neem oil @ 2% (1.3), garlic+green chilli @ 8.75 kg/ha with (1.2), NSKE @ 5% (1.2), Karanj oil @ 2% (1.13), green chilli @ 10kg/ha (1.11), red chilli @ 2kg/ha having (1.0) and minimum population was recorded in mahua oil@ 2% (0.93) spider/plant.

Spider population at three days after second spray

After three days of second spray population of spider on soybean crop ranged from 0.73 to 1.7 spiders/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 0.73 spider/plant. Plant products in different treatments followed more or less similar to first day maximum population was recorded in garlic+green chilli @ 8.75 kg/ha with 1.23 spider/plant as against 1.7 spider/plant in untreated control. It was followed by Karanj seed extract @ 2.5% (1.23), Neem oil @ 2% (1.2), green chilli @ 10kg/ha (1.16), NSKE @ 5% (1.06), Karanj oil @ 2% (1.06), red chilli @ 2kg/ha 0.8 spider/plant and minimum population was recorded in mahua oil@ 2% (0.76).

Spider population at seven days after second spray

After seven days of second spray population of spider on soybean crop ranged from 0.56 to 1.73 spiders/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1.73 spider/plant. Plant products in different treatments followed more or less similar to first day maximum population was recorded in garlic+green chilli @ 8.75 kg/ha with 1.16 spider/plant as against 1.73 spider/plant in untreated control. It was followed by green chilli @ 10kg/ha (1.13), Neem oil @ 2% (1.1), Karanj seed extract @ 2.5% (1.06), , NSKE @ 5% (0.9), Karanj oil @ 2% (0.93), mahua oil@ 2% (0.66), and minimum population was recorded in red chilli @ 2kg/ha 0.63 spider/plant.

Spider population at fifteen days after second spray

After fifteen days of second spray population of spider on soybean crop ranged from 0.36 to 1.83 spiders/plant. Standard chemical insecticide *i.e* triazophos @ 750 ml/ha recorded the minimum population of 1.83 spider/plant. Plant products in different treatments followed more or less similar to first day maximum population was recorded in garlic+green chilli @ 8.75 kg/ha with 1.4 spider/plant as against 1.83 spider/plant in untreated control. It was followed by Karanj seed extract @ 2.5% (1.36), Neem oil @ 2% (1.36), NSKE @ 5% (1.3), Karanj oil @ 2% (1.23), green chilli @ 10kg/ha (1.13), red chilli @ 2kg/ha (1.06) spider/plant, and minimum population was recorded in mahua oil@ 2% (1.03).

Over all mean population of spider

Mean of spider population during first spray indicated that triazophos 40 EC @ 750 ml/ha recorded the minimum population of 0.66 spider/plant and among the different plant products garlic+green chilli @ 8.75 kg/ha recorded maximum population with (1.25 spider/plant) followed by Karanj seed extract @ 2.5% (1.24), Neem oil @ 2% (1.24), green chilli @ 10kg/ha (1.16), NSKE @ 5% (1.12), Karanj oil @ 2% (1.09), red chilli @ 2kg/ha (0.87), and mahua oil@2%(0.85).

Percent reduction of spider population over control

Percent reduction of spider population over control found higher in triazophos 40 EC @ 750 ml/ha (61.36%) and among the plant products, it was maximum in mahua oil@ 2% (51.70%), followed by red chilli @ 2kg/ha (51.13%), Karanj oil @ 2% (38.06%), NSKE @ 5% (36.36%), green chilli @ 10kg/ha (34.09%), Neem oil @ 2% (29.54%), Karanj seed extract @ 2.5% (29.54%), and lowest in garlic+green chilli @ 8.75 kg/ha (28.97%).

The results are in conformity with the findings of Kaethner (1991) who reported that neem extract and neem oil were harmless to eggs, larvae, adults of *C. carnea* and *C. septumpunctata*.

`Mollah *et al.* (2012) also reported that Neemoil @ 2.5ml/ha ensures maximum number of lady bird beetle.

