STUDIES ON SEASONAL INCIDENCE OF PEST COMPLEX OF CASTOR WITH SPECIAL REFERENCE TO *Conogethes punctiferalis* AND ITS MANAGEMENT WITH CHEMICALS

By

R. NAVEEN, B.Sc.

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ACHARYA N.G. RANGA AGRICULTURAL UNIVERISTY
TIRUPATI – 517 502. (A.P.) INDIA

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CERTIFICATE

Mr. R. NAVEEN *has satisfactorily prosecuted the course of research and that the thesis entitled* **"STUDIES ON SEASONAL INCIDENCE OF PEST COMPLEX OF CASTOR WITH SPECIAL REFERENCE TO *Conogethes punctiferalis* AND ITS MANAGEMENT WITH CHEMICALS"** *submitted is the result of original research work and of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.*

Date :

Place :

(Dr. K.V. HARI PRASAD)
Major Advisor

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON SEASONAL INCIDENCE OF PEST COMPLEX OF CASTOR WITH SPECIAL REFERENCE TO *Conogethes punctiferalis* AND ITS MANAGEMENT WITH CHEMICALS"** *submitted in partial fulfillment of the requirements for the degree of "**MASTER OF SCIENCE IN AGRICULTURE**" of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by* **Mr. R. NAVEEN** *under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.*

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

(Dr. K.V. HARI PRASAD)
Chairman of the Advisory Committee

Thesis approved by the Student's Advisory Committee

Chairman : **(Dr. K.V. HARI PRASAD)** ____________________
Assistant Professor
Department of Entomology
S.V. Agricultural College
TIRUPATI – 517 502

Member : **(Dr. K. SREEDEVI)** ____________________
Assistant Professor
Department of Entomology
S.V. Agricultural College
Tirupati – 517 502

Member : **(Dr. K. BALAKRISHNA REDDY)** ____________________
Professor
Dept. of Plant Physiology
S.V. Agricultural College
Tirupati – 517 502

DECLARATION

I **Mr. R. NAVEEN** hereby declare that the thesis entitled **"STUDIES ON SEASONAL INCIDENCE OF PEST COMPLEX OF CASTOR WITH SPECIAL REFERENCE TO *Conogethes punctiferalis* AND ITS MANAGEMENT WITH CHEMICALS"** submitted to Acharya N.G. Ranga Agricultural University, Hyderabad for the degree of **MASTER OF SCIENCE IN AGRICULTURE** is the result of original research work done by me. I also declare that the material contained in this thesis has not been published earlier.

Date: **(R. NAVEEN)**

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
@	:	At the rate of
<	:	Less than
>	:	Greater than
a.i	:	Active ingredient
cm	:	Centimeter
DAG	:	Days after germination
DAT	:	Days after treatment
DOR	:	Directorate of Oilseeds Research
et al.,	:	And others
Fig.	:	Figure
g	:	Gram
ha	:	Hectare
i.e	:	That is
K	:	Potassium
Kg	:	Kilogram
lt	:	Litre
m	:	Meter
m^2	:	Square meter
ml	:	Milliliter
MT	:	Metric tonnes
N	:	Nitrogen
P	:	Phosphorus
RBD	:	Randomized block design
S. No.	:	Serial Number
spp	:	Species
Var.,	:	Variety
viz.,	:	Namely

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University	:	Acharya N.G. Ranga Agricultural University
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ABSTRACT

Field studies on incidence of insect pest complex of castor, management of major insect pest *Conogethes* (*Dichocrosis*) *punctiferalis* (Guenee) with certain new insecticides and screening of certain castor genotypes for their reaction to leafhoppers and defoliators were carried out during rabi 2008 at S.V. Agricultural College, Tirupati.

Castor crop (Var., Jyothi) was sown three times at fortnightly intervals starting from December 20th 2008 to assess seasonal incidence of different insect pests, trials on evaluation of insecticides against shoot and capsule borer *C. punctiferalis* and screening castor genotypes for their reaction to leafhoppers and defoliators were sown on December 20th 2008 and January 5th 2009, respectively.

