

Diversity and visitation frequency of major insect pest population under *Gmelina arborea* based Agrisilviculture system

THESIS

Submitted to

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

**In partial fulfilment of the requirements
for the Degree of**

MASTER OF SCIENCE

In

FORESTRY

(Silviculture & Agroforestry)

By

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2020

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This is to certify that the thesis entitled “**Diversity and visitation frequency of major insect pest population under Gmelina arborea based Agrisilviculture system**” submitted in partial fulfilment of the requirement for degree of **MASTER OF SCIENCE (FORESTRY) in Silviculture & Agroforestry** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of bonafide research work carried out by **Miss. Arpana Sharma** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.

All the assistance and help received during the course of the investigation has been acknowledged by him.

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I, **Arpana Sharma**, D/o Mr. Gopal Krishna Singh, certify the work embodies in the thesis entitled : “**Diversity and visitation frequency of major insect pest population under *Gmelina arborea* based Agrisilviculture system**” is my own first hand bonafide work carried out under the guidance of Dr. R. Bajpai at Department of Forestry, College of Agriculture, Jabalpur during 2019-2020.

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

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Place: Jabalpur

Date:/...../.....

(Arpana Sharma)

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LIST OF ABBREVIATION

Abbreviation and symbols.	Stand for
g	Gram
et al.	And others
etc.	And the rest
@	At the rate of
%	Percentage
©	Copyright
SEm±	Standard error of mean
CD	Critical difference
√	Square root
°C	Degree centigrade
J.N.K.V.V	Jawaharlal Nehru Krishi Vishwa Vidyalya
M.P	Madhya Pradesh
NBSSLUP	National Bureau of Soil Survey and Land use planning
no.	Number
SS	Sum of Square
MSS	Mean Sum of Square
Cal.	Calculated
Tab.	Tabulated
df	Degree of Freedom
SMW	Standard Meterological Week
ANOVA	Analysis of variance
eg.	As for example
mh	Million hectare
m	Meter
m ²	Meter square
WAS	Weeks after showing
mm	Milli meter

Chapter-I

INTRODUCTION

INTRODUCTION

Agroforestry is a practical and low budget means of implementing many forms of integrated land management and it contributes to a green economy by promoting long-term sustainable and renewable forest management especially for small-scale producers. In other words agroforestry is a collective name of land use system where woody perennials are deliberately grown on the same land unit as arable crops or animals. In agroforestry systems there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1982).

The total area under Agroforestry in world is 1023 mh (FAO, forest resource assessment report 2000). It is estimate that 823 million hectare area globally is under Agroforestry and Silvipastoral system. However the area under Agroforestry is increasing continuously, example in India, in 2007 it is reported 7.4 million hectare (Zomer et al., 2007) but in 2013 it reached up to 25.32 million hectare (Dhyani et al., 2013).

In agroforestry systems, in which woody perennial sand arable crops are grown together, the insect-pests is one of the component that can affect the other. Therefore, it is essential to know about the insect-pests of each component plant and their aggregation with each and every component. As per ICRAF (International Centre for Research in Agroforestry, now World Agroforestry Centre), “agroforestry is a deliberate integration of woody components with agricultural and pastoral operations on the same piece of land either in a spatial or temporal sequence in such a way that both ecological and economic interactions occur between them.”

It is well known fact that, an ecosystem comprises of various communities that interact and collaborate with each other for their remission. It has been defined as the effect of one component of a system on the performance of another component and or the overall system.

The Interactions among the components of the agroforestry system can be either positive, negative or neutral. They are regarded as negative when pest problems are increased in an agroforestry system when compared

with a monoculture block plantation. A reduction in pest activity under agroforestry indicates a positive interaction, while no change in pest intensities between monoculture and agroforestry denotes a neutral interaction from the insect-pest management (Rathore MP Singh 1995).

Insect pests are the most important group of organisms causing injury to plants in agroforestry systems. Therefore, the management of insect pests in these systems is utmost important to sustained production, and even farmers have recognized this as a priority issue for agroforestry research (Prinsley RT., 1991).

In Agroforestry system the insect-pest are one of the essential component like the crops and woody perennials. The pest situation in these systems will be influenced by the degree of interaction between the components.

Gmelina arborea is a fast growing deciduous tree species of tropical and subtropical forest upto 1,100 meters above sea level. It is popularly known as Coomb teak, Candhar tree, Gambhari. It provides one of the most durable timbers after teak in India. Due to its drought tolerance and excellent wood properties, is emerging as an important plantation species. *Gmelina arborea* is a medium to large tree that grows up to 35m in height and 3m in diameter, often with large multiple stems and a wide spreading crown under natural conditions (Dvorak 2004).

Pigeon pea (*Cajanus cajan*) belongs to the family Fabaceae. It is an important multi-purpose shrub legume of the tropics and subtropics. Pigeonpea is a tropical grain legume mainly grown in India and ranks second in area and production and contribute about 90% of the world's pulse production. In India pigeon pea is cultivated in an area of 4.04 million ha and production of about 2.65 million tonnes, with a productivity of 656 kg /ha. In Madhya Pradesh pigeonpea occupies 13.50% (0.53 million ha) area with 12.60% (0.33 million tonnes) production of India and productivity of 656 kg/ha (DES, 2012).

Green gram or golden gram (*Vigna radiate* L.; Family: Fabaceae) is also known as mung or moong bean is native to the Indian subcontinent and

mainly cultivated in Philippines, Thailand, India, Bangladesh, Vietnam, Cambodia and Indonesia. It is used as an ingredient in various dishes. The major producing states are Madhya Pradesh (23%), Uttar Pradesh (18%), Maharashtra (14%), Rajasthan (11%), Andhra Pradesh (9%), and Karnataka (6%) where pulses are grown in arid and semi-arid regions as rainfed crops. About 80.15 per cent supply of pulses is contributed by these five states.

Cow pea (*Vigna unguiculata*) belongs to family Fabaceae also known as black-eyed pea or southern pea etc. and has multiple uses like food, feed, forage, fodder, green manuring and vegetable. It is favoured because of its wide adaptation and tolerance to several stresses. It is an important food source and is estimated to be the major protein source.

Insect-Pest management in agroforestry had not received much attention yet so far, but now a days huge emphasis is given on producing highly valuable tree products in agroforestry by using genetically modified things in traditional systems, this increases the emergence of pest problems in agroforestry systems increases the awareness among people.

This work is a small attempt to compile the scattered information at this place to provide the detailed knowledge on various insect pest species, their identification, nature of damage and period of infestation. Keeping above mentioned facts in view, the present investigation entitled “Diversity and visitation frequency of major insect pest population under *Gmelina arborea* based Agrisilviculture system” has been proposed with following objectives:

1. Identification and quantitative assessment of pest damage in *Gmelina arborea* plantation.
2. Association analysis of insect-pest incidence with tree-crop component.
3. Correlation studies of insect population with weather parameters.

Chapter-II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Pal *et al.*, (1977) studied the population fluctuation of insect pests on several varieties of mung bean (*V. radiata*) in relation to climatic conditions at Jodhpur. The main pests were *A. Craccivora* and *Crytozemiocognata* (Mshl.) which occurred on all varieties throughout the growing season. The data showed that ideal conditions for the outbreak of *A. craccivora*, thrips and ants were about 80 per cent R.H., 27.5 to 28° C temperature and lower sunshine hours.

Zeya A (1981) studied the two insects doing serious damage to planted Yemane (*Gmelina arborea*) in Yezin and Moswe Areas. In Yezin and Moswe areas in Pyinmana Division planted yemane was attacked by *Tingis beesoni* (Hemiptera; tingidae) and *Alcides gmelinae* (Coleoptera; curculionidae) respectively. Methods of attack by these two insects, effect of injuries and duration of the epidemic period have been studied. Life of *A. gmelina* has also been studied, and field control of the two insects have been discussed.

Sinha *et al.*,(1982) recorded the seasonal occurrence of various insect pests on green gram (*Phaseolus aureus* Rosb.) during summer and *Kharif* in 1980 in North Bihar and reported Galerucid beetle, *Madurasia obscurella* Jacoby, Pod borer, *Euchrysops anejus* Fab. during summer (Mid March to mid June) and *M. obscurella*, *Empoasca kerri* Pruthi, *Aphis craccivora* Koch., *Mylabris spp.*, *E. anejus*, *Maruca testulali* sand *Bemisiatabaci* Genn. during *Kharif* (last week of June to end of October).

Sharma HC (1998) performed his work on topic Bionomics, host plant resistance, and management of the legume pod borer, *Maruca vitrata* - a review. Legume pod borer, *Maruca(testulalis) vitrata*(Geyer) is one of the major constraints in increasing the production and productivity of grain legumes in the tropics. Screening for resistance has been carried out using natural infestations. Several natural enemies have been recorded on *M vitrata*. Cultural practices such as intercropping, weeding, time of planting, and planting density reduce its damage in cowpea. There is a need to generate information on insect-plant-environment interactions and use of natural enemies for integrated pest management in diverse agro-ecosystems.

Kalia and Lal (1999) conducted surveys in nurseries, plantations, and natural forests at TFRI, Jabalpur, Madhya Pradesh, India for insect-pests of *Dalbergia sissoo*, a highly valued deciduous tree. Results revealed that occurrence of 22 phytophagous insect species, on *D. sissoo* namely *Clania crameri*, *Hypolixus truncatulus*, *Oides andrewsi*, *Leucoptera sphenograpti*, *Miresa albipuncta*, *Dasychira dalbergiae*, *D. fusiformis*, *Dichomeris eridantis*, *Heliiothis armigera*, *Plecoptera reflexa*, *Spodoptera litura*, *Hyposidra successaria*, *Laspeyresia jaculatrix*, *Taragama siva*, and *Brachytrupes portentosus*.

Schroth *et al.*, (2000) performed their study on pests and diseases in agroforestry systems of the humid tropics. Few studies have included detailed investigations of the interactions of agroforestry techniques with pests and diseases, although the relevance of such interactions has long been recognized. The objectives of the review are to provide basic information on pests and diseases in tropical agroforestry systems and to develop concepts which can assist in the future in the systematic data collection and analysis in this field. The emphasis is on simultaneous agroforestry systems with annual and perennial crops, although rotational systems are also discussed. However, reduced pest and disease risk is not automatically achieved by introducing perennial plants and increasing the plant diversity in a system.

Lauridsen EB. And Kjaer ED.(2002) has done his investigation on provenance research in *Gmelina arborea* Linn., Roxb. A summary of results from three decades of research and a discussion of how to use them. More than 60 *Gmelina arborea* provenance trials were established in the mid-seventies as a joint effort between 20 countries, mainly outside the natural distribution areas of *gmelina*. The results allow identification of provenances that in general perform well on a number of sites. More detailed results are found on Danida Forest Seed Centre's web-site, which show performance of provenances in specific trials and include information on more characters. An interesting observation is that plants originating from plantations often perform very well compared to those originating from natural forests.

Jonathan *et al.*(2003) performed their study on thinning scenarios for *Gmelina arborea* plantations in south-western Nigeria using density

management diagrams. Thinning scenarios were developed for *Gmelina arborea* plantations in south-western Nigeria using density management diagram. Data were collected from even-aged plantations of 5 to 25 years. Density (number of trees ha⁻¹) decreased with increase in tree size. Density management diagram, with upper and lower growing stock lines, was developed, with references to these lines, three thinning scenarios A (*no-thinning*), B (*moderate thinning*) and C (*heavy thinning*) were developed. This result indicates that *Gmelina* would react strongly to thinning by way of diameter increase, which only applies if thinning commences at early ages.

Ahmad M., (2003) performed his studies on a checklist of natural enemies of *Helicoverpa armigera* (Hubner). It is a serious threat to cotton production in Pakistan. The control strategies of *H. armigera* revolve around synthetic chemicals and therefore causing health and environmental concerns. The literature assessment of natural enemies including parasitoids, predators, microbial pathogens will help in developing sustainable control strategy of *Helicoverpa armigera*.

Wingfield MJ and Robinson DJ., (2004) studied on diseases and insect pests of *Gmelina arborea*: real threats and real opportunities Forestry and Agricultural Biotechnology Institute. Perhaps the greatest threat to plantations of this tree is damage due to pests and diseases. Numerous insect pests and pathogens have been recorded in stands of *Gmelina* in areas where the trees are native. In plantations within the natural range of the tree, insects have caused substantial damage. Among these, the defoliator *Calopepla leayana* appears to be most important. Its indication are that pathogens and insect pests will become much more serious impediments to the propagation of *Gmelina* in the future.

Roshetko *et al.*(2004) performed his study on *Gmelina arborea* – a viable species for small holder tree farming in Indonesia? Across Indonesia there are millions of hectares of degraded land in need of rehabilitation. Smallholders often practice tree farming to generate income and traditionally cultivate a wide range of tree species in mixed agroforestry systems. *Gmelina arborea* (*gmelina*) is easy to cultivate and grow at the smallholder level. It has been widely grown in plantations in South and Southeast Asia, including

Indonesia timber. Most *Gmelina* seed originates in Central Java, from where large quantities of seed are shipped annually to other parts of Indonesia. *Gmelina* holds promise as one component for a multi-species small holder tree farming systems to produce short-rotation timbers for household use and local markets.

Singh *et al.* (2004) found that 143 species of insects infest both indigenous as well as exotic species of poplars in north western India, with about 65 species infesting *Populus deltoids* alone. The survey included 36 nurseries, 84 large (≥ 3 ha) and 255 small (< 3 ha) block and bund plantations and recorded seven species causing outbreaks. However, eight insects having wide spread distribution in this region were identified as posing a threat to agroforestry with *P. deltoids* and need to be managed. Amongst these, three species were ranked as 'major pests' as they had relatively higher incidence ($>50\%$ of attack) and caused extensive economic loss during outbreaks, coupled with tree mortality which persisted for several years in succession over large areas.

Oparaeke AM. (2005) studied on insecticidal potential of extracts of *Gmelina arborea* products for control of field pests of cowpea, *Vigna unguiculata*(L.) walp: The Pod borer, *Maruca vitrata* and The Coreid bug, *Clavigralla tomentosicollis*. The insecticidal efficacy of *Gmelina arborea* L. product extracts was assayed for suitability in controlling the legume pod borer *Maruca vitrata* Fab. (Lepidoptera:Pyralidae) and the pod sucking bug *Clavigralla tomentosicollis* (Hemiptera:Coreidae) on cowpea. Field studies conducted in 1999 and 2000 cropping seasons at the research farm of the Institute for Agricultural Research, Samaru showed that extract of *Gmelina arborea* fruit at 10%(w/v) caused impressive reduction of both pests and protected the pods from serious damage.

Singh S (2005) investigated the description of a new species of *Euderus* (Hymenoptera: Chalcidoidea: Eulophidae), an egg parasitoid of *Alcidodes ludificator* (Coleoptera: Curculionidae) a pest of *Gmelina arborea* A new eulophid species *Euderus alcidode* ssp. novo bred from eggs of *Alcidodes ludificator* (Col.Curculionidae), a pest of *Gmelina arborea* is described from Assam, India. The species is very distinctive from all the

known species in the Orient (except *torymoides*) by presence of long ovipositor. It has been compared with *E. torymoides* in detail.

Senthilkumar N and BarthakurND (2009) studied on *Alcidodes ludificator*: a serious insect pest of nursery and young plantations of *Gmelina arborea* (Roxb.) in northeastern India. Although *G. arborea* suffers multifarious insect injuries by a complex of insect pests including 21 defoliators and 13 shoot borers, Gamari Weevil, *Alcidodes ludificator* Faust. (Coleoptera: Curculionidae) is one of the serious pests of nursery and young plantations of *G. arborea*.

Naik *et al.*, (2009) investigated on assessment of morphological and genetic diversity in *Gmelina arborea* Roxb. *Gmelina arborea* is an important timber-yielding tree that grows naturally in the tropical and subtropical regions of Southeast Asia and has also been introduced as a plantation species outside these regions. Genetic diversity in this tree species was observed in stone/seed-related traits and in vitro responses of cultured nodal segments from plants of eight different populations representing natural forests, fragmented forests and plantations. Assessment of the genetic variation in *G. arborea* populations is an important step in selection of conservation strategies for this species since diversity forms the basis for species adaptation

Senthilkumar N. and Murugesan S. (2010) investigated on entomopathogenic Fungi for the management of *Calopepla leayana* on *Gmelina arborea* Entomopathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae* were isolated and identified as natural pathogens of *Calopepla leayana*. Both the species of fungi were effective against the larval and adult stages of *C. leayana* causing white and green muscardine diseases respectively. The larvae of 1st instar have shown highest mortality, which gradually decreased with the increase in age or decrease in the concentration of fungal spores. From the seven substrates tested, wheat flour was identified as one of the suitable substrates for the mass production of *B. bassiana*. A field trial was conducted to test their efficacy under field conditions. 72-93% mortality was observed in field.

Alison *et al.*, (2011) studied the genetic diversity in natural populations of *Gmelina arborea*: implications for breeding and conservation. *Gmelina arborea* is a valuable plantation tree species that is native to South and Southeast Asia. In this study, 534 samples representing 19 natural populations in India, China, Thailand and Myanmar were analyzed with 10 polymorphic microsatellite markers. Vegetative propagated clones of elite trees can be used for plantation to address the issue of high level of segregation among seed derived plants.

Nayak *et al.*,(2011) performed his studies on an overview on silviculture and traditional therapeutic uses of *Gmelina arborea* Roxb. The number of patients seeking alternate and herbal therapy is growing exponentially. Herbal medicines are the synthesis of therapeutic experiences of generations of practicing physicians of indigenous systems of medicine for over hundreds of years. *Gmelina* or Yemane (*Gmelina arborea* Roxb.) is a fast growing tree, which grows faster than some exotic species under the same conditions and it is planted in large areas of forest with the objective of producing solid wood using well known silvicultural techniques and taking advantages of properties of the wood qualities of fast growing trees species managed in short rotation system.

Swaminathan *et al.* (2012) studied on insect Pests of Green Gram *Vigna radiata* (L.) Wilczek and their Management. Pulses, the food legumes, have been grown by farmers since millennia providing nutritionally balanced food to the people of India (Nene, 2006) and many other countries in the world. The major pulse crops that have been domesticated and are under cultivation include black gram, chickpea, cowpea, faba bean, grass pea, green gram, horse gram, lablab bean, lentil, moth bean, pea and pigeon pea and including various aspect related to insect pest and their management.

Sharma AK and Bisen UK., (2013) performed their research on taxonomic documentation of insect pest fauna of vegetable ecosystem collected in light trap. The present study was conducted under the study of scope of light trap as IPM technology in vegetable ecosystem and data collected in Balaghat region of M.P. The data of trap catch during the year 2006 (Kharif season) was classified on taxonomic basis, economic aspect

(crop pest) and bio control significance (parasite and predators) a total of 56 species were recorded in Kharif cropping season of vegetable cropping area. Based on economic importance this collection was represented by 39 species of harmful insects (as crop pest) 17 species of predatory insects (useful as bio-control agents).Category of harmful insect pests includes the major and minor pest species of vegetables, major polyphagous pests, pests of Paddy, Pulses, Cereals, Oilseeds and other crops.