Guddewar *et al*. (1994) reported that extract of neem kernel was safer than synthetic insecticide to *C. septumpuctata*

Rosaiah (2001) recorded the predatory populations in okra ecosystem, among them spiders, chrysopids *Apanteles sp.* and coccinellids were most predominant and there were no significant differences between the populations of these predators in plant sprayed with different plant products. Thus clearly indicate that no harmful effects on the activity of natural enemies in plots treated with botanical insecticide.

4.4 Assessment of benefit cost ratio

Among the plant products, the maximum benefit cost ratio was found in garlic+green chilli @ 8.75 kg/ha having 6.99, which was followed by Karanj seed extract @ 2.5% (6.59), red chilli @ 2kg/ha (5.7), mahua oil @ 2% (5.25), Neem oil @ 2% (4.15), green chilli @ 10kg/ha (3.17), NSKE @ 5% (2.66), and the minimum benefit cost ratio was recorded in the treatment Karanj oil @ 2% having only 1.96 and other than plant products the chemical treatment triazophos @ 750ml/ha which was used for management of insect pests of soybean the benefit cost ratio was maximum with 7.78.

Present findings are in agreement with those of Raghuvanshi *et al.* (2014) as they reported that triazophos gave the maximum better return on soybean crop.

In contradictory Panchabhavi *et al*. (1994) reported that lower pod damage and higher seed yield were recorded on pigeon pea when fenvalerate was applied twice at 15 days interval. However, highest cost benefit ratio was obtained in NSKE sprayed at 15 days interval with a seed yield of 12.0 q/h.

Table 4.21: Assessment of benefit cost ratio in soybean during *Kharif*, 2016

S.No.	Treatment	Qty. of spray/ha	No. of spray	Cost of treatment		Total cost (A)	Yield (q/ha)	Inc. yield over control (q/ ha)	Value of increased yield (Rs/ha)(B)	B.C. Ratio
				Cost of insecticides	Labour for spraying charge					
1	Neem oil	10lt.	2	3000	896	3896	23.56	5.41	16200	4.15
2	Karanj oil	10 lt.	2	3000	896	3896	20.7	2.55	7650	1.96
3	NSKE	25 lt.	2	3000	896	3896	21.61	3.46	10380	2.66
4	Karanj seed extract	12.5 lt.	2	2500	896	3396	25.61	7.46	22380	6.59
5	Garlic + green chilli	8.75 kg	2	2610	896	3506	26.32	8.17	24510	6.99
6	green chilli	10 kg	2	900	896	1796	20.05	1.90	5700	3.17
7	Red chilli	2 kg	2	1800	896	2696	23.32	5.17	15510	5.70
8	Mahua Oil	10 lt	2	2500	896	3396	22.87	4.72	14160	5.25
9	Triazophos	750 ml	2	600	896	1496	22.03	3.88	11640	7.78
10	control	-	-	-	-	-	18.15	-	-	-

CHAPTER-V
SUMMARY AND CONCLUSION

The present investigation entitled **"STUDIES ON SEASONAL INCIDENCE OF MAJOR INSECT PESTS OF SOYBEAN AND ITS BIO-RATIONAL MANAGEMENT"** was conducted during *Kharif* season, 2016 and result summarized below:

During the course of study, four species of insect-pests *viz*., defoliators– tobacco caterpillar, *Spodoptera litura* and green semilooper, *Chrysodeixis acuta*; and sucking pests – whitefly, *Bemisia tabaci*, and thrips, *Thrips tabaci*, as the major insect-pests of soybean crop. The activity of all these insect-pests commenced from last week of July.

The peak activity of defoliators, *S. litura* and *C. acuta* was recorded during second week of September (1.9 larvae per meter row) and first week of September (2.1 larvae per meter row) with a seasonal mean of 0.50 and 0.675 larva per meter row, respectively.

Among sucking pests, the population of white fly reached its peak density of 9.1 white flies per three leaves/plant during last week of September with a seasonal mean of 4.89 white flies per plant, whereas, thrips peak activity was recorded during last week of September *i.e* 3.4 thrips/plant with seasonal mean of 1.808.