Infestation by pests such as leafhoppers and leafminer increased with age of the crop and the population gradually declined in all sowings. Peak infestation of leafhoppers was observed in third week of March at 71 DAG in 2nd sowing (January 5th). High incidence of leaf miner was noticed in 2nd week of March at 64 DAG in 1st sowing (December 20th). Incidence of castor butterfly was high during third week of February at 43 DAG in 1st sowing (December 20th). Maximum incidence of thrips was recorded in 1st sowing (December 20th) at 99 DAG on 2nd week of April. High incidence of whitefly was noticed in first week of May at 99 DAG on 3rd sowing (January 20th). In case of shoot and capsule borer, peak per cent infestation of capsule was recorded on first week of April at 5 DAG in 2nd sowing (January 5th) and maximum incidence of red spider mites was recorded in 1st sowing (December 20th) at 85 DAG i.e. on first week of April.

The correlation was positive and significant for leafhoppers, whitefly, shoot and capsule borer, thrips and whitefly for mean maximum temperature/minimum temperature whereas for castor butterfly population negative and non significant correlation was noticed. The pest population of whitefly, thirps, leaf miner, castor butterfly and shoot and capsule borer exhibited negative and significant effect with relative humidity while leafhoppers exhibited negative correlation with significant effect.

Flubendiamide @ 0.1% and emamectin benzoate @ 0.003% were found to be highly effective against capsule borer, while lambda-cyhalothrin @ 0.003% was less effective.

The genotypes GCH 4 and PCS 171 exhibited high resistance to leafhopper injury while the genotypes Jyothi (DCS 9) and DPC 9 were highly susceptible. The genotypes PCH 222, GCH 4, PCS 95 and Jwala exhibited certain degree of resistance while genotypes PCS 170 and Haritha (PCS 124) are highly susceptible to defoliator damage.

CHAPTER - I

INTRODUCTION

Castor (*Ricinus communis L.*) is an important non-edible oilseed crop of the family Euphorbiaceae which occupies an important role in the country's vegetable oil economy.

Castor oil is mainly used for manufacture of wide range of ever expanding industrial products *viz.,* dye, detergents, plastics, printing ink, ointment, polishes, surface paints, adhesives, lubricants and hydraulic fluids.

India, ranks first among castor producing countries in the world with 68 per cent of area and 76 per cent of world castor production. Castor occupies an area of 7.43 lakh ha of arable land in India, with a production of 1 million tonnes and productivity of 1010 kg/ha (Ministry of Agriculture, Government of India. 2007-08).

India exported 0.17 million MT of castor oil earning Rs. 757.28 crores as foreign exchange in 2007-08. In the last 25 years, the total production of castor rose from 0.31 to 1.01 million tonnes while the productivity level increased from 556 to 1010 Kg/ha, with wide regional disparities in the productivity of castor.

Castor is grown in almost all the states in India, of which Gujarat, Andhra Pradesh, Tamilnadu, Rajasthan and Karnataka are important. Gujarat alone contributes 67 per cent of total country's production. Andhra Pradesh occupies second position in the country in terms of area and production i.e. 3.58 lakh ha and 1.29 lakh tones, respectively. (Ministry of Agriculture, Govt. of India. 2007-08).

Although 60 insect pests are recorded on castor, only half a dozen of them are of potential threat as sucking pests, foliage feeders and capsule borers. With the introduction of number of high yielding varieties and hybrids during the past two decades the pest scenario has changed aggravating the problem of sucking pests *viz*., leafhoppers, whitefly and thrips (Vijay Sing *et al.*, 1993).