Barman A. (2014) has done a brief perspective on Gmelina tree insect pest *Crspedonta leayana*. It is a coleopteran insect pest of economically important tree Gmelina. Its report of India is comparatively recent. This is a short account corresponding to a small observation of the insect's infestation, which also embraces about sixty Gmelina trees within. Interestingly, this insect has only single host to live upon. Few other conspicuous features of the insect draws attention and here is an attempt to discuss these in brief.

Kumar *et al.*,(2014) performed his study on quantification and distribution of agroforestry systems and practices at global level. Globally studied remote sensing and geographical information systems data indicated that over 1 billion hectares of agricultural land have more than 10% tree cover, and these areas are home to almost a third of the 1.8 billion people who live on agricultural land. It is practiced vary across the globe such as simple subsistence livestock and pastoral systems to shifting cultivation, home gardens, alley cropping etc. It is estimated that the area currently under agroforestry worldwide is 1,023 m ha.

Pathala *et al.*, (2015) has written a review on *Gmelina arborea Roxb* is one of the important medicinal plants most widely propagated and cultivated species of the family Verbenaceae. It is commonly known as "Kashmarya" and one of the herbs mentioned in all ancient scriptures of Ayurveda. It is a beautiful fast growing avenue tree that grows throughout India.

Kumar R *et al.*, (2016) dicussed the Major pest, *Calopepla leayana* Latr. (Coleoptera: Chrysomelidae) of *Gmelina arborea*(Roxb.) from Meghalaya and Assam (India) with emphasis on illustrated biology. *Calopepla leayana* is monophagous species, which feeds only on *G. arborea* plant and is reported

for the first time from Meghalaya, India with brief notes on biology. This plant is economically important for muga silkworms in addition to medicinal properties and distributed in N.E. India, Decan Peninsula, Foothills of N.W. Himalaya, Chittagong, Sri Lanka, Malaysia, Philippines. In the present study, the detailed photographic illustrated diagnostic feature with biology along with review of control measures and future strategies to control *C. Leayana* has been discussed.

Rishi RR and Barthaku ND (2016) studied an epidemic outbreak of *Craspedonta leayana* (Latreille) on *Gmelina arborea* Roxb. in Cachar (Barak Valley), Assam, India. The results of the present study demonstrated that native strain of entomopathogenic fungus, *B. bassiana* can be utilized for the effective control of the defoliator, *C. leayana* in nurseries and young plantations of *G. arborea*. There is growing interest in the use of entomopathogens for biological control, since they are naturally occurring and environmentally safe and can be easily made available to different user groups.

Rishi et al.(2016) has done his investigation on Efficacy of entomopathogenic fungi on *Craspedonta leayana*, a serious insect pest of *Gmelina arborea*. The chrysomelid beetle, *Craspedonta leayana* Latr., is the most destructive defoliator of *Gmelina arborea* Roxb. In North East India, severe outbreaks were recorded from April to October in *G. arborea* nurseries and plantations. The trees were completely defoliated during May to September. Considering the importance of the tree species, an attempt was made to manage this menace using entomopathogenic fungi (EPF). A total of five fungal isolates were recovered from the infected cadavers of *Galleria mellonella* through insect bait method. The fungal isolates were identified as *Beauveria bassiana*, *Fusarium* sp., *Metarhizium anisopliae*, *Paecilomyces* sp., and *Verticillium lecanii*.

Meshram PB and Bhowate S (2017) studied the role of lace bug *Tingis beelsoni* and control measures in top dying of *Gmelina arborea* plantation. Plantation of *Gmelina arborea* is facing the great problem of major insect pest i.e. sap sucker / lace bug *Tingis beelsoni* (Drake) resulting in top dying of shoots in tropical forest of Madhya Pradesh. The nymphs and adults of bug

feed entirely at the base of leaf blade on the under surface and the leaf axils. The leaf becomes spotted and brownish near the base. The affected leaves wither, dry, fall and plant become completely defoliated throughout the season. The shoot dry up, turn black and sooty mould grows all over plants leading to the top dying. The results revealed that lace bug; *T. beelsoni* was responsible for causing the top dying of *G. arborea*.

Kumar A and Chandra G (2017) had performed this study of Insect pest infestation on *Gmelina arborea* Roxb. in different agroclimatic zones of Jharkhand, India. The fast growing and multipurpose timber species *G. arborea* has problem of multiple insect pest attack in India. To understand the diversity of insect pest infestation abundance on *Gmelina arborea*, the data was collected on insect pest infestation (%) in three agro-climatic zones (Zone IV, V and VI) of Jharkhand province of India over a period of 3 years. Results showed that the plants were infested with total twenty insect pest species, out of these ten insect pest were recorded as new for *G. arborea*. The study may helpful to understand the expanding range of insect pest fauna of *G. arborea* in the country and framing insect pest management policy more effectively.

Pandey SA (2017) studied on pod infesting insect pest complex of pigeonpea *Cajanus cajan* L. (Millsp.) and their control with insecticides and biopesticides: A review. Pigeonpea (*Cajanus cajan*(L) Millsp.) is one of the most important pulse crops grown worldwide because it is endowed with several unique characteristics with diversified uses for human needs and is an important crop in semiarid tropical and subtropical areas. Especially in Asia it is a major source of protein for humans. The pigeon pea pod fly *Melanagromyza obtusa* Malloch (Diptera: Agromyzidae) is found throughout south and central Asia. Generally, pod yield losses due to this vary between 5-30 per cent during winter and spring from several countries hence, attempts were made to evaluate the efficacy of different insecticides and botanicals for the sustainable management of the pigeon pea pod fly.

Arora C. and Tamrakar V. (2017) reported *Gmelina arborea*: Chemical constituent, pharmacological activities and applications. *Gmelina arborea* widely used for reviewed the traditional uses, medicinal property isolated from research. The present article is aimed to provide information on recent

advances and new foundations and direction for further exploring research reviewed that activities including antidiuretic, antidiarrhoeal, antipyretic, antianalgesic, antioxidant, antidiabetic, antihelmintic gastro reported for its applications in treatment of bone fracture, hypertension and regeneration of cells.

Verma *et al.* (2017) performed the study on scaling up an Indigenous tree (*Gmelina arborea*) Based Agroforestry Systems in India. Scaling up of *Ghamar* (*Gmelina arborea*Roxb.) based agroforestry in India has a prime concern as it is a native species which has potential to replace and act as a substitute for other exotic timber trees in the country. The present paper highlights the multifaceted volume of *Gmelina* in agroforestry including carbon sequestration potential, manifold importance and desirability of under home gardens and agroforestry systems. In addition, the paper also points out the existing constraints and limitations which are responsible in fading it's the large scale production in agroforestry and farm forestry.

Sangeeta *et al.*(2017) surveyed on precious herb *Gmelina arborea* Linn. W.S.R to its medicinal uses and pharmacological activity.Traditional medicines play an important role in health services around the globe. *Gmelina arborea*Linn. an important medicinal plant is one of the most widely cultivated species of the family *Verbenaceae*. It is commonly known as '*Gambhari*', the term actually used by tribal people of Bihar.The roots, fruits and the leaves of *Gambhar*have great medicinal value traditionally. The present article provides all necessary information regarding its classical literature, general introduction, medicinal uses of its roots, leaves, flowers, fruit, bark, and pharmacological studies conducted till date.

Shahiduzzaman MD. (2017) surveyed on efficacy of insecticides in controlling pod borer (*Helicoverpa armigera* Hubner) infesting chickpea. A field experiment was carried out at the Regional Pulses Research Station of Bangladesh Agricultural Research Institute, Madaripur, Bangladesh during rabi season of 2013-14 and 2014-15 to select effective insecticides to control pod borer (*Helicoverpa armigera* Hubner) of chickpea (*Cicer arietinum*). Signinificantly the highest insect infestation and yield loss were recorded from untreated control. Spray with every insecticide for 3 times at 7 days interval

reduced insect infestation and yield loss significantly over control in both years. The highest grain yield was obtained with Tracer 45 SC (Spinosad) (1177 kg/ha) followed by Volium Flexi 300 SC (Thiamethaxam) (1045 kg/ha) and Belt 24 WG (Flubendiamide) (1020 kg/ha) in first year. In second year, Tracer 45 SC produced maximum yield (1396 kg/ha) followed by Volium Flexi 300 SC (1315 kg/ha) and Admire 200 SL (Imidacloprid) (1300 kg/ha).

Sarkar *et al.* (2018) investigated a review on Pigeon pea (*Cajanus cajan*) an important food legume in Indian scenario. According to Indian Institute of Pulses Research Vision document, India's population is expected to touch 1.68 billion by 2030 and the pulse requirement for the year 2030 is projected at 32 million tonnes with anticipated required annual growth rate of 4.2%. The leaves and immature stems can be used as a green manure. Fallen leaves can also be used as mulch and thus help to enhance the water holding capacity of soil. Its beneficial effect as an intercrop has also been reported. Additionally, pigeon pea shares a vital part in India's pulse import and export. Keeping all these in view the present review depicts the various aspects of pigeon pea cultivation and its status in Indian trade on pulse.

Singh *et al.* (2019) studied on seasonal incidence of sucking insect pests of green gram. The investigation on Seasonal Incidence and Management of Sucking Insect Pests of Green Gram [*Vigna radiata* (L.) Wilczek] under semi-arid condition was conducted at Agronomy Farm. The initiation of jassid and whitefly population recorded in the first week of August (32 SMW) which reached its peak in first week of September, *i.e.* 36th SMW (12.90 jassid and 14.20 whitefly/ three leaves) when maximum temperature, minimum temperature and relative humidity was 36.1 and 21.7 °C and 90 percent, respectively and gradually decline thereafter. The population of sucking pest (jassid and whitefly) had a significant positive correlation ($r=0.886$).

Murdock *et al.* (2019) performed his investigation on the legume pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Crambidae), an important insect pest of cowpea: a review emphasizing West Africa. The legume pod borer *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) is a pantropical insect pest

of legumes. In West Africa *Maruca vitrata* is the most devastating insect pest of cowpea, a food crop providing much-needed, inexpensive protein to farmers and consumers. Various approaches to controlling this pest have been tried, including cultural management, host plant resistance and use of synthetic and botanical pesticides, all with limited success. In this review we present information on the distribution, morphology, molecular characteristics, behaviour and host plants of *Maruca vitrata*.

Gurung *et al.*,(2020) studied the Host preference of Bihar hairy caterpillar *Spilosoma obliqua* in laboratory condition. Bihar hairy caterpillar (*Spilosoma obliqua*) is a serious polyphagous insect pest. An experiment was conducted to determine the host preference of Bihar hairy caterpillar in Entomology laboratory, Lamjung Campus at room temperature from March to April, 2019. The experiment was conducted in CRD with seven treatments namely; Cotton (*Gossypium hirsutum*), Cauliflower (*Brassicae oleraceae* var. botrytis), Cabbage (*Brassicae oleraceae* var. capitata), Broccoli (*Brassicae oleraceae* var. italica), Mulberry (*Morus alba*), Castor (*Ricinus communis*), Broad bean (*Vicia faba*).

Chapter-III

MATERIAL AND METHODS

MATERIAL AND METHODS

The explanation of material used and the methods adopted during the course of investigation entitled “**Diversity and visitation frequency of major insect pest population under Gmelina arborea based Agrisilviculture system**” under climatic conditions of Jabalpur (MP). Several materials and methodologies were put upon to accomplish this investigation. The materials used and methodologies employed are described in this chapter under the suitable hoardings.

3.1 Experimental Site

The present investigation was done at Dusty Acres Research Farm, Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidyalyaya, Jabalpur during Kharif season of 2019-20. The field selected for further investigation had uniform topography. All facilities needed to conduct the experiment were available on the research farm.

3.2 Location and extent

Experimental field lies at 23°09' North latitude & 79°58' East longitude with an average altitude of 411.78 meters above the mean sea level. Jabalpur comes under “Kymore plateau and Satpura Hills” agro- climatic zone as per norms of National Agriculture Research Project (ICAR) New Dehli. As per classification of norms of National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur, this area belongs to agro ecological region number 10 and sub-region 10.1, named as Central High Land (Malwa and Bundelkhand) sub region number as hot sub-humid (dry) eco-region (Malwa plateau, Vindhayan Scarpland and Narmada Valley).

3.3 Topography

The slope of the land vary from 0 to1%. The topography of the experimental area is plain to gental slope.

3.4 Climate and weather conditions

Jabalpur is located in the central part of Madhya Pradesh. The tropic of cancer passes through the middle of the district. The climate of region is characterized as arid and subtropical which is characteristics by hot dry summers and cool dry winters. The average maximum temperature reaches

as high as 46⁰C in the month of May and June while the minimum temperature goes down upto 4⁰C in the December and January months followed by occasional frosts. Generally the relative humidity remains very low (15 to 30%) during summer months, moderate (60 to 75%) during winter and attain high value (80 to 90%) in rainy season. The annual rainfall of this region varies from 1150 mm to 1270 mm and average of this is mostly 1220.9 mm mainly concentrated from June to September through South-West monsoon.

3.5 Weather conditions during crop season

The variations in season prevalent during the cultivation period of crop play a vital role in growth and development of tree and crop. The Standard meteorological week data pertaining to maximum and minimum temperatures, relative humidity, rainfall, number of rainy days, and sunshine hours during the Kharif season were recorded in the meteorological observatory, College of Agriculture Engineering, J.N.K.V.V., Jabalpur (M.P.).

Table 3.1 Meteorological parameters during Kharif season, 2019

Month	Meto. weeks	Temperature (°C)		Sun Shine hrs.	Rainfall (mm)	RH		Rainy days
		Max.	Min.			Mor.	Eve.	
July	27	29.9	23.1	1.3	178.8	94	87	3
	28	31.4	25.0	2.6	59.8	82	64	1
	29	34.9	25.0	8.7	24.4	82	59	2
	30	32.3	24.0	3.5	48.0	88	74	3
August	31	29.6	23.9	1.5	47.6	93	81	4
	32	29.9	23.5	2.7	210.0	92	81	4
	33	28.6	22.9	2.9	302.1	91	83	4
	34	29.2	22.5	1.4	212.9	97	83	7
September	35	30.9	23.4	3.3	57.2	93	75	4
	36	31.6	23.4	3.8	185.0	94	79	5
	37	28.5	23.4	1.2	101.4	93	83	5
	38	31.7	22.7	4.5	53.1	91	78	3
October	39	29.5	22.1	2.5	77.6	93	78	4
	40	30.1	21.0	7.2	14.3	90	66	2
	41	30.3	18.0	8.4	0.0	91	56	0
	42	29.2	18.7	5.6	2.2	93	63	0
November	43	27.1	19.1	0.9	1.0	92	60	0
	44	30.3	17.7	5.3	0.0	92	52	0
	45	29.6	14.0	6.5	0.0	92	52	0
	46	28.7	10.3	6.8	0.0	92	41	0

3.6 Experimental Methodology

Agroforestry System	Components	Functional Units
Agrisilvicultural system	(i) Non woody components (arable crop) (ii) Woody perennials	(a) Pigeon pea(TJT-105) (b) Green gram(TJM-37) (c) Cowpea(local)

3.7 Planting geometry

The plantation is done in lines from North to South directions and spacing between them is of 8.0x2.5 m in different combinations.

3.8 Experimental details:

Table 3.2: Experimental details of different tree crop combinations

Treatments	Combinations
T ₁	<i>Gmelina arborea</i> + Pigeon pea
T ₂	<i>Gmelina arborea</i> + Cowpea
T ₃	<i>Gmelina arborea</i> + Greengram
T ₄	Sole <i>Gmelina arborea</i>
T ₅	Sole Pigeon pea
T ₆	Sole Cowpea
T ₇	Sole Green gram

Number of treatments	7
Number of replications	3
Gross plot size	24x7.5=180 m ²
Net plot size	16x5=80 m ²
Spacing between silvi trees	8x2.5 m
Experimental Design	Randomized Block Design

3.9 Observations to be recorded:

1. To record insect pests associated with agroforestry systems at weekly intervals.
2. To study pattern of infestation and intensity of damage.

$$\text{Damage (\%)} = \frac{\text{Number of branches damaged by insect pest}}{\text{Total number of branch examined}} \times 100$$

3. Effect of insect population on agroforestry systems.
4. Effect of tree component on pest population.
5. To study which plant part is damaged by insect.

3.10 Characteristics of species:-

3.10.1 *Gmelina arborea* (Khamer)

Gmelina arborea (Linn.) belongs to family Verbinaceae, commonly known as Khamer, Kashmarya, Gambhari, Gamari, kashmir tree, White teak, Ghomar tree, Coomb teak. It occurs throughout greater part of India, Western Ghats, from foot of North-West Himalaya to Chittagong and throughout Deccan Peninsula. The wood of this species is an excellent source for pulp and paper industries and suitable for manufacture of matchboxes splints. It produces a light-weighted wood which is used in light construction, packaging, furniture, particle board etc. It is a fast growing and multipurpose tree species of tropical and subtropical regions of India. It is naturally grown throughout India from the foot of Himalayas to Kerala and Andaman.

It thrives well in shade in the temperature range of 30°C- 47°C, 60-100% humidity and the annual rainfall between 750mm to 4500mm. It also does not thrive on heavy clay soils. It does not thrive in waterlogged conditions and remains stunted on dry, sandy or otherwise poor soil. It is one of the light-demanding and ideal choice for farm forestry and large scale afforestation initiatives. It is one of the light-demanding and ideal choice for farm forestry and large scale afforestation initiatives. It is a medium sized to large deciduous tree attaining a height of 15-20m.

3.10.2 *Cajanus cajan* (Pigeon pea)

Cajanus cajan (L.) belongs to family Fabaceae, commonly called as Pigeon pea, Arhar, Red gram or tur is a very old crop of this country. Arhar is the second most important pulse crop in the country. It is mainly eaten in the form of split pulse as 'dal'. Seeds of arhar are also rich in iron, iodine, essential amino acids like lycine, threonine, cystine and arginine etc. It is one of the dominant crop of tropical areas mainly cultivated in semi arid regions of India. It can be grown with a temperature ranging from 26°C to 30°C in the rainy season (June to October) and 17°C to 22°C in the post rainy (November to March) season.

Pigeonpea is very sensitive to low radiation at pod development, therefore flowering during the monsoon and cloudy weather, leads to poor pod formation. It is successfully grown in black cotton soils, well drained with a pH ranging from 7.0-8.5. the variety used for plantation is TJT-105.

3.10.3 *Vigna radiata* (Green gram)

Vigna radiata (L.) belongs to family Fabaceae commonly called as Mung bean or Moong. This originate in India and Central Asia. Green gram is cultivated in the countries of India, Burma, Srilanka, Pakistan, China, Fiji, Queens land and Africa. It requires a hot and warm climate and considered to be hardiest among all pulse crops and can tolerate drought to a great extent. Hence, it is successfully grown in any adverse conditions and particularly in drought prone areas during kharif season. It can be grown on a variety of soils ranging from sandy loam to black cotton soils having good drainage capacity. Green gram is very sensitive to water logging conditions.