Two species of lady bird beetle, *M. sexmaculata* and *C. septumpunctata* and orb weaver spider, *Neoscona* sp. were found predating mainly upon whiteflies and thrips. Whereas, lynx spider, *Oxyopes* sp. and a predatory pentatomid bug, *E. furcellata* was noticed sucking the body sap of lepidopterous larvae.

Correlation between coccinellid beetles and sucking pests was found to be positive and significant at 5 percent level with "r" value 0.867. The correlation coefficient between spiders and defoliator pests was found to be positive and

significant at 5 per cent level with “r” values 0.652 and between predatory pentatomid bug and defoliator pests was found to be positive and non significant at 5 per cent level with “r” values 0.327.

A positive and significant correlation between predatory population of coccinelid beetle and all sucking pests with “r” value 0.867. The regression equation worked out for the two variables was y= 10.94x + 2.414, R2=0.752. Similarly, there existed a positive and significant correlation between predatory population of spider and defoliator pests with “r” value 0.652. The regression equation worked out for the two variables was y = 0.469X + 0.419, R2=0.424. There existed a positive and non significant correlation between predatory population of pentatomid bugs and defoliator pests with “r” value 0.327.

The effect of different weather parameters on seasonal incidence of lepidopterous caterpillars and sucking pests was observed on the crop during last week of July.

The peak activity of defoliator pests (*S. litura* and *C.acuta*) was observed during second week of september with 31.1°C maximum temperature, 24.3°C minimum temperature, 95% morning and 80% evening R.H, a rainfall of 132.8 mm, respectively and 2.9 mm wind velocity.

The peak density of total sucking pests was observed during last week of September which was associated with 30.0°C maximum temperature, 24.5°C minimum temperature, morning and evening R.H. 97 % and 89 % , rainfall 134.8 mm respectively, and 2.8 mm wind velocity.

The screening trial was conducted during *kharif*, 2016 under two categories, the initial varietal trial (IVT) and advanced varietal trial (AVT). In IVT, thirty nine soybean entries along with the four checks- RKS-18, Bragg, JS-335 and JS-97-52 were screened against major insect-pests of soybean. The results obtained for this study are as follows:

Genotype PS-1589 with least number of lepidopterous caterpillars per meter row (1.0 number of larvae per meter row) and genotypes NSO-626 with least number

of sucking pests per plant (6.0 numbers of sucking pests per plant) were found to be tolerant against these insect pests. However, the highest yield was recorded with genotypes NRC-126 (675 gm/plot) as against 350, 560, 390, and 365gm/plot grain yields from check varieties, which were found tolerant against different insect-pests in soybean.

Genotype RV S-2010-1 and RVS-2008-24 with minimum larval count (0.7 larvae per meter row) and minimum sucking pests (whiteflies and thrips) with 11.0 per plant was identified to be tolerant against lepidopterous defoliators and sucking pests. The highest grain yield was recorded with genotype PS-1572 (0.976 q/ha) which was found tolerant to sucking pests and lepidopterous defoliators.

The results on the efficacy of plant products in the management of defoliator *S. litura*, the minimum overall larval population was recorded in garlic+green chilli @ 8.75 kg/ha after first spray having 0.29 and after second spray 0.17 larva/mrl. It was followed by karanj seed extract @ 2.5% 0.34, 0.18 after first spray and second spray respectively shows the best treatment as compare to other treatment.

Percent reduction of defoliator pests was maximum in garlic+green chilli @ 8.75 kg/ha after first spray having 89.29% and 93.11% after second spray, which was followed by karanj seed extract @ 2.5% after first spray 87.45 and second spray 92.71 percent.

Overall mean larval population of *C. acuta* was recorded minimum in Garlic+green chilli @ 8.75 kg/ha having only 0.57, 0.27 larva/mrl after first spray and second spray , followed by karanj seed extract @ 2.5% 0.72, 0.36 after first spray and second spray.