A number of species of leafhoppers infest castor and among them *Empoasca kerri* Pruthi is an important species in south India. Among major lepidopteran pests, the castor shoot and capsule borer, *Conogethes punctiferalis* (Guen). is an important one as it reduces the yield of castor considerably by boring into tender shoots and capsules. It has been reported to damage 4-10 per cent of inflorescences and 16-82 per cent spikes of castor, thus reducing the yield by 9-23 percent (David *et al.*, 1964). Losses to an extent of 174 kg/ha have also been reported by Shah *et al.*, 1972.

The concept of pest management embodies the idea that knowledge of pest ecology is essential for appropriate control strategies. Information on incidence of different pests of castor at different growth stages of the crop and its relation with weather parameters will be of great help to adopt appropriate control measures.

Pesticides continue to be one of the most powerful tools available for the control of pests and increasing crop yield in oil seed crops such as castor. Since *Conogethes punctiferalis* is one of the major pests infesting the economic produce in castor, there is every need to evaluate efficacy of promising new groups of chemicals in reducing the pest population which are safe to environment and natural enemies.

Within IPM, the use of resistant varieties is one of the most economical approaches and would be inexpensive in the long run. Incorporation of resistant plant genotypes into integrated pest control system minimizes the number of insecticides application, lessens the expenses involved in plant protection and conserves the natural enemies besides preserving the environmental safety.

Keeping all the above facts in view, the present investigation was taken up with the following objectives.

1. Seasonal incidence of insect pest complex on popular genotypes of castor.

2. Management of insect pest of castor shoot and capsule borer, *Conogethes punctiferalis* with new chemical molecules.

3. Screening of certain castor genotypes for their reaction to leafhoppers and defoliators.

CHAPTER - II

REVIEW OF LITERATURE

The review pertaining to the seasonal incidence of major pests of castor, management of shoot and capsule borer (*Conogethes punctiferalis*) with insecticides and screening of certain castor genotypes for their reaction to leafhoppers and defoliators has been presented here under.

2.1 SEASONAL INCIDENCE OF INSECT PEST COMPLEX ON POPULAR GENOTYPE OF CASTOR

2.1.1 Leafhoppers (*Empoasca (Empoasca) kerri* Pruthi)

According to Singh *et al.*, (1991) *Empoasca kerri* was found to feed on crops such as groundnut, castor, pigeon pea, cowpea etc., during winter in 1987 - 1989 at Palem, Mahboobnagar District, Andhra Pradesh.

E.motti Pruthi and *E. kerri* Pruthi were found to have attained pest status on castor and groundnut (Sudha Jacob *et al.*, 2000)

Jayaraj and Basheer (1964) reported that lowest population of leafhopper (*E. flavesens* F.) on castor was observed during the hot weather and during South-West monsoon period, whereas, the multiplication rate increased during North-East monsoon season and attained the peak in the cold weather season.

According to Senapathi and Khan (1978), *Amarasca biguttula biguttula* occurred throughout the year in considerable number from November to February with a peak level in December month. Senapathi and Mohanty (1980) reported a progressive increase in *A. biguttula biguttula* from the second week of December attaining peak during the third week of January and thereafter their number declined from second week of March upto July on cotton crop.

The effect of climatic factors on the population build up of cotton jassid, *A. biguttula biguttula* was studied by Sekhon and Singh (1985) which revealed that maximum temperature varying from 32 to 36°C and minimum temperature of 20 to 28°C were found to be congenial for the population build-up, whereas relative humidity below 75% during dry season (no rainfall) were considered most favourable conditions for the development, while rainfall above 4.4 mm reduced the population.

The population of jassid (*E. flavescens*) on castor started building up from November and remained high during December 1988 and February to March 1989 at Mandor, Rajasthan. Among the sucking pest complex, jassids were the first to infest castor crop in second fortnight of January followed by whitefly a month later (DOR Annual Progress Report, 1989).

Incidence of *E. flavescens* on castor crop at S.K. Nagar, Gujarat during mid-September to mid –March ranged from 0.6 to 10.5 jassids/plant and peak incidence occurred during mid-December to mid-February that coincided with lower maximum and minimum temperature (maximum range 27.04 – 29.81°C and minimum range 8.0-9.5°C) (DOR Annual Progress Report, 1996).