Green gram is an excellent source of high quality protein (25%) having high digestibility. It is also a good source of Riboflavin, Thiamine and Vitamin C (Ascorbic acid). When green gram is sprouted, seeds synthesized remarkable quantity of ascorbic acid (Vitamin C). Green gram is also used as green manure crop. It being a leguminous crop has capacity to fix the atmospheric nitrogen (30-40 kg N/ha). Green gram can be used as feed for cattle. After harvesting the pods, green plants are uprooted or cut from the ground level and chopped into small pieces and fed to the cattle. The husk of

the seed can be soaked in water and used as cattle feed. In North India, it is cultivated in both kharif and summer seasons and in South. India, it is cultivated in rabi season. The important green gram growing States in the country are Orissa, Maharashtra, Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan and Bihar. The variety used for plantation is TJM-37.

3.10.4 *Vigna unguiculata* (Cowpea)

Vigna unguiculata (L.) belongs to family Fabaceae and commonly known as Lobia, Barbati, Black eyed pea, Cowpea and Southern pea. It is native of Africa. This crop is known as drought hardy nature, its wide and droopy leaves keeps soils and soil moisture conserved due to shading effect. It has multiple uses like food, feed, forage, fodder, green manuring and vegetable. Cowpea seed is a nutritious component in the human diet, and cheap livestock feed as well. Both the green and dried seeds are suitable for canning and boiling as well.

Cowpea restrain various essential nutrient such as Protein - 22-24%, Carbohydrate - 55-66 %, Iron - 0.005%, Calcium - 0.08 – 0.11 % and amino acids (lysine, leucine and phenylalanine). Well drained loam or slightly heavy soil are best suited. In Indian context, it is a minor pulse cultivated mainly in arid and semiarid tracts of grown in pockets of Punjab, Haryana, Delhi, and West UP along with considerable area in Rajasthan, Karnataka, Kerala, Tamil nadu, Maharashtra and Gujarat. The Local variety id used for the plantation.

3.11 Collection of experimental observations:-

3.11.1 Weather data

The Weather data during the course of investigation was recorded during Kharif season at Meteorological observatory, College of Agricultural Engineering, JNKVV, Jabalpur.

3.11.2 To record insect-pest distribution and associated with agroforestry systems weekly intervals

To know the distribution and association of various insect-pest in Jabalpur (Dusty acre farm under Department of Forestry, JNKVV, Jabalpur, M.P.) both agroforestry systems were surveyed at weekly interval and the

observation were noted for the incidence of major insect-pests and minor pests from each replication and treatments. Randomly selected branches in each plant were observed for major and minor pest.

3.11.3 To study the pattern of infestation and intensity of damage in agroforestry systems

The observations were recorded on the various types and number of insect-pests at weekly intervals from each agroforestry systems. To study infestation, trees were randomly selected per replication and from which five branches were randomly selected at lower and upper canopy levels. Based on the data collected on the infestation of various insect pests, the susceptibility and level of tolerance was screened.

3.11.4 The infestation / Damage would be consider accordingly as:

Both healthy as well as infested branches were counted and per & infestation was worked out.

$$\text{Damage (\%)} = \frac{\text{Number of branches damaged by insect pest}}{\text{Total number of branch examined}} \times 100$$

3.12 Statistical analysis:-

Cochran and Cox (1950) suggested the method of analysis of variance from which the data calculated for experiment were tabulated and analyzed. The significance of the treatment mean square at 5 per cent level was tested with 'F' test. When 'F' test showed the significance of treatment using the significance of critical differences at 5 per cent level further tested the differences between the treatment means.

Table 3.3 Skeleton for analysis of variance (ANOVA)

Source of variance	d.f.	S.S	M.S.S	'F' value	
				Cal. value	Tab. Value(5%)
Replication	(r - 1)	RSS	RMS		2.71
Treatments	(t - 1)	TSS	TMS		2.87
Error	(r - 1)(t - 1)	ESS	EMS		
Total	(rt - 1)				

$$\text{Mean sum of square (MSS)} = \frac{\text{Sum of square}}{\text{Degree of freedom}} \quad \text{or} \quad \frac{\text{SS}}{\text{d.f.}}$$

$$\text{'F' value} = \frac{\text{Treatment mean sum of squares (TMSS)}}{\text{Error mean sum of squares (EMSS)}}$$

$$\text{SEm } \pm = \frac{\sqrt{\text{Error variance}}}{\text{Number of replication}}$$

The critical difference to test the difference between two mean values was calculated as follows: -

$$\text{CD 5\%} = \text{SE} \times \text{t value at 5\% Level of significance at error df.}$$

Where,

R = Number of replication

T = Number of treatment

d.f = degrees of freedom

S.S = Sum of squares

MSS = mean sum of square

RSS = Replication sum of square

TSS = Treatment sum of square

ESS = Error sum of square

RMS = Replication mean sum of square

TMS = Treatment mean sum of square

EMS = Error mean sum of square

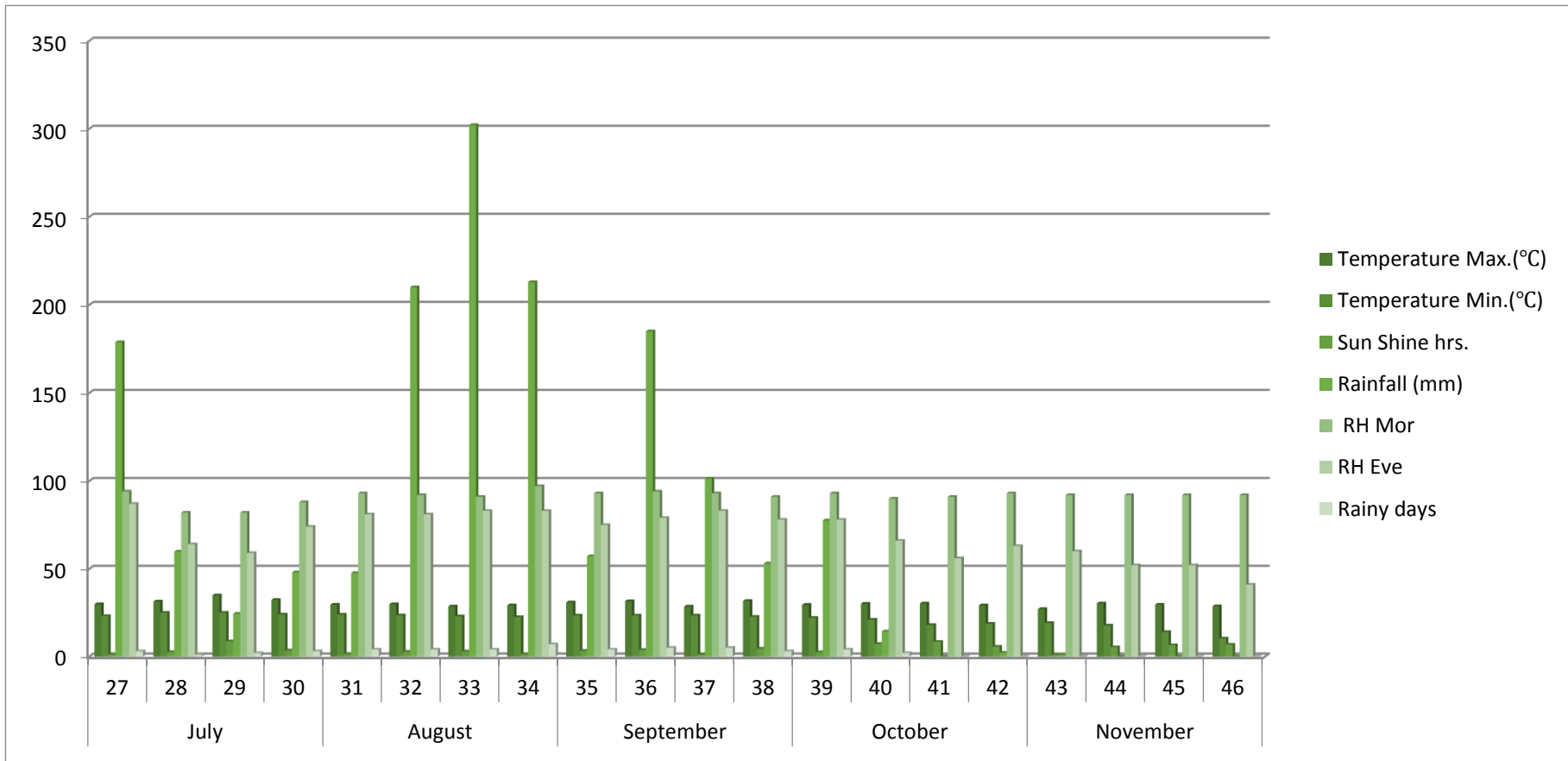


Figure 1 Graphical presentation of weekly meteorological parameters during July 2019 to November 2019.

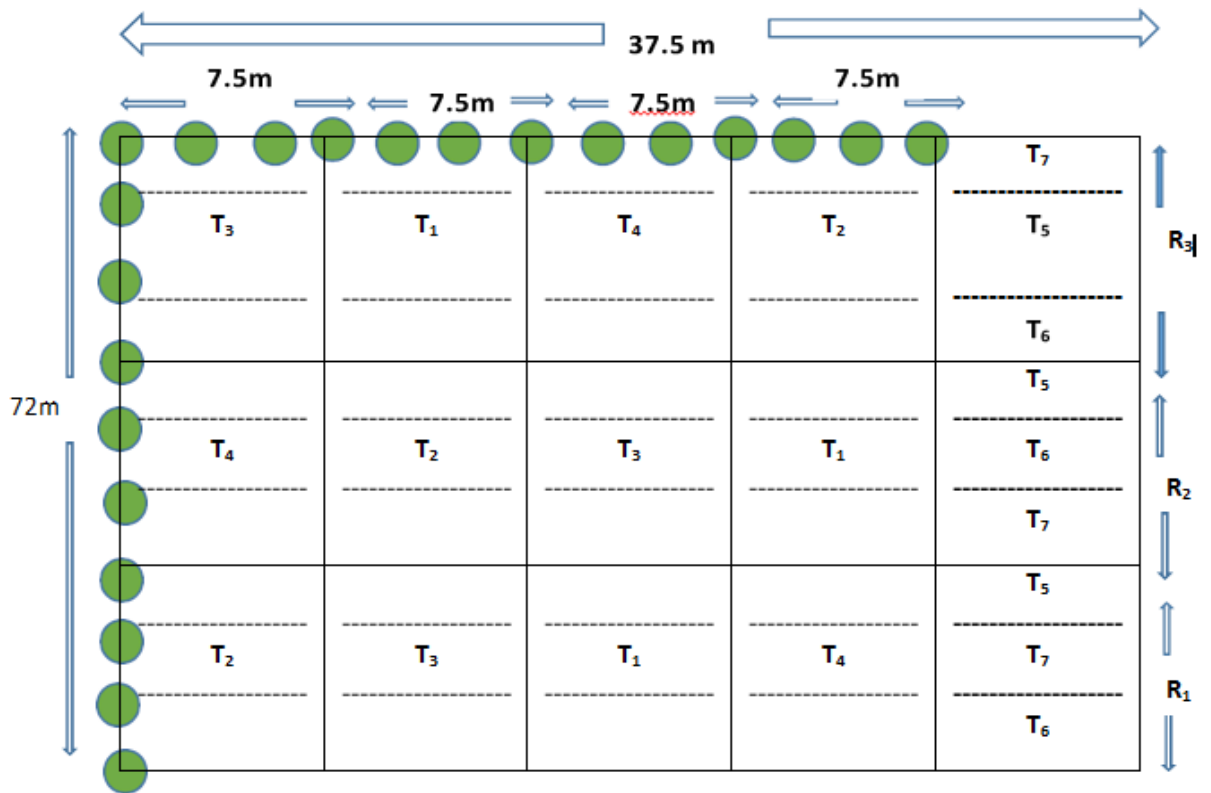


Fig.2 Layout plan of experimental field

- **GA (*Gmelina arborea*) Gamhar**

T₁ = GA + Arhar

T₂ = GA + Cowpea

T₃ = GA + Green gram

T₄ = Sole GA

T₅ = Sole Arhar

T₆ = sole Cowpea

T₇ = Sole Green gram

Chapter-IV

RESULTS

RESULTS

Present investigation on “**Diversity and visitation frequency of major insect pest population under *Gmelina arborea* based Agrisilviculture system**” was carried out during the year 2019-20 in Kharif season at Forestry research farm, New Dusty Acre area, Department of Forestry, College of Agriculture, J.N.K.V.V, Jabalpur. The obtained results in the investigation are presented in this chapter under following objectives:-

1. Identification and quantitative assessment of pest damage in *Gmelina arborea* plantation.
2. Association analysis of insect-pest incidence with tree-crop component.
3. Correlation studies of insect population with weather parameters.

Identification and quantitative assessments of pest damage in *Gmelina arborea* plantation 2019-20.

Study was worked out on insect-pest communities under agrisilviculture system in different treatment and replications. The result of investigation reveals that about 10 species of insect in agrisilviculture system. The data on mean number of various insect-pest population was recorded at weekly interval during the crop duration from July to November , Madhya Pradesh during 2019-20.

Table 4.1 Population dynamics of insect-pest communities in agrisilviculture system during 2019-20.

S. No.	Common Name	Scientific Name	Order	Family
<i>Gmelina arborea</i>				
1.	Khamer defoliator	<i>Calopepla leayana</i>	Coleoptera	Chrysomelidae
2.	Sap sucker/ Lace bug	<i>Tingis beelsoni</i>	Hemiptera	Tingidae
3.	Bark-eating caterpillar	<i>Indarbela quadrinotata</i>	Lepidoptera	Indaebelidae
4.	Defoliator	<i>Eupterote geminata</i>	Lepidoptera	Eupterotidae

S. No.	Common Name	Scientific Name	Order	Family
Pigeon pea				
1.	Tur pod fly	<i>Melanagromyza obtusa</i>	Diptera	Agromyzidae
2.	Plume moth	<i>Exelastis atomosa</i>	Lepidoptera	Pterophoridae
Green gram				
1.	Gram pod borer	<i>Helicoverpa armigera</i>	Lepidoptera	Noctuidae
2.	Pod bugs	<i>Riptortus pedestris</i>	Hemiptera	Coreidae
Cow pea				
1.	Cowpea pod borer	<i>Maruca vitrata</i>	Lepidoptera	Crambidae
2.	Hairy caterpillar	<i>Spilosoma obliqua</i>	Lepidoptera	Erebidae

4.1 Identification and effect of insect pest under agrisilviculture system.

4.1.1 Gmelina arborea

- Khamer defoliator *Calopepla leayana* (Coleoptera : Chrysomelidae)
- Sap sucker *Tingis beeoni* (Hemiptera:Tingidae)
- Bark eating caterpillar *Indarbela quadrinotata* (Lepidoptera: Indarbelidae)
- Defoliator *Eupterote geminata* (Lepidoptera:Eupterotidae)

4.1.1.1Khamer defoliator *Calopepla leayana* (Coleoptera: Chrysomelidae)

Description:

This is a serious major pest of economically important timber species. The beetles were found in group. The life cycle involves five larval instar stages. The adult beetle lay eggs as a case called 'ootheca' underneath the stem branches. The full grown larvae pupate on the leaf. Adults are metallic in colour 12-16mm in length, violet to blue and pale yellow to reddish brown. Larvae are having lateral spines. The excrement instead of being ejected is

extruded in fine black filaments; longer than body and formed bunches at anal end. The molted skin is also attached to the last abdominal segment. When disturbed the larvae assumes defensive posture. Pupae are dull coloured and attached to infested leaves.

Nature of damage:

It is one of the monophagous insect. The beetle feed voraciously on leaves and buds. Young trees of *G.arborea* subject to repeated attack of the insect both larval and adult stages become weak and succumb. Similarly young seedlings of this economically important tree species grown in nurseries are severely attacked by the insect and resulting in loss of healthy planting stock. The heavy attack causes the leading shoots of the young tree to dry up and tree remains leafless for about four months in the growing season.

4.1.1.2 Sap sucker *Tingis besoni* (Hemiptera: Tingidae)

Description:

It is a dark or black coloured bug. The measurement of lace bugs is about 4 mm X 1.7 are pale or brown in colour and quite active. The wings are transparent, lace like texture held flat on the back. The adults fly fairly well. Nymphs are oval and colourless at birth, but soon turn black and spiny.. Both the adults and nymphs actively move underneath the leaves and on shoots.

Nature of damage:

T. besoni leads to the top dying, which assembles in crowded on the leaves and soft tissues. The nymphs and adults suck the sap at the base of the leaf axils, which results in discoloration of leaf in the form of patches on both the sides of lamina. The infested leaves become blotched brown near the base, which ultimately wither and fall down. This causes the upper leaf surface to appear stippled with minute white spots. Heavier feeding causes leaves to appear white or bleached before they dry completely and fall off. Damage typically appears first on mature leaves and later on new flush. Lace bug infestation can easily be determined by examining the underside of the leaves.

4.1.1.3 Bark eating caterpillar *Indarbella quadrinotata* (Lepidoptera: Indrabelidae)

Description:

The larva is brown to pale black in colour. Larva is smooth skinned with triangular chitinous patches on each abdominal segment. The medium sized moth having rows of dark rusty red spots on forewings. The pupation occurs in the tunnel. It feeds on the bark.

Nature of damage:

The larvae excavate a hole at the branch initiation point and remains because of nocturnal in nature. It prepares tunnels frass materials made up of cellulose, excreta and saliva. The colour of frass materials varies as per chemical constituent of the bark concerned. Plants become weak and succumb to natural calamities due to boring by larvae. This penetrate into the tree through eating bark and makes the path path for other organism too.

4.1.1.4 Defoliator *Eupterote geminata* (Lepidoptera: Eupterotidae)

Description:

The medium sized moth of this species are orange yellow with dark transverse bands on wings. The wingspan is 58-80mm. The forewings have a single medial indistinct slightly curved line. Both wings have a prominent post medial slightly curved line

Nature of damage:

The larva of this moth is polyphagous on the foliage of several trees. The larvae and adults start feeding voraciously, defoliating the leaf completely. The larvae feed gregariously on the leaves of tree. These defoliator has one generation in a year.

4.1.2 *Cajanus cajan* (L.)

- Tur pod fly *Melanagromyza obtuse* (Diptera:Agromyzidae)
- Plume moth *Exelastis atomosa* (Lepidoptera: Pterophoridae)

4.1.2.1 Tur pod fly *Melanagromyza obtuse* (Diptera:Agromyzidae)

Description:

The tur pod fly is the key pest of pigeon pea throughout south and south-east Asia. Both male and female are 2-3 mm long and appear black in colour. The wings are clear. The female deposit eggs in the green pods of pigeon pea. The larva feeds on the unripe seed and destroys it completely. They damage the pod with dark brown encrustation on the pod wall.

Nature of damage:

The Tur pod fly directly influenced the grain yield of the crop. Although a large number of insect pests were noticed in the vegetative stage of the crop, they hardly had any significant influence on the yield performance. The Stripes can be seen on the surface of the affected grains, while the attacked pods are some what twisted or deformed. In case of severe damage, as many as 80 per cent pods and 60 per cent grains may be damaged.

4.1.2.2 Plume moth *Exelastis atomosa* (Lepidoptera: Pterophoridae)

Description:

The Plume moth is greenish or yellowish green with small spiny projections. It bores into the pods and feeds on the seeds inside and also on flowers. The adult is small with yellowish brown wings. The forewings are cut into plumes and hind wings into three.