Percent reduction was maximum in garlic+green chilli @ 8.75 kg/ha having 72.85, 82.91 percent after first spray and second spray, followed by karanj seed extract @ 2.5% after first spray having 65.71and second spray 77.21%.

In the present investigation, efficacy of plant products in the management of sucking pests white fly was found that karanj seed extract @ 2.5% after first spray having 3.98 whiteflies per plant and second spray with 3.90 was most effective

followed by garlic+green chilli @ 8.75 kg/ha after first spray 4.30 and second spray with 4.04.

Percent reduction was maximum in karanj seed extract @ 2.5% after first spray with 47.04% and 49.08% with second spray which was followed by garlic+green chilli @ 8.75 kg/ha after first spray having 42.81% and 48.01% with second spray.

Similarly, overall mean population of thrips tabaci was recorded minimum in karanj seed extract @ 2.5% having 1.16 and 2.12 after first spray and second spray thrips per plant which was most effective and followed by garlic+green chilli @ 8.75 kg/ha after first spray 1.24 and second spray 4.68 thrips/plant.

Percent reduction was maximum in karanj seed extract @ 2.5% with 76.89, 75.11 percent after first spray and second spray which was followed by garlic+green chilli @ 8.75 kg/ha after first spray (75.29%) and second spray (74.26%).

Overall mean population of natural enemies coccinellids, garlic+green chilli @ 8.75 kg/ha recorded maximum population of 1.57 and 1.45 after first spray and second spray which was most safe and followed by karanj seed extract @ 2.5% having population of 1.56, and 1.38 after first spray and second spray.

Percent reduction in population was minimum in garlic+green chilli @ 8.75 kg/ha having 14.20, 17.61 percent after first spray and second spray which was followed by karanj seed extract @ 2.5% after first spray with 14.75% and second spray 21.59%.

Similarly, mean of spider recorded maximum population with garlic+green chilli @ 8.75 kg/ha with 1.34 and 1.25 spider per plant after first spray and second spray which was most safe and followed by karanj seed extract @ 2.5% after first spray having 1.32 and second spray 1.24 spider per plant.

Percent reduction was minimum in garlic+green chilli @ 8.75 kg/ha with 24.71, 28.97 percent after first spray and second spray and followed by karanj seed extract @ 2.5% after first spray with 25.84% and second spray with 29.54%.

Among the plant products, the maximum benefit cost ratio was found in the treatment garlic+green chilli @ 8.75 kg/ha having 6.99. In rest of the plant products, more or less similar benefit cost ratio was obtained like 6.59 in Karanj seed extract @ 2.5% which was followed by red chilli @ 2kg/ha (5.7), mahua oil @ 2% (5.25), Neem oil @ 2% (4.15), green chilli @ 2% (3.17), NSKE @ 5% (2.66) , and the minimum benefit cost ratio was recorded in Karanj oil @ 2% (1.96), and other than plant products the chemical treatment triazophos @ 750ml/ha which was used for management of insect pests of soybean the benefit cost ratio was maximum with7.78.

Conclusion:

It is seen that four different insect pests damaged the soybean crop from time to time. Among these *S. litura, C. acuta, B. tabaci, and Thrips tabaci* were most serious pests of soybean in this region.

The peak activity of defoliators pests *i.e. S. litura* (1.9 larvae per meter row) and *C. acuta* (2.1 larvae per meter row) was recorded during second week of September and first week of September, and that of sucking pests *i.e. B. tabaci* (9.1 whiteflies per three leaves) was recorded during last week of September and *Thrips tabaci* (3.4 thrips/plant) in last week of September, respectively.

Two species of lady bird beetle, *M. sexmaculata* and *C. septumpunctata* and orb weaver spider, *Neoscona* sp. were found predating mainly upon white flies, jassids and thrips. Whereas, lynx spider, *Oxyopes* sp. and a predatory pentatomid bug, *E. furcellata* was noticed sucking the body sap of lepidopterous larvae. Correlation between spiders and sucking pests was found to be positive but significant with “r” values 0.740.