Men *et al.,* (1996) reported that jassid population was positively correlated with maximum temperature, while there was a significant negative correlation existed with minimum temperature, morning and evening relative humidities on sunflower.

During rabi season, a maximum of 51.0 jassids/plant (*E. flavesens*) were recorded on castor during January moth. Jassid population remained low during March at Hiryur, Karnataka (DOR Annual Progress Report, 1998).

Germ plasm lines sown on 08-10-1999 recorded a population range of 2 - 23.7 jassids/plant (three leaves) and maximum were noticed during January and February months in Andhra Pradesh (DOR Annual Progress Report 1999).

Asokan and Kempuchetty (2000) observed that peak incidence of leafhopper (*E. flavescens*) occurred in November–December which extended up to February coinciding with the low night temperature with high humidity and the zero bloom varieties exhibited 75-90 per cent hopper burn symptoms in castor.

Manjunath and Shree (2001) reported that the incidence of leafhoppers (*E. flavescens*) on mulberry plants was maximum in September and February, while, it was minimum in January and May.

Singh *et al.,* (2002) documented that the incidence of leafhoppers (*E.flavescens*) on cowpea showed a positive correlation with maximum temperature and relative humidity and a negative correlation with minimum temperature.

Lakshmi *et al.,* (2005) carried out studies on castor crop and revealed that *E. flavescens* incidence was highest in crops sown on 26^{th} October and the lowest in crops sown on 10^{th} November.

Prasad *et al.,* (2008) documented that peak incidence of leafhoppers (*Amrasca biguttula biguttula*) was observed from 37^{th} to 47^{th} standard week (mid September to November) and the incidence of leaf hoppers exhibited high and significant correlation with all the weather parameters.

2.1.2 Whitefly (*Trialeurodes ricini* Misra)

David and Radha (1964) investigated the seasonal incidence of castor whitefly, *Trialeurodes ricini* M. and revealed that the aleurodid was prevalent throughout the year with severe occurrence form March to June and in low number during November to January on castor crop.

Heavy sporadic rains and cool temperature resulted in a temporary reduction in *Aleurodicus dispersus* population which, however, rose again in warm dry weather in Hawaii. Mortality of immature stages increased significantly between 40 and 45°C and of adults between 35 and 40°C. Temperatures below 10°C also caused mortality (Cherry, 1979).

Seif (1980) reported that low whitefly population on Cassava was present in June and thereafter reached a peak in January. Through multiple regression, he indicated that the climatic parameters accounted for about 51 percent of the variation in whitefly population. Temperatures and relative humidity interaction were highly correlated, while solar radiation and rainfall had no significant correlation with levels of whitefly. However, rainfall had an indirect effect through host plant.

Vetten and Allen (1982) reported that there was a pronounced effect of season on the number of whiteflies in legumes emerging with maximum numbers being recorded in April-May following the on set of rains after the dry season (Dec – Jan).

Gerling *et al.,* (1985) reported that the developmental rate of *Bemisia tabaci* correlated positively with increase in day length and negatively with rise in temperatures above 30-33°C. They further concluded that very low and very high relative humidity were unfavorable for its development, the former often being an important factor in the field.

Waterhouse and Norris (1989) reported that the whitefly was not recorded as an important pest until the end of 1987. Significant negative correlation was obtained between relative humidity and whitefly population (Chandrasekara, 1990).

Lakshminarayana (1992) reported that the whitefly *T. ricini* infested castor crop during the month of February a month after sowing.

In southern Taiwan, *A. dispersus* occurred all round the year, with rapid population build up in October, reaching a peak in November and declining gradually after December (Wen *et al.*, 1995). The population escalated in February and fall by April on Tapioca (Palaniswami *et al.*, 1995).