Nature of damage:

The larvae are a serious pest of pigeon pea. They damage seeds and at the end drop the flowers, buds and pods. They also damage the developing grains. Small circular holes are seen on the infested pods.

4.1.3 *Vigna radiate* (L.)

- Gram pod borer *Helicoverpa armigera* (Lepidoptera: Noctuidae)
- Pod bug *Riptortus pedestris* (Hemiptera : Coreidae)

4.1.3.1 Gram pod borer *Helicoverpa armigera* (Lepidoptera: Noctuidae)

Description:

After hatching the colour changes into dark brown in colour. It is pomegranate in shape with 0.4-0.5mm in diameter. The first and second larval instars are generally yellowish –white to reddish- brown in colour. The antennae are covered with fine hairs. Hindwings pale yellow with a brown band at the posterior edges and a dark round spot in the middle. It is polyphagous in nature.

Egg: Spherical in shape, yellowish eggs are laid singly on tender parts and buds of plant.

Larva: Caterpillars are of varying colour, initially brown and later turn greenish with darker broken lines along the side of the body. Body covered with radiating hairs. When full grown, they measure 3.7 to 5 cm in length.

Adult: Moth is medium sized with brownish / greyish forewings with a dark cross band with a wing expanse of 3.7cm.

Nature of damage:

The larvae bore into pods and consume the developing seed. The mature larva bore circular holes on fruits. The internal tissues are eaten severely and completely hollowed out. Warm weather condition followed by light rains and dry spells are favourable for multiplication. This pest mainly bored fruits within round holes, fed leaves, shoots and buds.

4.1.3.2 Pod bug *Riptortus pedestris* (Hemiptera : Coreidae)

Description:

- The nymphs are brownish black and hemispherical which resembles brown ant.
- The female bud lays an average of 115 eggs singly on pods at their base.
- The pods are poorly filled with shrivel grains .

Role of insect:

- The nymphs and adults suck the juice of unripe seeds from the green pods. In case of severe infestation the tender parts get shrivelled and later dries up. The bugs are seen clustered around around on the pods.

4.1.4 Vigna unguiculata (L.)

- Cowpea pod borer *Maruca vitrata* (Lepidoptera: Crambidae)
- Hairy caterpillar *Spilosoma obliqua* (Lepidoptera: Erebidae)

4.1.4.1 Cowpea pod borer *Maruca vitrata* (Lepidoptera: Crambidae)**Description:**

The legumepod borer is a serious pest of legume. The eggs are laid on the stem, young leaves, flowers and pods. They are pale cream in colour with two rows of dark dots on their backs. The moths have front wings brown in colour with white patches.

Role of insect:

The caterpillars rolls the leaves and web these with the top shoot. Caterpillar bore into the pods and feed on the seeds, if flower and pods are not available larvae feed on foliage. The damaged pod consists of tunnelling by foraging larvae.

4.1.4.2 Hairy caterpillar *Spilosoma obliqua* (Lepidoptera: Erebidae)**Description:**

The larvae are covered with long yellowish to black hairs. The adult is a brown moth with a red abdomen. The forewings have black spots.

Role of insect:

They feed on the leaves, buds and flowers of many plants. They have several generations in one year. It is major insect of cowpea. It cuts the juvenile plants and eat away all the green matter of the leaves.

4.2 Association analysis of insect-pest incidence with tree-crop component.

4.2.1. *Gmelina arborea*

- Khamer defoliator *Calopepla leayana* (Coleoptera : Chrysomelidae)
- Sap sucker *Tingis beeoni* (Hemiptera:Tingidae)
- Bark eating caterpillar *Indarbela quadrinotata* (Lepidoptera: Indarbelidae)
- Defoliator *Eupterote geminata* (Lepidoptera:Eupterotidae)

4.2.1.1. Khamer defoliator *Calopepla leayana*.

Population dynamics:-

The Khamer defoliator feed on the leaf, making large circular holes and also eats the young shoots. It was observed on 1st week of August. The number of insect varied in every treatment and replications. The number of insect varied according to various abiotic and biotic factors.

Table 4.2 shows the result of population dynamics and prevalence of Khamer defoliator which started from 1st week of August that is shown in the form of standard metrological week 31st the minimum and maximum temperature was 23.9^oC, 29.6^oC and relative humidity was 93% in the morning and 81% in evening.

Maximum population was recorded on the 3rd week of August (33rd meteorological week) the minimum and maximum temperature was 22.9^oC and 28.6^oC with the relative humidity of 91% in the morning and 83% in the evening where the insect population was 3.50, 2.33, 2.00, 3.00, 0.67, 0.83 and 0.83 respectively in all treatments.

Minimum population of Khamer defoliator in first week of August (31st meteorological week) was observed 0.67, 0.83, 1.00, 1.33, 0.83, 0.50 and 0.67. The minimum and maximum temperature was 23.9^oC and 29.6^oC and relative humidity was 93% in the morning and 81% in the evening.

Average mean population of khamer defoliator in all treatment and replication was 2.23, 1.59, 1.56, 2.33, 0.76, 0.79 and 0.86 respectively.

Table 4.2 Population dynamics and frequency of Khamer defoliator.

Treatment	Standard week				
	31	32	33	34	35
T1	0.67	1.50	3.50	3.00	2.50
T2	0.83	1.33	2.33	2.00	1.50
T3	1.00	1.50	2.00	1.83	1.50
T4	1.33	1.83	3.00	3.00	2.50
T5	0.83	1.00	0.67	0.67	0.67
T6	0.50	1.00	0.83	0.83	0.83
T7	0.67	1.17	0.83	0.83	0.83
SEm _±	0.27	0.28	0.34	0.32	0.30
CD	0.80	0.82	1.00	0.95	0.88
	S	S	S	S	S

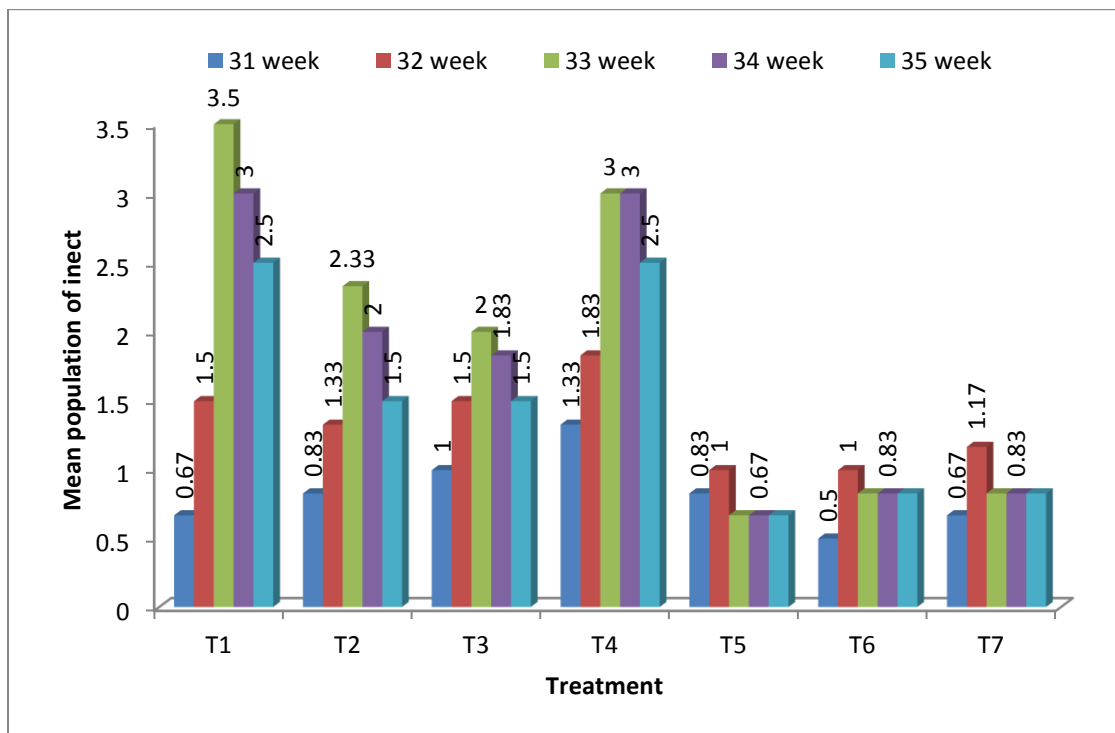


Figure 3. Population dynamics and frequency of Khamer defoliator.

4.2.1.2 Sap sucker *Tingis beeoni*

Population dynamics:-

The first assemblance of the sap sucker was seen in crowd on the leaves and soft shoots. It was observed during first week of August. The number of insect varied from treatment to treatment. The number of insect varied due to weather parameter.

Table 4.3 Shows the result of population dynamics and prevalence of sap sucker which started from the first week of August which is viewed in the form of standard meteorological week 31st the minimum and maximum temperature was 23.9⁰C, 29.6⁰C and the relative humidity was 93% in the morning and 81% in the evening. The average number of insect observed was 1.67, 1.33, 1.67, 2.83, 0.67, 0.67 and 0.83 respectively.

The maximum population was recorded on 3rd week of August (34th meteorological week) the minimum and maximum temperature was 22.5⁰C and 29.2⁰C and the relative humidity in the morning was 97% and 83% in the evening respectively. The insect population recorded was 2.83, 2.17, 2.33, 3.83, 0.83, 1.00 and 1.00.

The minimum population was recorded in first week of September (36th meteorological week) was 1.17, 1.00, 1.17, 2.50, 0.50, 0.50 and 0.67 respectively. There are three generation each lasting about six weeks. The minimum and maximum temperature was 23.4⁰C , 31.6⁰C where the relative humidity was 94% in the morning and 79% in the evening.

The average mean population of Sap sucker in all treatments and replications was 2.1, 1.6, 1.8, 3.1, 0.6, 0.72 and 0.77 respectively.

Table 4.3 Population dynamics and frequency of Sap sucker.

Treatment	Standard week					
	31	32	33	34	35	36
T1	1.67	2.17	2.33	2.83	2.67	1.17
T2	1.33	1.67	1.67	2.17	2.00	1.00
T3	1.67	1.83	1.83	2.33	2.33	1.17
T4	2.83	3.17	3.33	3.83	3.50	2.50
T5	0.67	0.67	0.67	0.83	0.83	0.50
T6	0.67	0.67	0.67	1.00	0.83	0.50
T7	0.83	0.67	0.67	1.00	0.83	0.67
SEm _±	0.30	0.34	0.38	0.39	0.30	0.29
CD	0.87	1.00	1.13	1.16	0.88	0.85
	S	S	S	S	S	S

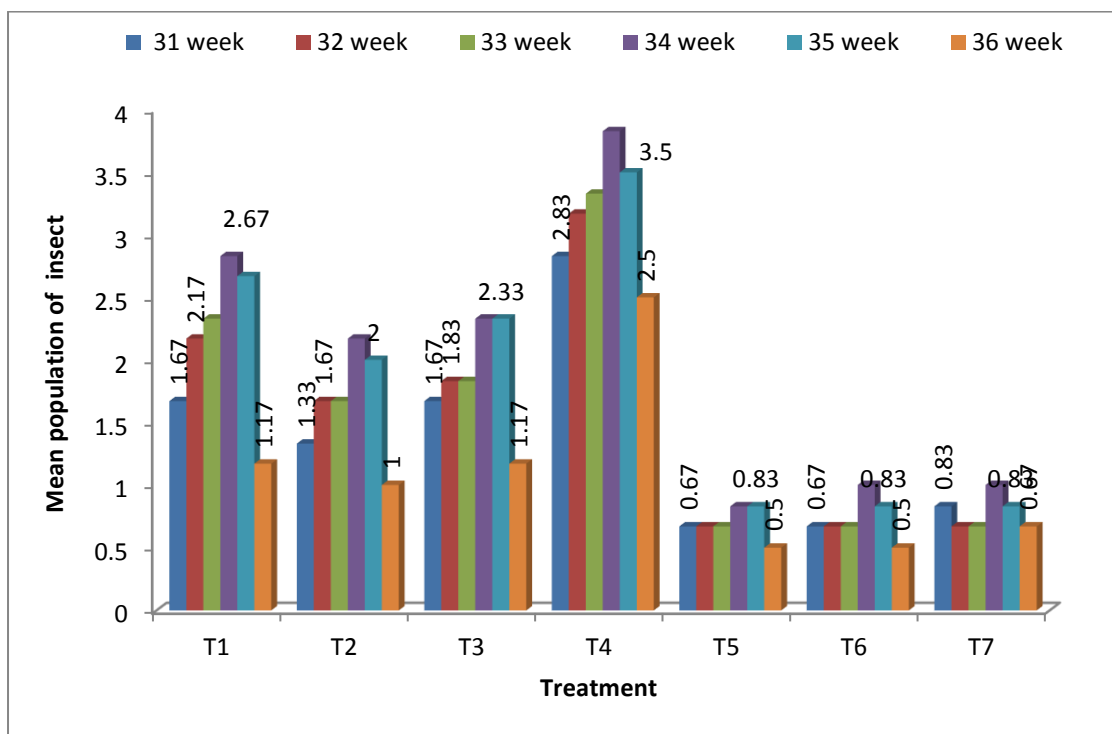


Figure 4 Population dynamics and frequency of Sap sucker

4.2.1.3. Bark eating caterpillar *Indarbela quadrinotata*

Population dynamics:-

The larva bores a short tunnel like hole in the wood. Bark eating caterpillar has one generation in a year. It was observed during the fourth week of July. The number of insect varied due to various abiotic factors such as weather parameter.

Table 4.4 shows the result of population dynamics and frequency of Bark eating caterpillar which started from fourth week of July that is discussed in the form of standard meteorological week (30th standard meteorological week). The minimum and maximum temperature was 24.0°C, 32.3°C with the relative humidity of 88% in the morning and 74% in the evening. The average number of insect was 0.67, 0.67, 0.83, 1.00, 0.67, 0.67 and 0.50 respectively.

The maximum population of insect was recorded on 3rd week of August (33rd meteorological week) the minimum and maximum temperature was 22.9°C, 28.6°C with the relative humidity of 91% in the morning and 83% in evening where as the insect population was 0.67, 0.83, 1.00, 1.50, 0.83, 0.67 and 0.50 respectively.

The minimum population was recorded in first week of September (35th meteorological week) was observed 0.50, 0.67, 0.67, 1.00, 0.50, 0.50 and 0.50 respectively. The minimum and maximum temperature was 23.4°C and 30.9°C with the relative humidity of 93% in morning and 75% in evening.

Average mean population of Bark eating caterpillar in all treatments and replications was 0.66, 0.78, 0.86, 1.13, 0.67, 0.67 and 0.50 respectively.

Table 4.4 Population dynamics and frequency of Bark eating caterpillar

Treatment	Standard week					
	30	31	32	33	34	35
T1	0.67	0.83	0.67	0.67	0.67	0.50
T2	0.67	0.83	0.83	0.83	0.83	0.67
T3	0.83	0.83	1.00	1.00	0.83	0.67
T4	1.00	1.00	1.50	1.50	0.83	1.00
T5	0.67	0.67	0.67	0.83	0.67	0.50
T6	0.67	0.50	0.67	0.67	0.83	0.50
T7	0.50	0.50	0.50	0.50	0.50	0.50
SEm _±	0.26	0.29	0.30	0.34	0.23	0.19
CD	0.78	0.85	0.89	1.01	0.69	0.57
	S	S	S	S	S	S

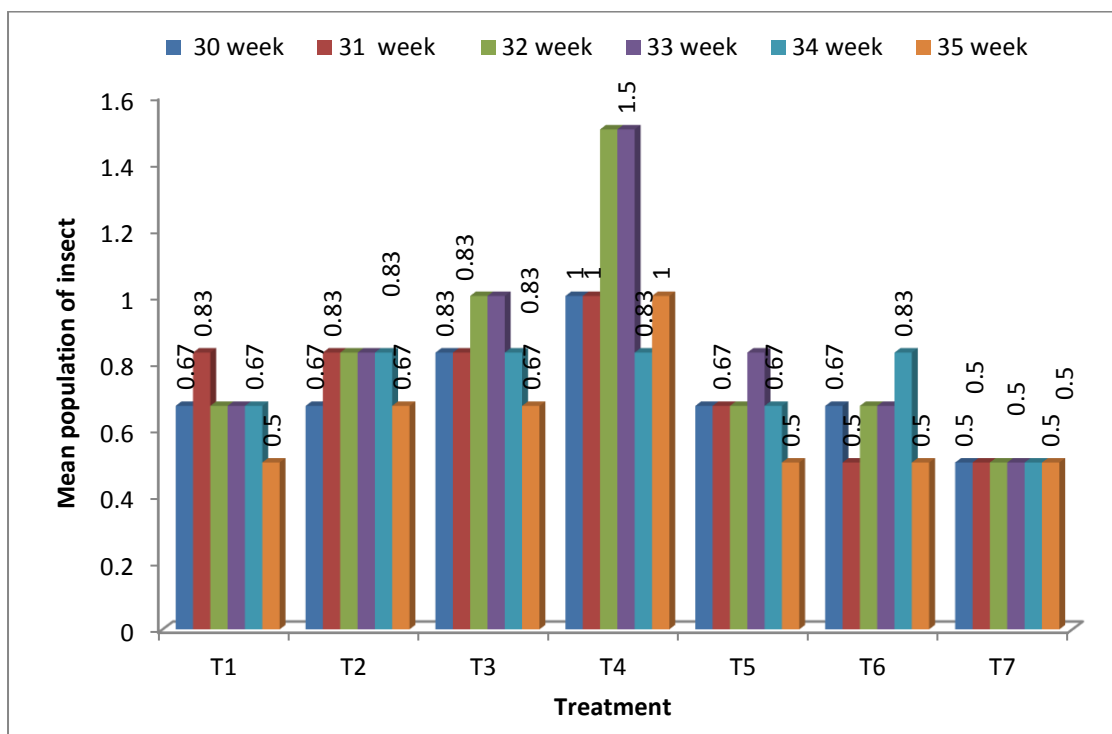


Figure 5 Population dynamics and frequency of Bark eating caterpillar

4.2.1.4 Defoliator *Eupterote geminata*

Population dynamics:-

It was observed during first week of July. The number of insect varied from replication to replication due to the different treatment.

Table 4.5 Shows the result of population dynamics and frequency of *Eupterote geminate* which started from first week of July that is shown in the form of standard meteorological week 27th the minimum and maximum temperature was 23.1⁰C , 29.9⁰C and the relative humidity was 94% in the morning and 87% in the evening. The average number of insect was 0.83, 0.67, 0.67, 0.67, 1.50, 0.67, 0.50 and 0.67 respectively.

The population of defoliator was recorded maximum in the 1st week of August (31st meteorological week) the minimum and maximum temperature was 23.9⁰C, 29.6⁰C and the relative humidity was 93% in the morning and 81%in the evening where as the insect population recorded in this particular week is 2.00, 1.83, 2.00, 2.50, 1.17, 0.83 and 0.83 respectively.

The population of defoliator was recorded minimum in the 3rd week of August (33rd meteorological week) was observed 0.83, 0.67, 0.83, 1.17, 0.67, 0.50 and 0.50 respectively. The minimum and maximum temperature was 22.9⁰C and 28.6⁰C with the relative humidity of 91% in the morning and 83% in the evening.