Correlation between coccinellid beetles and sucking pests, and between spiders and leaf defoliator pests was found to be positive and significant with “r” values and regression equation [r = 0.867; regression equation y= 10.94x + 2.414], [r = 0.652; regression equation y =0.469X + 0.419] and respectively.

Genotype PS-1589 with least number of lepidopterous caterpillars per meter row (1.0 number of larvae per meter row) and genotypes NSO-626 with least number

of sucking pests per plant (6.0 numbers of sucking pests per plant) were found to be least susceptible against these insect pests. However, the highest yield was recorded with genotypes NRC-126 (675 gm/plot) as against 350, 560, 390, and 365gm/plot grain yields from check varieties, which were found tolerant against different insect-pests in soybean.

Genotype RV S-2010-1 and RVS-2008-24 with minimum larval count (0.7 larvae per meter row) and minimum sucking pests (whiteflies and thrips) with 11.0 per plant was identified to be tolerant against lepidopterous defoliators and sucking pests. The highest grain yield was recorded with genotype PS-1572 (0.976 q/ha) which was found tolerant to sucking pests and lepidopterous defoliators.

Among the eight plant products tested against major insect pests of soybean, garlic+green chilli @ 8.75 kg/ha was most effective against defoliators *S. litura* and *C. acuta* after first spray having 0.29, 0.17 and in second spray having 0.57, 0.27 larva/mrl, respectively and in sucking pests karanj seed extract @ 2% after first spray having 3.98 whiteflies/plant and 1.16 thrips/plant and after second spray 3.90 whiteflies per plant, 2.12 thrips/plant, respectively with benefit cost ratio of garlic+green chilli @ 8.75 kg/ha 6.99 and karanj seed extract @ 2% 6.59 .

The plant products, garlic+green chilli @ 8.75 kg/ha was comparatively most safer for both natural enemies *i.e* coccinellids and spider after first spray having maximum population of 1.57 coccinellid/plant, 1.34 spiders/plant and after second spray 1.45 coccinellid/plant, 1.25 spiders/plant.

Suggestions for future research work:

1. The experiments should be repeated to confirm the present findings.
2. Continuous studies on weather parameters and incidence of insect-pests of soybean should be carried out in other seasons also. So that, modules for forecasting the incidence of insect-pests can be prepared well-in-advance.
3. Efficient predators and parasitoids should be identified and utilized for the management of major insect-pests of soybean.

4. Insecticides which are comparatively safer to natural enemies should be identified from further studies. The insect pest of soybean can be managed by the chemical and botanical insecticides, but it is necessary to find out the most selective insecticides, safer for parasites and predators and showing toxicity against the eggs, larvae and adult of the pest. Detailed works are needed for control of the major insect pests by plant product for IPM strategies.

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Appendix A: Weekly meteorological data during crop growth period (from 16 July, 2016 to 07 October, 2016)

SMW	Month	Date	Temperature (^{o} C)		Rainfall (mm)	Relative Humidity (%)		Wind Velocity
			Max.	Min.		I	II	(Km/h)
29	Jul	16-22	30.6	24.5	207.0	94	79	6.1
30		23-29	31.9	25.4	56.2	91	69	3.9
31		30-05	30.7	25.3	28.0	92	81	7.0
32	Aug	06-12	32.3	28.6	22.0	91	77	8.7
33		13-19	28.7	21.6	11.6	89	77	9.4
34		20-26	31.9	25.6	4.2	90	70	5.0
35		27-02	32.2	26.0	22.2	90	67	3.6
36	Sep	03-09	30.7	25.3	62.8	87	68	5.9
37		10-16	31.1	24.3	132.8	95	80	2.9
38		17-23	32.2	24.9	91.6	94	69	2.5
39		24-30	30.0	24.5	134.6	97	89	2.8
40	Oct	01-07	26.5	24.8	48.2	95	72	2.7

RESUME

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