Tirupati Reddy (2002) reported that maximum incidence of whitefly was observed during the months of June to March, while the weather factors such as maximum temperature, minimum temperature and morning relative humidity were non significantly and positively correlated with whitefly population in castor crop.

Chaudhuri *et al.*, (2001) carried out studies on seasonal incidence and population density of *B. tabaci* on tomato and revealed that the highest population density (1.68 whiteflies per plant) was observed during mid-February. High infestation levels were maintained from mid-February to mid-March when temperature, relative humidity and sunshine hours per day ranged from 17.07-22.13°C, 65.29-72.78% and 7.79-8.9 h, respectively with 5 mm of rainfall.

2.1.3 Thrips, (*Thrips tabaci* Lind.)

As the literature regarding to incidence of thrips on castor is meagre, related literature available on other crops is reviewed here under.

Madhusudhan *et al.*, (1989), reported that there was a significant positive correlation between relative humidity and population density/percentage damage, and a negative correlation between sunshine hours and population density/ percentage damage in both the nursery and transplanted crop in rice.

Jaydeb Ghosh Chatterjee and Senapathi (1999) assessed the seasonal incidence of thrips on okra and thrips were prevalent throughout the year. The maximum number was observed during April and the lowest number was observed during the winter months, i.e., December- January.

Salman *et al.*, (2001) documented that *T. tabaci* population appeared in the field at relatively few numbers during the first three Weeks of January, increased gradually then attained its peak in March.

Khan *et al.*, (2008) reported that incidence of thrips on cotton was highly affected by weather factors like mean air temperature; relative humidity and rainfall and concluded that temperature played a significant and positive role for thrips (r = 0.045), where as rainfall was positively associated with thrips population.

Correlation studies with weather parameters and insect incidence revealed that rainfall was significantly and negatively correlated with population of thrips on grape vine (Kulkarni *et al.*, 2008).

Reddy *et al.*, (2001) studied the influence of abiotic factors on the major insect pests of pigeon pea and reported that *Megalurothrips usitatus* showed positive correlation with maximum temperature, morning relative humidity and sunshine hours, whereas, negative relation to minimum temperature and evening relative humidity was observed.

Seal (2001) reported seasonal patterns of *T. palmi* populations on potato and aubergine vegetable growing season in Southern Florida, USA during 1991-92 and 1992-93. *T. palmi* population on potato initially were low, but thrips increased in aubergines as the season progressed. The pest population peaked during May and declined during the remainder of the growing season.

Sahu *et al.*, (2005) reported significantly less thrips population (2.09 thrips per plant) in cultivars sown on 5 November, while those sown on 20 December had the highest thrips population (5.58 thrips per plant).

Patel *et al.*, (2009) reported that *Scirtothrips dorsalis* Hood exhibited significant positive correlation between thrips population and maximum temperature, sunshine hours and evaporation where as morning/afternoon humidity showed significant negative association on castor.

2.1.4 Leaf miner [*Liriomyza trifolii* (Burgess)]

Literature regarding incidence of leaf miner on castor is limited , thus information available on other crops is furnished as follows.

Lakshminarayana *et al.*, (1992) reported that *Liriomyza trifolii* was widespread in all castor growing areas of the country and the infestation declined from mid September onwards.

Bagmare *et al.,* (1995) documented that mean maximum temperature and sunshine hours had a positive correlation with population of *L. trifolii* while relative humidity had a negative correlation.

Harvir Singh *et al.,* (1996) referred sunshine and rainfall as key factors for development of *L. trifolii* on castor.

Choudary and Rosaiah (2000) reported that incidence of tomato the leaf miner, *L. trifolii* in tomato commenced form the third week of November and reached a peak in forth week of January. A second peak was observed in the second week of February and the influence of weather parameters on the leaf miner incidence revealed that minimum temperature and relative humidity had negative correlation while wind velocity and sunshine hours showed positive correlation.