Average mean population of defoliator in all treatment and replication was 1.23, 1.14, 1.28, 1.78, 0.69, 0.67 and 0.62 respectively.

Table 4.5 Population dynamics and frequency of Eupterote geminate.

Treatment	Standard week						
	27	28	29	30	31	32	33
T1	0.80	1.00	1.17	1.50	2.00	1.33	0.83
T2	0.60	0.83	1.17	1.33	1.83	1.50	0.67
T3	0.60	1.00	1.50	1.50	2.00	1.50	0.83
T4	1.50	1.50	2.17	2.17	2.50	1.50	1.17
T5	0.60	0.50	0.67	0.67	1.17	0.50	0.67
T6	0.50	0.67	0.83	0.83	0.83	0.50	0.50
T7	0.67	0.50	0.67	0.67	0.83	0.50	0.50
SEm _±	0.21	0.25	0.27	0.29	0.31	0.26	0.20
CD	0.61	0.74	0.81	0.86	0.93	0.77	0.60
	S	S	S	S	S	S	S

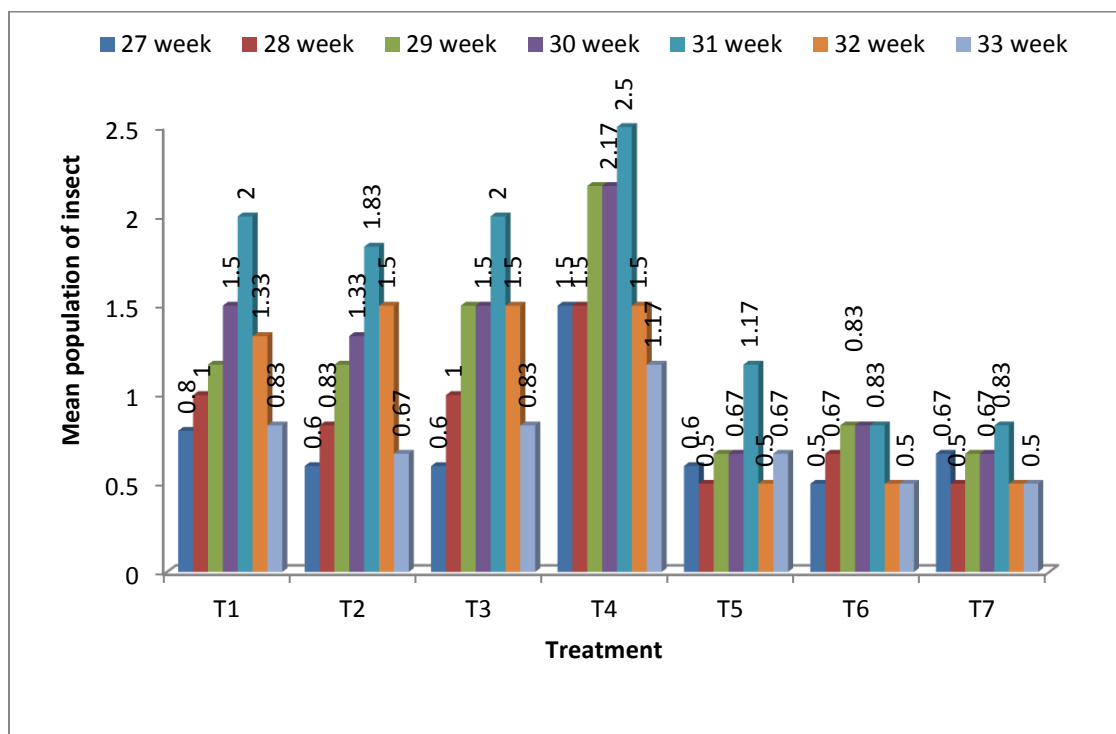


Figure 6 Population dynamics and frequency of Eupterote geminate.

4.2.2 Pigeon pea

- Tur pod fly *Melanagromyza obtuse* (Diptera:Agromyzidae)
- Plume moth *Exelastis atomosa* (Lepidoptera:Pterophoridae)

4.2.2.1 Tur pod fly *Melanagromyza obtuse*

Population dynamics:-

Tur pod fly being an internal feeder, both the larva and pupal stages are present inside the pods. It was observed during third week of October. The number of insect varied from block to block due to various factors such as biotic and abiotic.

Table 4.6 Shows the result of population dynamics and frequency of Tur pod fly which started from the third week of October.

Maximum population was recorded on the first week of November (44th meteorological week) the maximum and minimum temperature was 17.7^oC and 30.3^oC with the relative humidity of 92% in the morning and 52% in the evening where as the insect population recorded was 2.00, 1.00, 0.50, 0.83, 2.17, 0.50 and 0.67 respectively.

Minimum population of Tur pod fly was recorded in the 3rd week of October (42nd meteorological week) was 1.17, 0.67, 0.50, 0.50, 1.33, 0.50 and 0.50. the minimum and maximum temperature was 18.7^oC, 29.2^oC and the relative humidity was 93% in the morning and 63% in the evening.

Average mean population of Tur pod fly in all treatments and replication was 1.6, 0.73, 0.50, 0.63, 1.76, 0.50 and 0.53 respectively.

Table 4.6 Population dynamics and frequency of tur pod fly.

Treatment	Standard week				
	42	43	44	45	46
T1	1.17	1.67	2	1.83	1.33
T2	0.67	0.83	1	0.67	0.5
T3	0.5	0.5	0.5	0.5	0.5
T4	0.5	0.67	0.83	0.67	0.5
T5	1.33	1.67	2.17	2	1.67
T6	0.5	0.5	0.5	0.5	0.5
T7	0.5	0.5	0.67	0.5	0.5
SEm _±	0.16	0.17	0.20	0.22	0.21
CD	0.48	0.49	0.59	0.64	0.61
	S	S	S	S	S

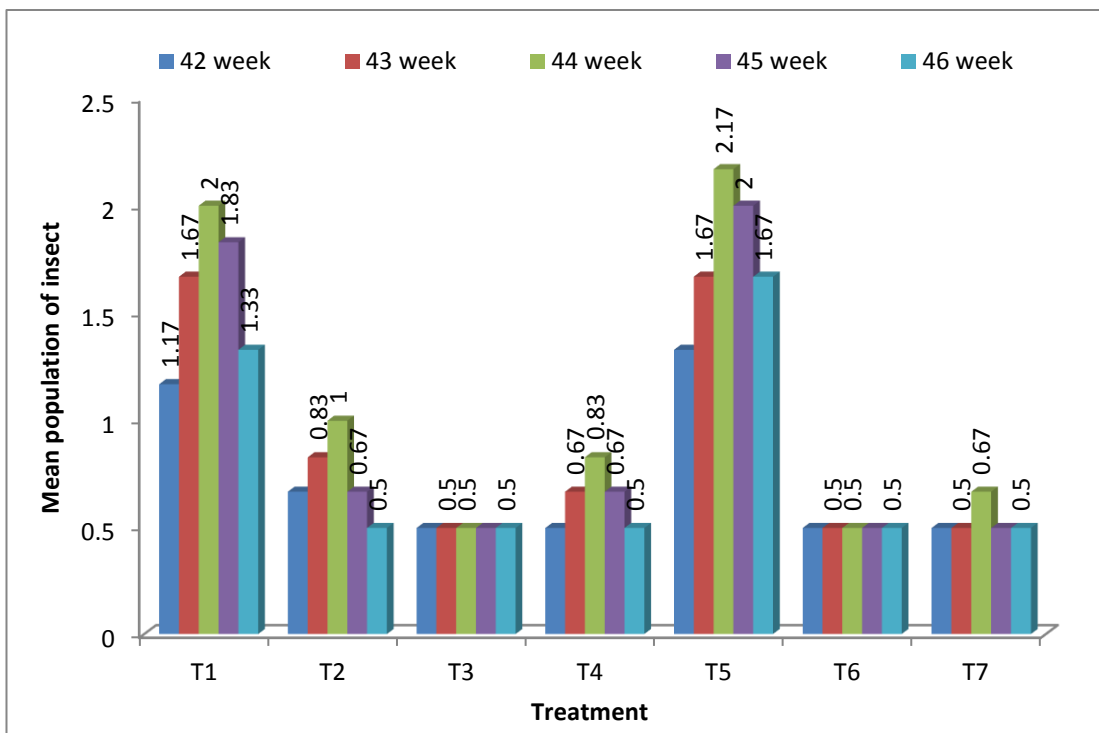


Figure 7 Population dynamics and frequency of tur pod fly.

4.2.2.2 Plume moth *Exelastis atomosa*

Population dynamics:-

Plume moth was observed during fourth week of October. The plume moth usually appear at flowering time of the crop. The number of insect varied from block to block due to various treatment and replications.

Table 4.7 Shows the result of population dynamics and frequency of Plume moth which started from the fourth week of October which is 43rd Standard meteorological week.

The maximum population was recorded in the mid November (46th meteorological week. The minimum and maximum temperature was 10.3^oC and 28.7^oC with the relative humidity of 92% in the morning and 41% in the evening. The insect population recorded was 2.83, 1.00, 0.67, 0.50, 2.83, 0.83 and 0.50 respectively.

The minimum population was recorded in the initial phase of the insect that is 43rd standard meteorological week with the minimum and maximum temperature of 19.1^oC and 27.1^oC and the relative humidity of 92% in the morning and 60% in the evening. The insect population recorded was 1.33, 0.67, 0.67, 0.50, 1.67, 0.50 and 0.67 respectively.

Average mean population of Plume moth in all treatments and replication was 2.11, 0.80, 0.67, 0.50, 2.27, 0.69 and 0.55 respectively.

Table 4.7 Population dynamics and frequency of Plume moth

Treatment	Standard week					
	43	44	45	46	47	48
T1	1.33	1.83	2.33	2.83	2.67	1.67
T2	0.67	0.67	0.83	1.00	0.83	0.83
T3	0.67	0.67	0.67	0.67	0.67	0.67
T4	0.05	0.50	0.50	0.50	0.50	0.50
T5	1.67	2.17	2.5	2.83	2.67	1.83
T6	0.5	0.67	0.83	0.83	0.83	0.5
T7	0.67	0.67	0.50	0.50	0.50	0.50
SEm _±	0.22	0.23	0.24	0.30	0.21	0.15
CD	0.63	0.69	0.7	0.89	0.63	0.43
	S	S	S	S	S	S

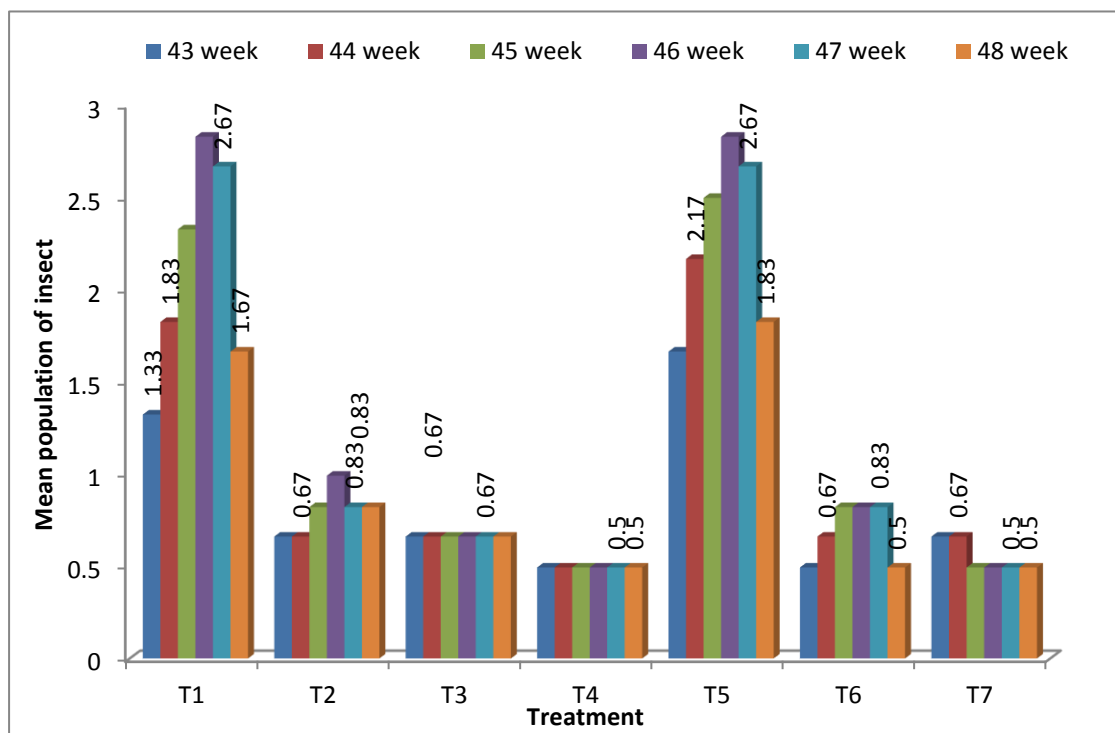


Figure 8 Population dynamics and frequency of Plume moth

4.2.3 Green gram

- Gram pod borer *Helicoverpa armigera* (Lepidoptera: Noctuidae)
- Pod bug *Riptortus pedestris* (Hemiptera : Coreidae)

4.2.3.1 Gram pod borer *Helicoverpa armigera*

Gram pod borer is one of the major major insect of the legume crop. It was observed on the second week of October at the pod development phase. The number of insect varied from block to block due to different treatment and replications.

Table 4.8. Shows the result of the population dynamics and frequency of the gram pod borer which started from the second week of October that is shown in the form of standard meteorological week 41st with the minimum and maximum temperature was 18.0^oC, 30.3^oC and the relative humidity was 91 %in the morning and 56%in the evening. The average number of insect recorded was 0.67, 0.83, 1.83, 0.67, 1.17, 0.83 and 2.17 respectively.

The maximum population was recorded on the fourth week of October (43rd meteorological week) in which the minimum and maximum temperature was 19.1^oC and 27.1^oC with the relative humidity 92% in the morning and 60% in the evening. The insect population recorded was 0.83, 1.17, 3.00, 0.83, 1.50, 1.17 and 3.17 respectively.

The minimum population of gram pod borer was recorded in second week of November (45th meteorological week) which is 0.50,0.50, 1.50, 0.50, 1.50, 0.50 and 1.67 respectively. The minimum and maximum temperature was 14.0^oC, 29.6^oC and the relative humidity was 92%in the morning and 52% in the evening.

Average mean population of gram pod borer in all treatments and replication was 0.73, 0.86, 2.06, 0.66, 1.16, 0.86 and 2.23 respectively.

Table 4.8 Population dynamics and frequency of Gram pod borer.

Treatment	Standard week				
	41	42	43	44	45
T1	0.67	0.83	0.83	0.83	0.50
T2	0.83	1.00	1.17	0.83	0.50
T3	1.83	2.33	3.00	1.67	1.50
T4	0.67	0.67	0.83	0.67	0.50
T5	1.17	1.17	1.50	0.50	1.50
T6	0.83	1.00	1.17	0.83	0.50
T7	2.17	2.50	3.17	1.67	1.67
SEm _±	0.24	0.30	0.34	0.26	0.20
CD	0.7	0.90	0.99	0.77	0.50
	S	S	S	S	S

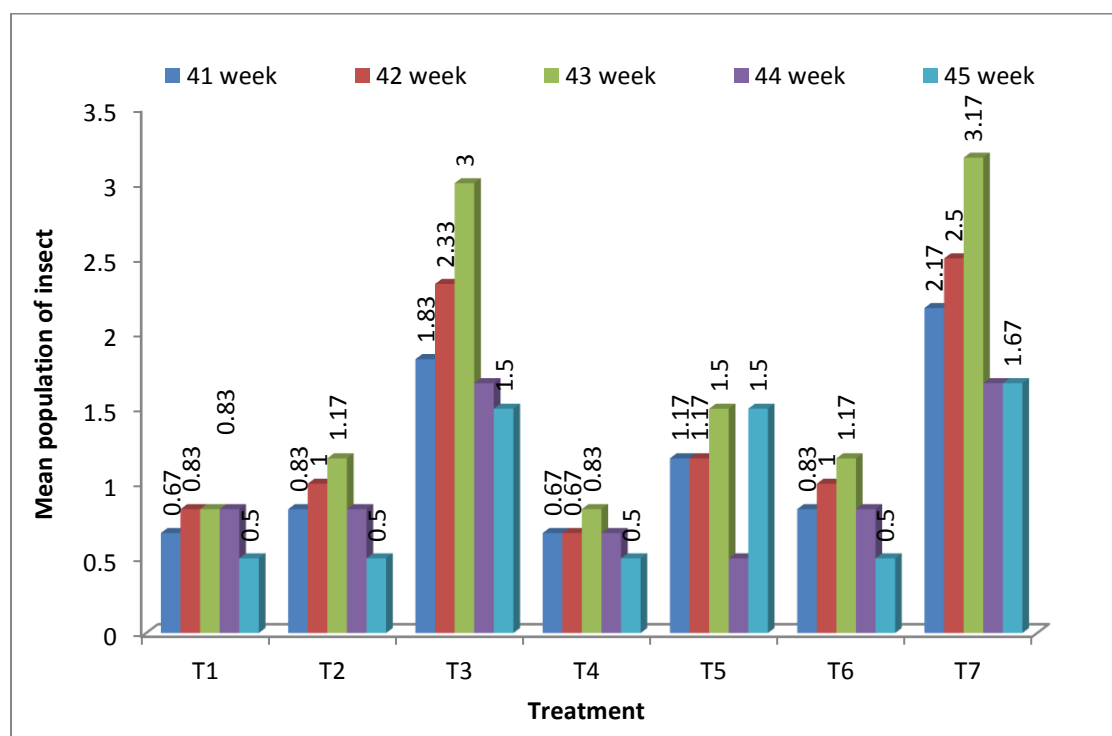


Figure 9 Population dynamics and frequency of Gram pod borer.

4.2.3.2 Pod bug *Riptortus pedestris*

The pod bug was observed during first week of October. The number of insect varied from block to block due to various abiotic factors such as weather parameter and arrangement of block.

Table 4.9. Shows the result of population dynamics and occurrence of Pod bug which started from first week of October that is shown in the form of standard meteorological week which is 40th. The minimum and maximum temperature was 21⁰C and 30.1⁰C with the relative humidity of 90% in the morning and 66% in the evening. The average number of insect recorded was 0.67, 0.67, 1.33, 0.50, 0.83, 1.17 and 1.67 respectively.

The population of Pod bug was recorded as maximum on the fourth week of October (43rd standard meteorological week) with the minimum and maximum temperature was 19.1⁰C and 27.1⁰C where as the relative humidity was 92% in the morning and 60% in the evening. The average population recorded of Pod bug was 1.33, 1.33, 3.50, 1.17, 1.33, 2.17 and 3.33 respectively.

The population of Pod bug was recorded as minimum on the first week of November (44th standard meteorological week) with the minimum and maximum temperature was 17.7⁰C and 30.3⁰C where as the relative humidity was 92% in the morning and 52% in the evening. The average population recorded was 0.82, 0.67, 1.17, 0.50, 1.50, 0.50 and 1.33 respectively.

Average mean population of Pod bug in all treatment and replications recorded was 1.00, 0.96, 2.10, 0.76, 1.16, 1.36 and 2.00 respectively.