Chaudhuri and Senapati (2004) observed that higher level of leaf miner (*L. trifolii*) infestation in tomato was observed from late March to late May and leaf miner incidence was significantly and positively correlated with maximum temperature and rainfall but was non-significantly and positively correlated with the average relative humidity.

Hemalatha and Maheswari (2004) reported that initial incidence of *L. trifolii* on tomato was noticed during first week of July (27^{th} standard week) and it peaked during the first week of October and January (40^{th} and 1^{st} standard weeks) respectively.

Reddy and Kumar (2005) observed that the peak incidence of *L. trifolii* occurred during March-April, which coincided with the vegetative and reproductive stages of tomato crop. The population declined during November – December. A highly significant and negative correlation between the seasonal abundance of the pest and mean rainfall (-0.6481 and -0.5863), total rainfall (-0.7206 and -0.6979) was observed, while correlations between the seasonal abundance of the pest, and the maximum and minimum temperatures (0.1172 and 0.2648; 0.1193 and 0.2398, respectively were positive but not significant.

Singh *et al.,* (2005) documented that the bottle gourd sown on 3^{rd} March recorded maximum population of leafminer (*L. trifolii*) followed by those sown on 16^{th} February and 1^{st} February.

Emam *et al.,* (2006) reported that the average number of leaf miners (*L. trifolii*) infesting leaves were 4.47 larva per leaflet per season.

Kharpuse and Rakesh Bajpai (2006) reported that leaf miner (*L. trifolii*) appeared on last week of December 2004, and the peak activity of leaf miner was recorded during second and last week of March 2005 in tomato crop.

Studies of Durairaj (2007) revealed that damage by tomato serpentine leaf miner, *L. trifolii* was on increase (>15.0%) starting from January and continued up to August, reaching the peak during March (28.7%) irrespective of the host plants observed. The damage was less than 15.0 per cent during rest of the period *viz*., September to December. Leaf miner incidence exerted a positive association with maximum/minimum temperatures and sunshine hours while the association was negative with relative humidity, rainfall and rainy days.

2.1.5 Shoot and capsule borer, (*Conogethes puntiferalis* Guen.)

Srivastava and Awasthi (1961) observed that the larvae of *C. punctiferalis* entered into a quiescent stage during December, January and first half of February and over wintering larvae resumed their activity when they are exposed to a temperature of 25°C. Mishra and Teotia (1965) studied seasonal history of capsule borer which revealed that the pest was generally active in main crop season with occurrence of all stages from March to April.

Castor shoot and capsule borer was found all through the year and was usually severe during November to March in the main crop season (Rai, 1976).

Goel and Kumar (1990) reported that maximum and minimum temperature influenced positively with significant effect on per cent infestation of capsule by shoot and capsule borer, *C. punctiferalis*.

The capsule borer incidence was more in the month of October, 1994 in Karnataka. The maximum temperature recorded was 29.8°C during October and December, 1994 (DOR Annual progress Report, 1994).

The activity of the pest was noticed during November and December months on kharif sown castor crop, whereas, in rabi sown crop, it was observed in March and the lowest (5%) incidence of the pest was noticed in November and the highest (40%) by the end of the March at Palem (DOR Annual progress Report, 1999).

Maximum of 14.6 per cent capsule damage was recorded during second fortnight of September to December. However, it was low during December, 1999 at DOR, Hyderabad. Temperatures (29.3°C and 19°C) coupled with 80-83 per cent relative humidity favoured for incidence of capsule borer (DOR Annual progress Report, 1999).

A maximum of 40 per cent incidence was recorded on Jyothi (DCS-9) sown on 20.12.1998 in Nagarkurnool, Andhra Pradesh. In Erode district, Tamilnadu, capsule borer damage was 5% in December, 1998 and maximum capsule damage of 20 per cent was reached by February (DOR Annual Progress Report, 1999).

Asokan and Kempuchetty (2000) reported that incidence of capsule borer, *C. punctiferalis* started from November-December with 1 to 3 per cent capsule damage in the rainfed castor as intercrop. The peak period of damage was more during January-February and extended up to March – April. However, castor as pure irrigated crop (hybrid) was attacked by capsule borer even during October and 30-50 per cent damage was noticed in November-December.

Singh *et al.,* (2000) studied the lepidopteran larvae associated with castor capsules and found that *C. punctiferalis* was dominant over other capsule borer larvae with peak occurrence at end of February month.

Thirupati Reddy (2002) reported that the initial incidence of the infestation of capsule by *C. punctiferalis* started in first week of February with 14.16 per cent and the maximum damage of capsules was observed during last week of March (32.94 per cent) capsule infestation. The relationship between the weather parameters and capsule infestation was significant and positive between percent infestation of capsule and maximum temperature/minimum temperature, while negative and significant relation was found between infestation and humidity.

Virender Kaul Kesar (2003) documented that the highest incidence (20%) of guava fruit borers *viz*., *Virachola isocrates* (*Deudorix isocrates*) and *Dichocrosis punctiferalis* (*Conogethes punctiferalis*) was observed in the

32nd standard week and the multiple correlation analysis of the data showed that the abiotic factors like maximum temperature, minimum temperature and relative humidity had significant and positive effect on the incidence of borers.

Madhuri (2005) reported that the activity of shoot and capsule borer was observed initially during the last week of January and capsule infestation reached peak level by first week of March. The correlation between capsule infestation and mean maximum temperature was significant and positive while relative humidities had significant negative correlation and rainfall had non significant negative and non significant correlation.

2.1.6 Red spider mite, (*Tetranychus cinnabarians* (Boisd))

Information pertaining to incidence of red spider mite on castor is limited , hence certain literature available on other crops is reviewed.

Ahuja (1994) carried out studies on seasonal incidence and chemical control of oriental mite, *Eutetranychus orientalis* (Klein) on castor and reported that populations of the mite were (on in July – August to negligible in September – January with a peak in February and March.

Kapoor *et al.,* (1997) documented that population of *Oligonychus indicus* and *Schizotetranychus* spp. in sugarcane were greatest in April and smallest in November-December.

Rajkumar *et al.,* (2005) observed that the mite population in Jasmine appeared during the 6th standard week (First week of February) and increased as summer progressed and only the maximum and minimum temperatures had positive and significant relationship with the mite population, where as rainfall morning and evening relative humidity recorded negative and significant relationship.

Yadav Babu *et al.,* (2007) noticed that the population of *O. indicus* peaked during March-May, but declined during June due to the onset of monsoon, increase in relative humidity in arecanut crop.

Anitha and Nandihalli (2008) documented that the pest incidence in okra commenced from the 49th standard week (of December 2006), while peak incidence of mite (*T. cinnabarinus*) was noticed during the 10th standard week (first week of March, 2007) with 30.17 mites per 3 leaves.

2.2 MANAGEMENT OF INSECT PEST OF CASTOR SHOOT AND CAPSULE BORER, *Conogethes punctiferalis* Guen WITH NEW CHEMICAL MOLECULES.

2.2.1 Efficacy of test chemical on castor pest complex

Review pertaining to the efficacy of insecticides viz., endosulfan, phosalone, lambda-cyhalothrin, thiodicarb, emamectin benzoate., indoxacarb and flubendiamide against castor capsule borer (*Conogethes punctiferalis* Guen) of castor is presented here under.

Mandal *et al*., (1978) reported that four sprayings of carbaryl @ 0.25% were effective against capsule borer (*C. punctiferalis*).

Patel *et al*., (1988) concluded that the lowest incidence of castor capsule borer (*C. punctiferalis*) was recorded in monocrotophos 0.05% (0.48 per cent incidence) treated plot followed by endosulfan 0.07% (3.94 per cent incidence), while untreated plots suffered high percentage incidence of *C. punctiferalis*.