Table 4.9 Population dynamics and frequency of Pod bug.

Treatment	Standard week				
	40	41	42	43	44
T1	0.67	1	1.17	1.33	0.83
T2	0.67	1	1.17	1.33	0.67
T3	1.33	2	2.5	3.5	1.17
T4	0.5	0.83	0.83	1.17	0.5
T5	0.83	1	1.17	1.33	1.5
T6	1.17	1.33	1.67	2.17	0.5
T7	1.67	2.17	2.5	3.33	1.33
SEm _±	0.23	0.33	0.36	0.42	0.25
CD	0.69	0.96	1.06	1.24	0.73
	S	S	S	S	S

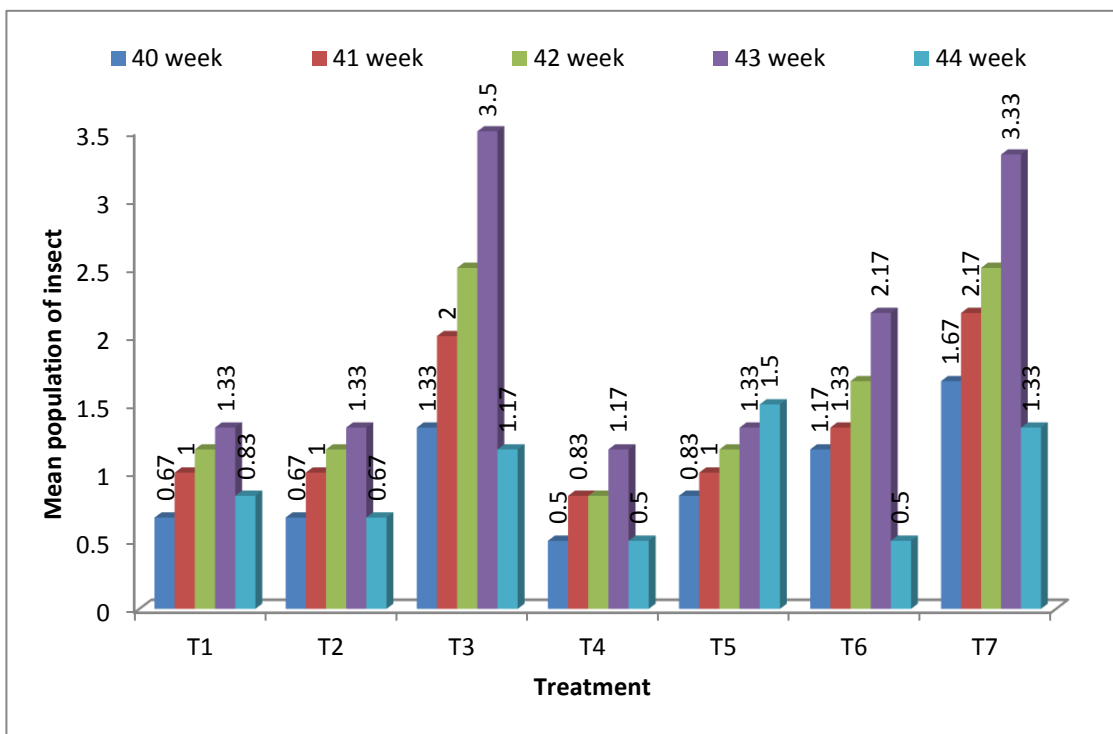


Figure 10 Population dynamics and frequency of Pod bug.

4.2.4 Cow pea

- Cowpea pod borer *Maruca vitrata* (Lepidoptera: Crambidae)
- Hairy caterpillar *Spilosoma obliqua* (Lepidoptera: Erebidae)

4.2.4.1 Cowpea pod borer *Maruca vitrata*

The Cow pea pod borer found under the lower leaves of the host plant. It was first observed during first week of August at the time of onset of monsoon. The number of insect varied from block to block due to different treatment and replications.

Table 4.10. Shows the result of the population dynamics and frequency of the Cow pea pod borer which started from the first week of August (31st standard meteorological week) with the minimum and maximum temperature was 23.9°C, 29.6°C and the relative humidity was 93% in the morning and 81% in the evening. The average number of insect recorded was 0.50, 1.17, 0.67, 0.50, 0.50, 1.50 and 0.50 respectively.

The maximum population was recorded on the third week of August (33rd meteorological week) in which the minimum and maximum temperature was 22.9°C and 28.6°C with the relative humidity 91% in the morning and 83% in the evening. The insect population recorded was 0.67, 2.17, 1.00, 0.67, 0.83, 2.83 and 0.67 respectively.

The minimum population was recorded in fourth week of August (34th meteorological week) which is 0.50, 1.17, 0.67, 0.50, 0.67, 1.17 and 0.50 respectively. The minimum and maximum temperature was 22.5°C, 29.2°C and the relative humidity was 97% in the morning and 83% in the evening.

Average mean population of Cow pea pod borer in all treatments and replication was 0.58, 1.58, 0.79, 0.58, 0.62, 1.91 and 0.54 respectively.

Table 4.10. Population dynamics and frequency of the Cow pea pod borer

Treatment	Standard week			
	31	32	33	34
T1	0.50	0.67	0.67	0.50
T2	1.17	1.83	2.17	1.17
T3	0.67	0.83	1.00	0.67
T4	0.50	0.67	0.67	0.50
T5	0.50	0.50	0.83	0.67
T6	1.50	2.17	2.83	1.17
T7	0.50	0.50	0.67	0.50
SEm _±	0.20	0.24	0.27	0.17
CD	0.60	0.70	0.8	0.49
	S	S	S	S

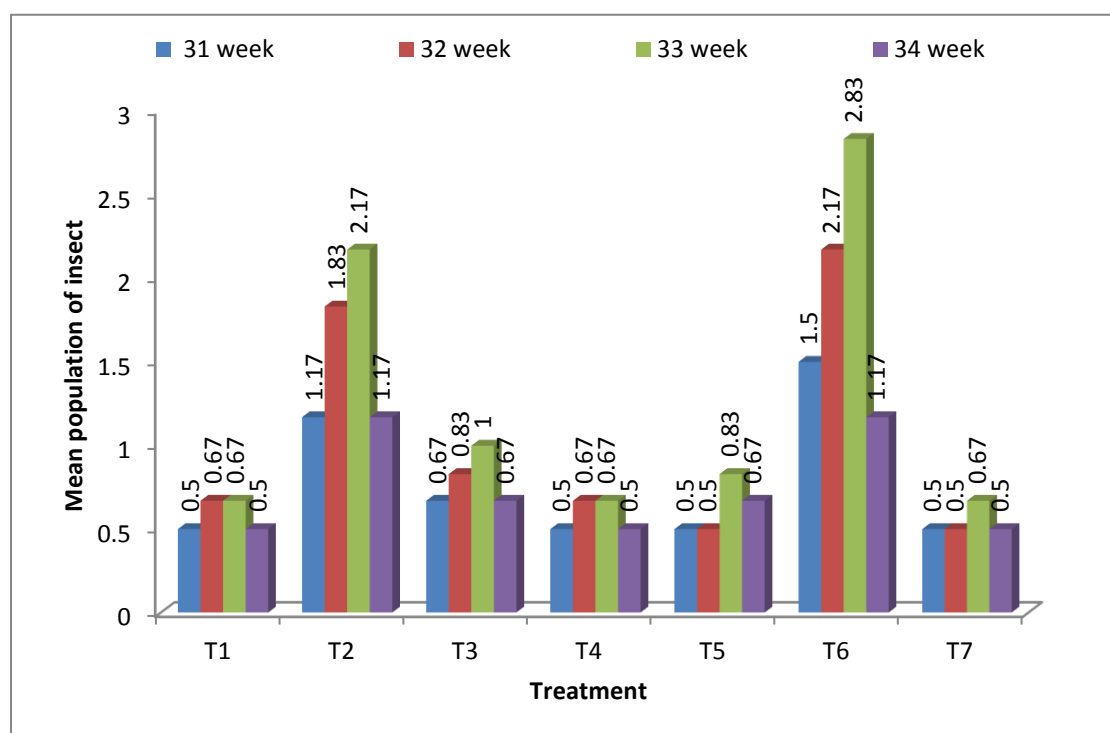


Figure 11 Population dynamics and frequency of the Cow pea pod borer

4.2.4.2 Hairy caterpillar *Spilosoma obliqua*

The Hairy caterpillar was observed during second week of July. The number of insect varied from block to block due to different treatment and replications.

Table 4.11. Shows the result of the population dynamics and frequency of the Hairy caterpillar which started from the second week of July (28th standard meteorological week) with the minimum and maximum temperature was 25.0°C, 31.4°C and the relative humidity was 82% in the morning and 64% in the evening. The average number of insect recorded was 0.50, 2.00, 0.50, 0.50, 0.50, 2.00 and 0.67 respectively.

The maximum population was recorded in the fourth week of July (30th meteorological week) in which the minimum and maximum temperature was 24.0°C and 32.3°C with the relative humidity 88% in the morning and 74% in the evening. The average number of insect population recorded was 0.80, 3.17, 0.83, 0.67, 0.67, 3.17 and 0.83 respectively.

The minimum population was recorded in second week of August (32nd meteorological week) which is 0.50, 1.33, 0.50, 0.50, 0.50, 1.50 and 0.50 respectively. The minimum and maximum temperature was 23.5°C , 29.9°C and the relative humidity was 92% in the morning and 81% in the evening.

The average mean population of Hairy caterpillar in all treatments and replication was 0.66, 2.29, 0.66, 0.53, 0.53, 2.26 and 0.63 respectively.

Table 4.11. Population dynamics and frequency of the Hairy caterpillar

Treatment	Standard week				
	28 week	29 week	30 week	31 week	32 week
T1	0.5	0.83	0.83	0.67	0.5
T2	2	2.67	3.17	1.83	1.33
T3	0.5	0.67	0.83	0.83	0.5
T4	0.5	0.5	0.67	0.5	0.5
T5	0.5	0.5	0.67	0.5	0.5
T6	2	2.5	3.17	2.17	1.5
T7	0.67	0.5	0.83	0.67	0.5
SEm _±	0.2	0.22	0.24	0.2	0.18
CD	0.59	0.66	0.7	0.6	0.53
	S	S	S	S	S

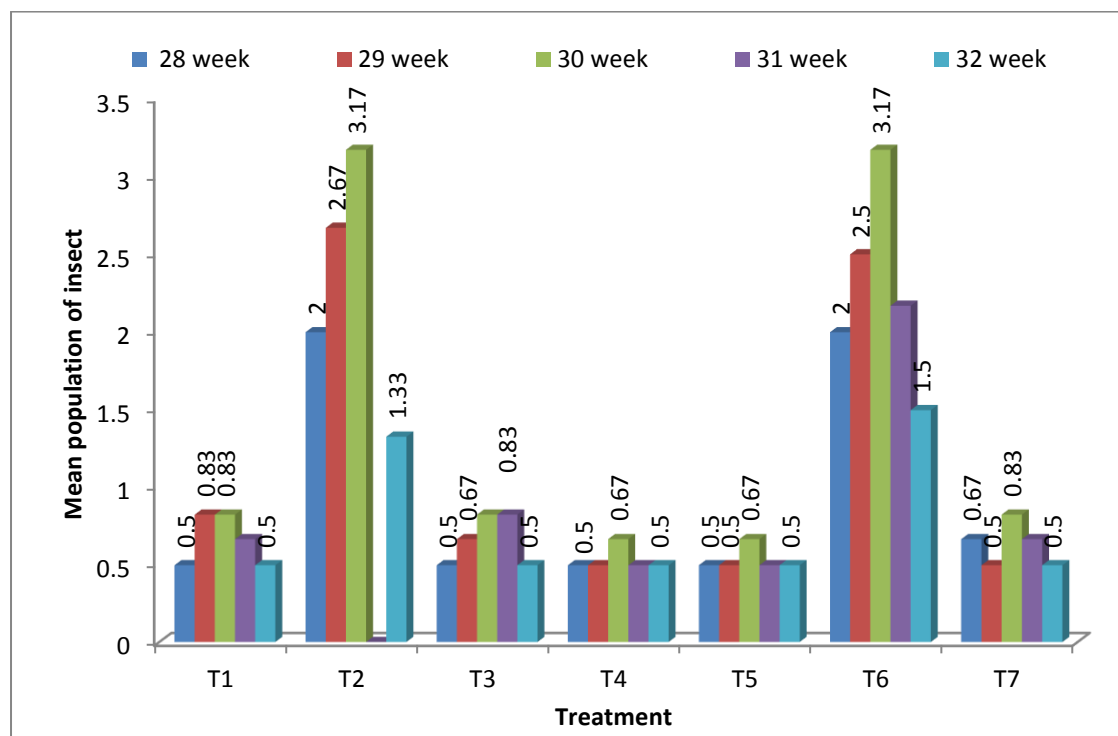


Figure 12 Population dynamics and frequency of the Hairy caterpillar.

4.3 Correlation studies of insect population with weather parameter.

Under this heading the correlation analysis was of insect population found in agrisilviculture system was done with the weather parameter. In this analysis we had observed the population of insect pest is positively or negatively associated with each other.

4.3.1 Correlation studies of *Gmelina arborea* insect population with weather parameter.

4.3.1.1 Khamer defoliator *Calopepla leayana*

The correlation analysis amongst the average population of Khamer defoliator *Calopepla leayana* was done with the weather parameter (Table 4.12).

The correlation analysis revealed that it had the highest positive correlation with average population of insect.

Table 4.12 Correlation studies of Khamer defoliator population with weather parameter.

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainy Days	Average Population of insect
	X2	X3	X4	X5	X6	X7	Y
X1 Max. Temperature	0.493	0.397	-0.751	0.008	-.935*	-0.287	-0.211
X2 Min. Temperature	-	0.106	-0.687	-0.510	-0.435	-0.758	-.916*
X3 Sunshine hrs.	-	-	0.114	-0.671	-0.574	-0.625	0.266
X4 Rainfall (mm)	-	-	-	-0.128	0.704	0.238	0.642
X5 Relative Humidity (Morning)	-	-	-	-	0.147	.932*	0.325
X6 Relative Humidity (Evening)	-	-	-	-	-	0.408	0.132
X7 Rainy Days	-	-	-	-	-	-	0.550

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

4.3.1.2 Sap sucker *Tingis beoni*

The correlation amongst the average population of sap sucker with weather parameter was found positive and significant (Table 4.13).

The correlation analysis found highest and positive with relative humidity.

Table 4.13 Correlation studies of Sap sucker with weather parameter

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainy Days	Average Population of insect
	X2	X3	X4	X5	X6	X7	Y
X1 Max. Temperature	0.434	0.657	-0.461	0.119	-0.788	-0.099	-0.457
X2 Min. Temperature	-	0.164	-0.668	-0.478	-0.449	-0.726	-0.601
X3 Sunshine hrs	-	-	0.138	-0.430	-0.577	-0.410	-0.435
X4 Rainfall (mm)	-	-	-	-0.114	0.668	0.246	0.027
X5 Relative Humidity (Morning)	-	-	-	-	0.107	0.933**	0.343
X6 Relative Humidity (Evening)	-	-	-	-	-	0.366	0.042
X7 Rainy Days	-	-	-	-	-	-	0.382

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

4.3.1.3 Bark eating caterpillar *Indarbela quadrinotata*

The correlation studies of average population of bark eating caterpillar was done with the weather parameter (Table 4.14). The following table of analysis showed the association of weather parameter with the average population of Bark eating caterpillar related to each other.

Table 4.14 Correlation studies of Bark eating caterpillar with weather parameter.

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainy Days	Average Population of insect
	X2	X3	X4	X5	X6	X7	Y
X1 Max. Temperature	0.678	0.619	-0.748	-0.586	-.949**	-0.536	-0.593
X2 Min. Temperature	-	0.354	-0.756	-0.685	-0.633	-.818*	-0.243
X3 Sunshine hrs	-	-	-0.140	-0.771	-0.712	-0.717	-0.134
X4 Rainfall (mm)	-	-	-	0.237	0.763	0.398	0.794
X5 Relative Humidity (Morning)	-	-	-	-	0.562	.912*	-0.140
X6 Relative Humidity (Evening)	-	-	-	-	-	0.587	0.706
X7 Rainy Days	-	-	-	-	-	-	-0.008

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

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

4.3.1.4 Defoliator *Eupterote geminate*.

The present study showed the correlation studies of Defoliator average population with the weather parameter. Table 4.15 revealed the average population of Defoliator had highest negative value (-0.947).

This analysis revealed the association of various weather parameter with the average population of Defoliator.

Table 4.15 Correlation studies of Defoliator with weather parameter

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainy Days	Average Population of insect
	X2	X3	X4	X5	X6	X7	Y
X1 Max. Temperature	0.801*	.858*	-0.728	-0.786*	-0.864*	- 0.651	0.236
X2 Min. Temperature	-	0.590	-.830*	-0.892**	-0.947**	- 0.808*	0.301
X3 Sunshine hrs	-	-	-0.379	-0.699	-0.769*	- 0.393	0.107
X4 Rainfall (mm)	-	-	-	0.561	0.677	0.565	-0.651
X5 Relative Humidity (Morning)	-	-	-	-	0.975**	0.858*	0.063
X6 Relative Humidity (Evening)	-	-	-	-	-	0.801*	-0.127
X7 Rainy Days	-	-	-	-	-	-	0.237

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

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

4.3.2 Correlation studies of Pigeon pea insect population with weather parameter.

4.3.2.1 Tur pod fly *Melanagromyza obtuse*

This analysis showed the relatibility of the average population of Tur pod fly with various weather parameter such as temperature, rainfall, sunshine hours and relative humidity respectively.

Table 4.16 Correlation studies of Tur pod fly with weather parameter.

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Average Population of insect
	X2	X3	X4	X5	X6	Y
X1 Max. Temperature	-0.146	0.594	-0.298	0.102	-0.232	0.406
X2 Min. Temperature	-	-0.810	0.628	0.408	.915*	0.216
X3 Sunshine hrs.	-	-	-0.366	0.039	-0.719	-0.246
X4 Rainfall (mm)	-	-	-	0.896*	0.812	-0.609
X5 Relative Humidity (Morning)	-	-	-	-	0.614	-0.621
X6 Relative Humidity (Evening)	-	-	-	-	-	-0.090

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

4.3.2.2 Plume moth *Exelastis atomosa*

The presented analysis revealed that Plume moth had negative association with minimum temperature, rainfall and the relative humidity.

Table 4.17 Correlation studies of Plume moth with weather parameter.

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Average Population of insect
	X2	X3	X4	X5	X6	Y
X1 Max. Temperature	-0.067	0.507	-0.761	0.213	-0.307	0.199
X2 Min. Temperature	-	-0.853*	0.679	-0.092	0.858*	-0.680
X3 Sunshine hrs.	-	-	-0.907*	0.018	-0.945**	0.812*
X4 Rainfall (mm)	-	-	-	-0.083	0.762	-0.629
X5 Relative Humidity (Morning)	-	-	-	-	-0.011	-0.535
X6 Relative Humidity (Evening)	-	-	-	-	-	-0.791

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

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

4.3.3 Correlation studies of Green gram insect population with weather parameter.

4.3.3.1 Gram pod borer *Helicoverpa armigera*

The analysis shown below (Table 4.18) between the average population of the Gram pod borer with the weather parameter. This was done to show the relativity of various parameter with the average population of Gram pod borer.

Table 4.18 Correlation studies of Gram pod borer with weather parameter.

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Average Population of insect
	X2	X3	X4	X5	X6	Y
X1 Max. Temperature	-0.372	0.901*	-0.472	-0.295	-0.572	-0.878
X2 Min. Temperature	-	-0.415	0.535	0.122	0.706	0.735
X3 Sunshine hrs.	-	-	-0.360	-0.359	-0.379	-0.748
X4 Rainfall (mm)	-	-	-	0.799	0.920*	0.634
X5 Relative Humidity (Morning)	-	-	-	-	0.507	0.230
X6 Relative Humidity (Evening)	-	-	-	-	-	0.820

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

4.3.3.2 Pod bug *Riptortus pedestris*

The analysis shown here between the average population of Pod bug with the weather parameter. This was done to show the association of Pod bug with the various weather parameter.

The analysis revealed that the average population had highest association negative association with the temperature.

Table 4.19 Correlation studied of Pod bug with weather parameter.

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainy Days	Average Population of insect
	X2	X3	X4	X5	X6	X7	Y
X1 Max. Temperature	-0.119	.912*	0.218	-0.402	-0.238	0.287	-.911*
X2 Min. Temperature	-	0.018	.940*	-0.591	0.875	.904*	-0.073
X3 Sunshine hrs.	-	-	0.291	-0.480	0.007	0.337	-0.712
X4 Rainfall (mm)	-	-	-	-0.697	0.759	.989**	-0.404
X5 Relative Humidity (Morning)	-	-	-	-	-0.245	-0.784	0.494
X6 Relative Humidity (Evening)	-	-	-	-	-	0.665	0.191
X7 Rainy Days	-	-	-	-	-	-	-0.482

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

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

4.3.4 Correlation studies of Cow pea insect population with weather parameter.

4.3.4.1 Cowpea pod borer *Maruca vitrata*

The below presented analysis of Cowpea pod borer showed that the average population of insect related with the various weather parameter.

This analysis revealed the association of average population of insect is positive or negative with the various weather parameter.

Table 4.20 Correlation studied of Cow pea pod borer with weather parameter

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainy Days	Average Population of insect
	X2	X3	X4	X5	X6	X7	Y
X1 Max. Temperature	0.639	-0.236	-0.625	0.085	-0.873	-0.148	-0.503
X2 Min. Temperature	-	0.007	-0.725	-0.510	-0.928	-0.750	-0.121
X3 Sunshine hrs.	-	-	0.684	-0.812	0.037	-0.616	.955*
X4 Rainfall (mm)	-	-	-	-0.186	0.701	0.124	0.745
X5 Relative Humidity (Morning)	-	-	-	-	0.329	.951*	-0.790
X6 Relative Humidity (Evening)	-	-	-	-	-	0.577	0.252
X7 Rainy Days	-	-	-	-	-	-	-0.561

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

4.3.4.2 Hairy caterpillar *Spilosoma obliqua*

The different weather parameter with the average population had negative correlation (Table 4.21)

Table 4.21 Correlation studied of Hairy caterpillar with weather parameter

Character	Min. Temperature	Sunshine hrs	Rainfall (mm)	Relative Humidity (Morning)	Relative Humidity (Evening)	Rainy Days	Average Population of insect
	X2	X3	X4	X5	X6	X7	Y
X1 Max. Temperature	0.705	.936*	-0.558	-0.783	-0.856	-0.590	0.646
X2 Min. Temperature		0.579	-0.658	-.948*	-.957*	-.932*	0.253
X3 Sunshine hrs.			-0.362	-0.638	-0.755	-0.400	0.409
X4 Rainfall (mm)				0.511	0.567	0.490	-0.613
X5 Relative Humidity (Morning)					.980**	.960**	-0.365
X6 Relative Humidity (Evening)						.899*	-0.368
X7 Rainy Days							-0.266

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

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

4.4 Effect of tree component on pest population.

The number of insects varied from block to block due to various parameters. The number of insect. The population of insect recorded was shown in different meteorological week according to their favourable condition of incidence in tree as well as in crop.

4.4.1. Overall mean population of insect-pest in agrisilviculture system.

The overall average population of the of insect found in *Gmelina arborea* bases agrisilviculture system is shown below in the Table-4.22.

Table 4.22 Overall mean population of insect-pest on *Gmelina arborea*.

Treatment	<i>Calopepla leayana</i>	<i>Tingis beesoni</i>	<i>Indarbela quadrinotata</i>	<i>Eupterote geminata</i>
T1	2.2	2.1	0.6	1.2
T2	1.59	1.64	0.77	1.13
T3	1.56	1.86	0.86	1.27
T4	2.3	3.1	1.1	1.7
T5	0.76	0.69	0.66	0.68
T6	0.79	0.72	0.64	0.66
T7	0.86	0.77	0.5	0.62

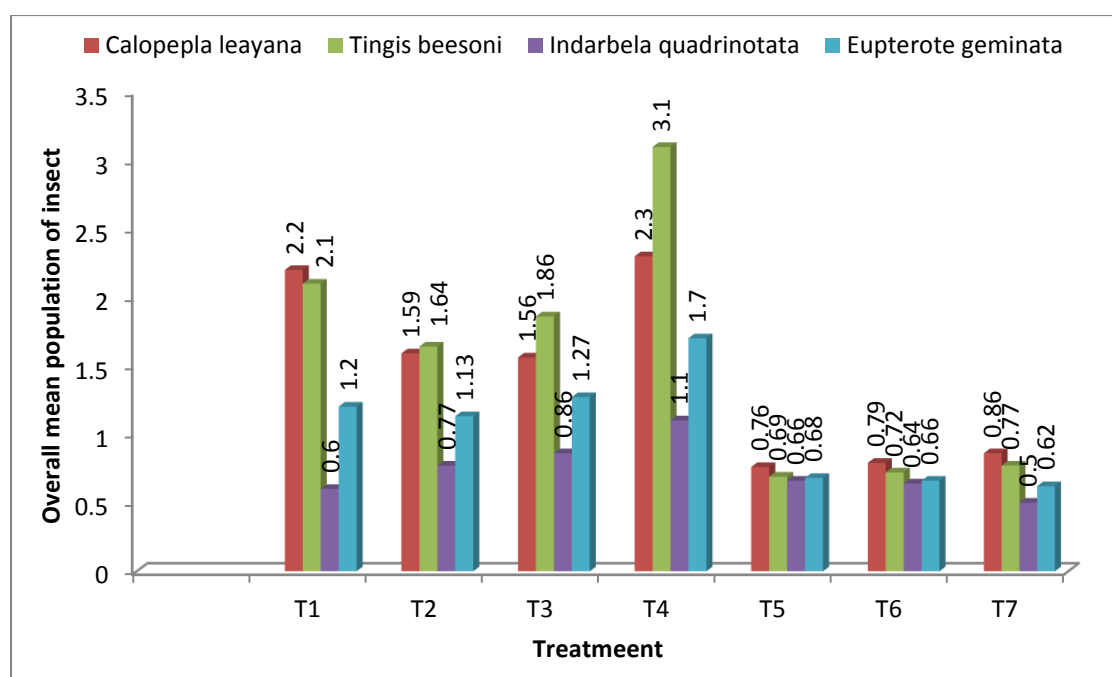


Figure 13 Overall mean population of insect-pest on *Gmelina arborea*.

The average population of insect found in the Pigeon pea under *Gmelina* based agrisilviculture system is shown below in the Table-4.23.

Table 4.23 Overall mean population of insect-pest on Pigeon pea

Treatment	<i>Melanagromyza obtusa</i>	<i>Exelastis atomosa</i>
T1	1.6	2.11
T2	0.73	0.8
T3	0.5	0.67
T4	0.63	0.5
T5	1.76	2.2
T6	0.5	0.69
T7	0.53	0.55

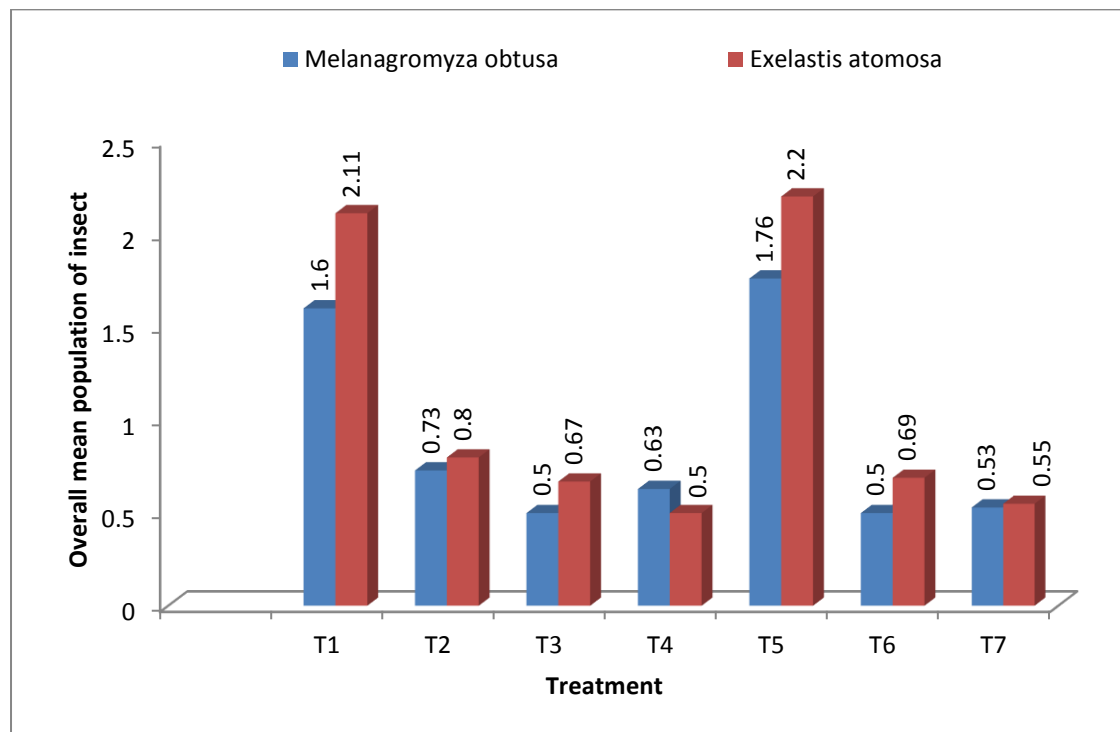


Figure 14 Overall mean population of insect-pest on Pigeon pea.

The overall mean population of the insect found in Green gram is shown below in the Table-4.24

Table 4.24 Overall mean population of insect-pest of Green gram.

Treatment	<i>Helicoverpa armigera</i>	<i>Riptortus pedestris</i>
T1	0.73	1
T2	0.86	0.96
T3	2.06	2.1
T4	0.66	0.76
T5	1.16	1.1
T6	0.86	1.3
T7	2.23	2.2

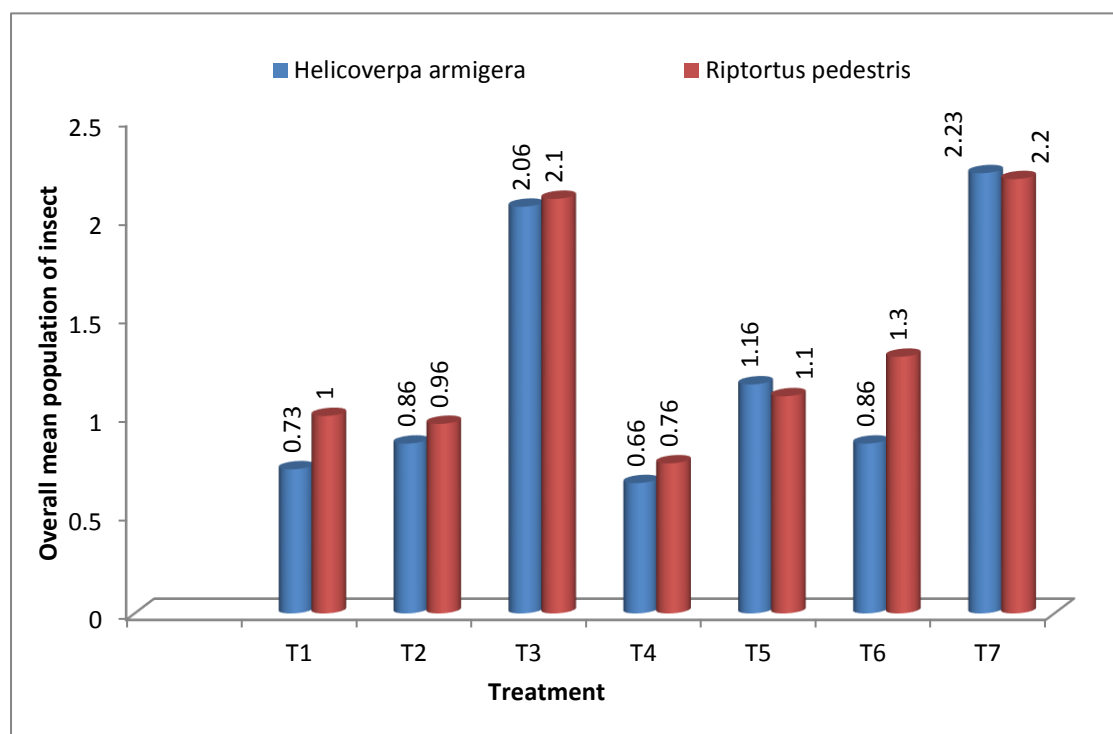


Figure 15 Overall mean population of insect-pest of Green gram.

The overall mean population of insect found in Gemlina based agrisilviculture is shown below in the Table-4.25

Table – 4.25 Overall mean population of insect-pest of Cowpea.

Treatment	<i>Maruca vitrata</i>	<i>Spilosoma obliqua</i>
T1	0.58	0.66
T2	1.5	2.2
T3	0.79	0.66
T4	0.58	0.53
T5	0.6	0.53
T6	1.9	2.2
T7	0.54	0.63

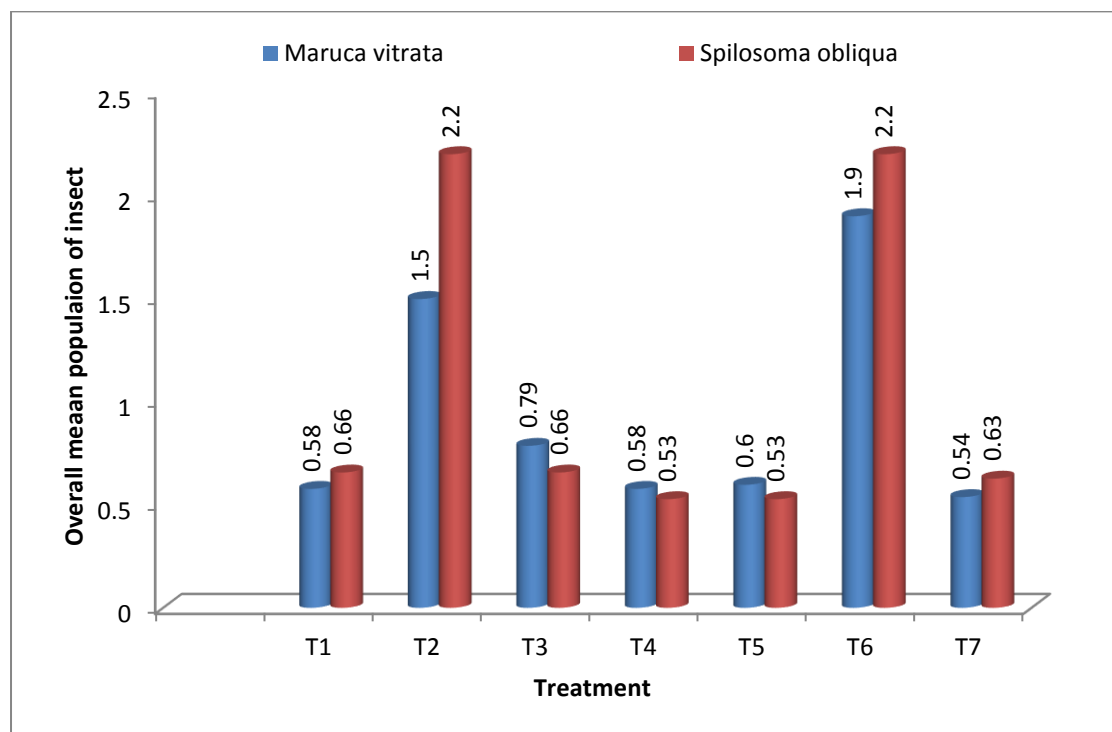


Figure 16 Overall mean population of insect-pest of Cowpea.



Plate 1 Over view of the experimental field (agrisilviculture system)



Plate 2 Handling & Collection of insect-pest under agrisilviculture system.



Second instar stage



Adult khamer defoliator



Bark eating caterpillar



Damaged part of the tree



Sap sucker (*Tingis beesonii*)



Defoliator (*Euterote geminate*)

Plate 3 Various insect-pest of *Gmelina arborea* under agrisilviculture system.



Tur pod fly (*Melanagromyza obtusa*)



Plume moth (*Exelastis atomosa*)



Gram pod borer (*Helicoverpa armigera*)



Pod bugs (*Riptortus pedestris*)



Cowpea pod borer (*Maruca vitrata*)



Hairy caterpillar (*Spilosoma obliqua*)

Plate 4 Various insect-pest of crop under agrisilviculture system.

Chapter-V

DISCUSSION

DISCUSSION

The experiment conducted on the “**Diversity and visitation frequency of major insect pest population under *Gmelina arborea* based Agrisilviculture system**” was done during the year 2019-20 in kharif season at Forestry research farm, New Dusty Acre area, Department of Forestry, College of Agriculture, J.N.K.V.V, Jabalpur. Discussion refers to the seasonal incidence, nature of damage and population dynamics of insect pest under agrisilviculture system.

Insect-pests are the utmost important group of organisms causing harmful effect to plants in agroforestry systems. Therefore, the management of insect-pests in agroforestry systems is pivotal to sustained production, and even farmers have considered this as a leading issue for agroforestry research.

An agroforestry system has the insect pest which are of its one of the components either from crops or from woody perennials. The dynamics of insect pests and their natural enemies are governed by the complexity and composition of the agroforestry system. The pest situation in these systems will be influenced by the degree of interaction between the components.

Research involving agrisilviculture system in agroforestry, however, suggests that vegetation diversity result in significant reduction of insect-pest problem. Woody perennials also affect pest infestations by acting as barriers for the movement of insects, masking the odours emitted by other components of the system and sheltering herbivores and natural enemies.

5.1 Identification and quantitative assessment of pest damage in *Gmelina arborea* plantation during 2019-20.

On *Gmelina arborea*

- Khamer defoliator *Calopepla leayana* (Coleoptera : Chrysomelidae)
- Sap sucker *Tingis beeoni* (Hemiptera:Tingidae)
- Bark eating caterpillar *Indarbela quadrinotata* (Lepidoptera: Indarbelidae)
- Defoliator *Eupterote geminata* (Lepidoptera:Eupterotidae)

On Pigeon pea *Cajanus cajan* (L.)

- Tur pod fly *Melanagromyza obtuse* (Diptera:Agromyzidae)
- Plume moth *Exelastis atomosa* (Lepidoptera: Pterophoridae)

On Green gram *Vigna radiate* (L.)

- Gram pod borer *Helicoverpa armigera* (Lepidoptera: Noctuidae)
- Pod bug *Riptortus pedestris* (Hemiptera : Coreidae)

On Cowpea *Vigna unguiculata* (L.)

- Cowpea pod borer *Maruca vitrata* (Lepidoptera: Crambidae)
- Hairy caterpillar *Spilosoma obliqua* (Lepidoptera: Erebidae)

5.1.1 Identification and quantitative assessment of pest damage in *Gmelina arborea* plantation.

Identification and quantitative assessment of Khamer defoliator *Calopepla leayana* which is one of the major insect started from 1st week of August to 1st week of September. The minimum and maximum temperature was 23.9⁰C, 29.6⁰C and relative humidity was 93% in the morning and 81% in evening. Similar results were also reported by Mathur RN and Singh B (1960). *Calopepla leayana* is the most destructive defoliator. Singh *et al.*, (2006) revealed that *Calopepla leayana* need to be reared on the large scale in the laboratory for the mass multiplication of its natural enemies. For maintaining the laboratory culture of *C. leayana* adults and eggs to be collected from the respective field stations and reared in the laboratory at room temperature 28±2⁰C and 70-80% RH. Tripathy MK and Dandapat B(2020) from Odisha reported that *Calopepla leayana* is the major defoliator of this species recorded at Bhubaneswar during the study period (2017-18). Out of the total 22 species recorded 10 species were foliage feeders(47.61%), 8 species were sap feeders (38.09%), one species each from shoot borer (4.76%) and bark feeder, and 2 species were recorded as root and bark feeders (9.52%). Gambhar defoliator larval population in leaves was first noticed during June 2018 with peak population recorded during 1st fortnight of September 2017(9.30/leaf) after which a downward trend was recorded up to November 1st fortnight 2017.

Sap sucker which appeared from the first week of August to first week of September with the minimum and maximum temperature was 23.9°C, 29.6°C and the relative humidity was 93% in the morning and 81% in the evening. It leads to the top dying of the tree. In this context similar work was conducted by Meshram PB and Bhowate S (2017). Plantation of *Gmelina arborea* is facing the great problem of major insect pest i.e. sap sucker / lace bug *Tingis beesoni* (Drake) resulting in top dying of shoots in tropical forest of Madhya Pradesh. The nymphs and adults of bug feed entirely at the base of leaf blade on the under surface and the leaf axils.. The shoot dry up, turn black and sooty mould grows all over plants leading to the top dying. The results revealed that lace bug; *T. beesoni* was responsible for causing the top dying of *G. arborea*.

Bark eating caterpillar which was first time observed from fourth week of July upto first week of September. The minimum and maximum temperature was 24.0°C, 32.3°C with the relative humidity of 88% in the morning and 74% in the evening. In this context similar work was conducted by Sasidharan KR and Varma RV (2008). Seasonal population variations of the bark eating caterpillar (*Indarbela quadrinotata*) in casuarinas plantation of Tamil Nadu. Kumar *et al.* (2020) done the work related to bark eating caterpillar. Estimating Bark Eating Caterpillar *Indaebela quadrinotata* in *Populus deltoids* using Ranked set sampling.

Defoliator *Eupterote geminate* observed on first week of July upto 3rd week of August with the minimum and maximum temperature was 23.1°C, 29.9°C and the relative humidity was 94% in the morning and 87% in the evening. The similar work is done by Sheik and Kalita (1995) reported the heavy infestation on *Gmelina arborea* in Assam.

5.1.2 Identification and quantitative assessment of pest damage in agricultural crops.

5.1.2.1 Pigeon pea

Tur pod fly *Melanagromyza obtuse* was recorded in the 3rd week of October upto 3rd week of November with the minimum and maximum temperature and the relative humidity was 93% in the morning and 63% in the

evening. Similar result was carried out by Srinivas *et al.*, (2019) revealed that The larval population of pod fly recorded in organic and conventional farming systems revealed that activity commenced from 14 WAS (44th SMW), which continued till 31 WAS (8th SMW) indicating their peaks (36.00 and 30.96 larvae/ 50 pods) at 4th SMW (27 WAS), the population however declined later indicating their lowest levels (0.94. Pandey *et al.*, (2016) The present study was aimed at observing the incidence pattern of pod fly and pod bug in pigeonpea ecosystem. The first appearance of pod fly *M. obtusa* was noticed in the 42 standard week with a mean population of 0.10 maggot/Plant whose maggot population peaked in 45 standard weeks with a mean population of 0.30 maggot/ Plant during year 2010-11..

Plume moth *Exelastis atomosa* was observed during fourth week of October upto last week of November. The minimum and maximum temperature of 19.1°C and 27.1°C and the relative humidity of 92% in the morning and 60% in the evening. The similar experiment was laid down by Lal *et al.*, (2019).Biology and morphometrics of pigeonpea plume moth, *E. atomosa* (Wals.) on pigeonpea variety viz., Saket was studied during Kharif-2018 at the under laboratory condition RVSKVV, Gwalior (M.P.) at the room temperature 28±2°C and relative humidity 72±2 per cent from October to November. Eggs were laid in singly on the pods sometimes on flower buds and occasionally on leaves of 5-50 eggs. The finding was including incubation period was ranged from 2-3 days with an average of 2.60±0.16 days. Eggs were measured 0.44±0.01, 0.34±0.01 mm in length and width. There were five larval instars with total larval duration ranged from 15-18 days with an average of 16.70±0.40 days to enter into pupal stage. The pupal period ranged from 6-9 days with an average of 7.30±2.01 days and measured ranged from 7.90-8.30 mm, 1.65-1.85 mm with an average of 8.12±0.04, 0.1.74±0.02 mm in length and width, respectively. Total life of *E. atomosa* was completed ranged in 31-36 days with an average of 34.10±0.66 days.

5.1.2.2 Green gram

Gram pod borer *Helicoverpa armigerawas* observed on the second week of October upto second week of November with the minimum and maximum temperature was 18.0°C, 30.3°C and the relative humidity was 91

%in the morning and 56%in the evening. In this context the similar result was shown by Pawar *et al.*, (2015) A field experiment was conducted at experimental field of Deptt. of Entomology, Live-stock Farm, Adhartal, J.N. Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during kharif season 2009-2010.It was observed that pod borer, *Helicoverpa armigera* (Hub.), start the infesting the crop during the reproductive stage i.e. 44 SW and 45 SW (0.01 eggs/plant and 0.35 larvae/plant) and population stock the pests egg and larva available up to maturity stage i.e. 01 SW (1.8 eggs/plant and 0.15 larvae/plant). Two natural the enemies, predatory lady bird beetle, *Cheilomenes sexmaculatus* Fab. were active in vegetative i.e. 38 SW (0.56 the beetles/plant) to 44 SW (0.08 beetles/plant) and larval parasitoid of Lepidoptera Cotesia (= Apanteles) sp wasp pupae during theand late reproductive i.e. 50 SW (2 pupae/25pods) to 52 SW (3 pupae/25pods) growth phase of the crop respectively. Correlation studies shown that pod borer ovi position favored positively by morning relative humidity while maximum and minimum temperature and morning vapour pressure impact it negatively. Among the various abiotic factors studied minimum temperature, rainfall, evening relative humidity, wind speed, morning and evening vapour pressure, and rainy days exerts significant positive whereas sunshine significant negative impact on incidence of lady bird beetles in pigeonpea.

Pod bug *Riptortus pedestris* was observed during first week of October upto first week of November. The minimum and maximum temperature was 21°C and 30.1°C with the relative humidity of 90% in the morning and 66%in the evening. The same study was done by Reddy *et al.*(2017) The present study was carried out to find the correlation between seasonal incidence of leaf footed bug, *Riptortus pedestris* with weather variables during kharif 2015-16 and kharif 2016-17 respectively. The data on the seasonal incidence of leaf footed bug, *R. pedestris* was recorded from third week of October during 42nd standard week to 4th standard week in kharif 2015 –16. The highest incidence of *R. pedestris* population was observed with two peaks i.e., once at 47th standard week (3rd week of November) and second one at 49th standard week (1st week of December) with 3.5 and 3.8 bugs per plant, respectively. Correlation studies between the population of leaf footed bug, *R. pedestris* with preceding one week (one week lag) weather parameters during

kharif 201516 revealed that there was a negative significant correlation with maximum temperature (-0.512*) and evaporation (-0.510*) at 5 % level of significance whereas significant positive correlation with morning relative humidity (0.071*) at 5 % level of significance.

5.1.2.3 Cowpea

Cowpea pod borer *Maruca vitrata* was first observed during first week of August upto last week of August. The minimum and maximum temperature was 23.9°C, 29.6°C and the relative humidity was 93% in the morning and 81% in the evening. The same result was found in the investigation done by Singh C and Singh NN (2014). The field experiment was carried out during cropping seasons of zaid , 2009-10 and 2010-11. The correlation and regression coefficients showed both positive and negative relationships of insect-pests infesting cowpea and their natural enemies with existing weather variables.

Hairy caterpillar *Spilosoma oblique* was observed during second week of July upto second week of August with the minimum and maximum temperature was 25.0°C, 31.4°C and the relative humidity was 82% in the morning and 64% in the evening. In this context same survey was done by Pudasini (2020). Bihar hairy caterpillar (*Spilosoma obliqua*) is a serious polyphagous insect pest. An experiment was conducted to determine the host preference of Bihar hairy caterpillar in Entomology laboratory, Lamjung Campus at room temperature from March to April, 2019. The experiment was conducted in CRD with seven treatments namely; Cotton (*Gossypium hirsutum*), Cauliflower (*Brassicae oleraceae* var. botrytis), Cabbage (*Brassicae oleraceae* var. capitata), Broccoli (*Brassicae oleraceae* var. italica), Mulberry (*Morus alba*), Castor (*Ricinus communis*), Broad bean (*Vicia faba*).

Chapter-VI
SUMMARY, CONCLUSION AND
SUGGESTION FOR FURTHER WORK

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORK

Present investigation on “Diversity and visitation frequency of major insect pest population under *Gmelina arborea* based Agrisilviculture system” was carried out during the year 2019-20 in Kharif season at Forestry research farm, New Dusty Acre area, Department of Forestry, College of Agriculture, J.N.K.V.V, Jabalpur. The obtained result in the present study are presented in this chapter under following heads:

1. Identification and quantitative assessment of pest damage in *Gmelina arborea* plantation.
2. Association analysis of insect-pest incidence with tree-crop component.
3. Correlation studies of insect population with weather parameters.

6.1 Summary

The present investigation revealed total ten insects of four order under agrisilviculture system in which one insect of Coleoptera eg. Khamer defoliator (*Calopepla leayana*), two insect of Hemiptera eg. Sap sucker (*Tingis beesonii*) and Pod bug (*Riptortus pedestris*) and one insect was of Diptera eg. Tur pod fly (*Melanagromyza obtusa*). Six insect was observed of Lepidoptera eg. Bark eating caterpillar (*Indarbela quadrinotata*), Defoliator (*Eupterote geminata*), Plume moth (*Exelastis atomosa*), Gram pod borer (*Helicoverpa armigera*), Cowpea pod borer (*Maruca vitrata*), Hairy caterpillar (*Spilosoma obliqua*).

6.2 Conclusion

On the basis of result the following conclusions are drawn from the present investigation.

1. The insect pest species observed on *Gmelina arborea* were Khamer defoliator (*Calopepla leayana*), Sap sucker (*Tingis beesonii*), Bark eating caterpillar (*Indarbela quadrinotata*), Defoliator (*Eupterote geminata*).
2. The insect pest species observed on agricultural crop were Tur pod fly (*Melanagromyza obtusa*), Plume moth (*Exelastis atomosa*), Gram pod

borer (*Helicoverpa armigera*), Pod bug (*Riptortus pedestris*), Cowpea pod borer (*Maruca vitrata*) and Hairy caterpillar (*Spilosoma obliqua*).

3. The number of insects varied from treatment to treatment due to various biotic and abiotic factors such as tree shade and various weather parameter. The correlation studies showed that relevance of the weather parameter with average insect population.
4. Maximum average population of insect was found on the sole block of tree and crop in their respective number of treatment.

6.3 Suggestion for further work

During the period of investigation, some of the facts came through which needs further research and detailed investigation that must be needed to done. Some of the important suggestions are:

- Present analysis gives the knowledge about insect-pest population of tree which one of the important emerging species of timber yielding.
- The detail survey should be carried out on biological control measures of the insect-pest of agrisilviculture system.
- The investigations on predators, parasites and parasitoids should be done more intensively to reduce the losses of farmer.
- This investigation should be done on the large scale to aware the farmers regarding the benefits of agroforestry systems.
- This survey should be further continued to save the deforestation and increase the plantation of one of the important timber tree.

Chapter-VII

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APPENDICES

APPENDICES

Appendix– I Population dynamics of insect-pest communities in *Gmelina arborea* plantation during 2019-2020.

S. No.	Common Name	Scientific Name	Order	Family
<i>Gmelina arborea</i>				
1.	Khamer defoliator	<i>Calopepla leayana</i>	Coleoptera	Chrysomelidae
2.	Sap sucker / Lace bug	<i>Tingis beelsoni</i>	Hemiptera	Tingidae
3.	Bark-eating caterpillar	<i>Indarbela quadrinotata</i>	Lepidoptera	Indaebelidae
4.	Defoliator	<i>Eupterote geminata</i>	Lepidoptera	Eupterotidae

Appendix–II Population dynamics of insect-pest communities in agrisilviculture system system during 2018 – 19.

S. No.	Common Name	Scientific Name	Order	Family
Pigeon pea				
1.	Tur pod fly	<i>Melanagromyza obtusa</i>	Diptera	Agromyzidae
2.	Plume moth	<i>Exelastis atomosa</i>	<i>Lepidoptera</i>	Pterophoridae
Green gram				
1.	Gram pod borer	<i>Helicoverpa armigera</i>	Lepidoptera	Noctuidae
2.	Pod bugs	<i>Riptortus pedestris</i>	Hemiptera	Coreidae
Cow pea				
1.	Cowpea pod borer	<i>Maruca vitrata</i>	Lepidoptera	Crambidae
2.	Hairy caterpillar	<i>Spilosoma obliqua</i>	Lepidoptera	Erebidae

Appendix– III Overall mean population of insect-pest at different pruning intensities in agrisilviculture system.

Appendix – III (a)

Treatment	<i>Calopepla leayana</i>	<i>Tingis beelsoni</i>	<i>Indarbela quadrinotata</i>	<i>Eupterote geminata</i>
T1	2.2	2.1	0.6	1.2
T2	1.59	1.64	0.77	1.13
T3	1.56	1.86	0.86	1.27
T4	2.3	3.1	1.1	1.7
T5	0.76	0.69	0.66	0.68
T6	0.79	0.72	0.64	0.66
T7	0.86	0.77	0.5	0.62

Appendix – III (b)

Treatment	<i>Melanagromyza obtusa</i>	<i>Exelastis atomosa</i>
T1	1.6	2.11
T2	0.73	0.8
T3	0.5	0.67
T4	0.63	0.5
T5	1.76	2.2
T6	0.5	0.69
T7	0.53	0.55

Appendix – III (c)

Treatment	<i>Helicoverpa armigera</i>	<i>Riptortus pedestris</i>
T1	0.73	1
T2	0.86	0.96
T3	2.06	2.1
T4	0.66	0.76
T5	1.16	1.1
T6	0.86	1.3
T7	2.23	2.2

Appendix – III (d)

Treatment	<i>Maruca vitrata</i>	<i>Spilosoma obliqua</i>
T1	0.58	0.66
T2	1.5	2.2
T3	0.79	0.66
T4	0.58	0.53
T5	0.6	0.53
T6	1.9	2.2
T7	0.54	0.63

Appendix– IV ANOVA for maximum population of Khamer defoliator under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	0.38	0.13	0.18	2.45
reatment	7	93.14	13.31	19.27	2.18
Error	12	8.29	0.69		
Total	22	101.81			

Appendix–V ANOVA for maximum population of Sap sucker under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	0.29	0.10	0.10	2.45
Treatment	7	90.67	12.95	14.07	2.18
Error	12	11.05	0.92		
Total	22	102.00			

Appendix –VI ANOVA for maximum population of Bark eating caterpillar under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	0.29	0.10	0.14	2.45
Treatment	7	7.62	1.09	1.56	2.18
Error	12	8.38	0.70		
Total	22	16.29			

Appendix– VII ANOVA for maximum population of Defoliator under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	1.52	0.51	0.85	2.45
Treatment	7	30.57	4.37	7.34	2.18
Error	12	7.14	0.60		
Total	22	39.24			

Appendix–VIII ANOVA for maximum population of Tur pod fly under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	1.24	0.41	1.79	2.45
Treatment	7	35.24	5.03	21.87	2.18
Error	12	2.76	0.23		
Total	22	39.24			

Appendix–IX ANOVA for maximum population of Plume moth under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	0.10	0.03	0.06	2.45
Treatment	7	80.29	11.47	20.94	2.18
Error	12	6.57	0.55		
Total	22	86.95			

Appendix– X ANOVA for maximum population of Gram pod borer under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	1.24	0.41	0.61	2.45
Treatment	7	71.33	10.19	15.11	2.18
Error	12	8.10	0.67		
Total	22	80.67			

Appendix–XI ANOVA for maximum population of Pod bug under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	1.24	0.41	0.39	2.45
Treatment	7	72.95	10.42	9.80	2.18
Error	12	12.76	1.06		
Total	22	86.95			

Appendix–XII ANOVA for maximum population of Cowpea pod borer under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	0.67	0.22	0.50	2.45
Treatment	7	55.24	7.89	17.76	2.18
Error	12	5.33	0.44		
Total	22	61.24			

Appendix– XIII ANOVA for maximum population of Hairy caterpillar under agrisilviculture system.

ANOVA Table					
Source	DF	SS	MS	F cal	F tab.
Replication	3	2.67	0.89	2.67	2.45
Treatment	7	99.14	14.16	42.49	2.18
Error	12	4.00	0.33		
Total	22	105.81			

CURRICULUM VITAE

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Date of Birth: 19th January 1995



The author of this thesis Arpana Sharma D/o Mr. Gopal Krishna Singh and Mrs. Rajmanti Devi was born on 19 January 1995 at Ranchi (Jharkhand). She has joined the following institution and successfully completed the degree of M.Sc. (Forestry) during the year 2019-20.

S. No.	Degree's granted	Institution	University/ Board	Year
1.	M.Sc. (Forestry)	College of Agriculture, Jabalpur	JNKVV, Jabalpur	2020
2.	B.Sc. (Forestry)	SHUATS	Naini, Allahabad	2018
3.	12 th	Central academy, Ranchi	CBSE	2013
4.	10 th	D.A.V, Piparwar	CBSE	2010

For the partial fulfillment of the master's degree programme. She was allotted a research problem "Diversity and visitation frequency of major insect pest population under Gmelina arborea based Agrisilviculture system" which was successfully conducted by her and being submitted in the form of the thesis.