Field evaluation of 12 insecticides against the semilooper (*A. janata*) and capsule borer (*C. punctiferalis*) of castor indicated that the best control of the semilooper and higher seed yield were obtained with endosulfan @ 0.5 kg a.i. ha^{-1} when sprayed thrice at 21 days interval from 48 days after sowing castor (Senapati and Dash, 1989).

Two field trials were conducted during 1999-2000 and 2000-2001 on shoot and capsule borer (*C. punctiferalis*) in cardamom and the highest yield was recorded in lambda-cyhalothrin treated at 80 ppm concentration, while 20 ppm was on par with standard check, monocrotophos, was considered suitable for field application. (Suresh Kumar *et al.*, 2004).

According to Nagapasupathi *et al.*, (2003) the average larval weight and weight gain of sixth instar larvae of *Spodoptera litura* treated with thiodicarb were significantly low with low growth rate as compared to those fed on castor leaves.

2.2.2. Efficacy of insecticides against other insect pests of castor

Literature pertaining to the reports about efficacy of insecticides against other pest complex on castor is presented below.

Patel *et al.*, (1988) concluded that 0.01% carbaryl spray gave moderate control against castor leafhopper and whitefly.

Parthasarathy and Rao (1989) reported that fenvalerate 0.02% was the most effective against castor semilooper (*Achaea janata* L.) (82.94 per cent) followed by endosulfan 0.07%, carbaryi 0.1% and phosalone 0.07% with 60.92, 56.69 and 50.48 per cent mean reduction of the larvae, respectively.

Ashiraf *et al.*, (1992) evaluated the toxicity of certain insecticides against neonate larvae of tobacco caterpillar under laboratory conditions and concluded that endosulfan was more toxic than fenitrothion, quinalphos, dichlorovos, dimethoate, malathion, phosalone and chlorfenphos.

Swarajyalakshmi (1994) concluded that profenofos at 0.125% gave 55.20 percent reduction of S. *litura* over control on castor.

Kadam *et al.,* (1995) carried out studies on efficacy of diflubenzuron against castor semilooper and revealed that diflubenzuron adversely effected larval growth and weight. The duration of each larval instar following treatment increased compared to the untreated control.

Balikai *et al.,* (1996) stated that applications of 3 I endosulfan 35 EC/ha, 20 kg fenvalerate (0.4%) dust/ha, 0.75 l fenvalerate 20 EC/ha or 1.5 lt methyl parathion (parathion-methyl) 50 EC/ha were effective in controlling *A. janata*.

Basappa and Lingappa (2002) concluded that fenvalerate (0.01%) spray at 45 DAS followed by IPM package offered good protection to castor from *A. janata* and proved to be cost effective with highest cost benefit (C:B) ratio (1:4.99).

Studies on six-day-old *S. litura* larvae which were dipped in different concentrations of lambda-cyhalothrin (0.1, 0.05, 0.025, 0.01, 0.005 and 0.0025%) for 10 sec and provided with fresh castor leaves revealed that the LC_{50} values obtained in the present study were higher than those obtained in previous experiments, indicating a probable development of resistant in the population (Singh *et al.,* 2002).

Tirupati Reddy (2002) stated that endosulfan 0.07% was moderately effective against *S. litura* on castor.

Basappa and Lingappa (2004) reported that among the 13 insecticides tested against castor semilooper, profenofos 50 EC (0.03%) was one of the best chemical in controlling the pest.

Parmar *et al.,* (2004) reported that imidacloprid 0.006% was the most effective chemical with 81 per cent mortality against castor leaf hoppers.

Saroj Singh *et al.,* (2005) evaluated integrated pest management (IPM) technology for castor (*Ricinus communis*) under Rainfed agro-ecosystem and concluded that with IPM package utilizing endosulfan at 0.07% was effective in getting good yields.

Basappa (2006) conducted studies on evaluation of IPM module in the castor growing areas of Mahaboobnagar district of Andhra Pradesh and stated that in addition to IPM components to reducing pest loads, endosulfan (0.07%) was effective in keeping pest population below economic threshold – level and it was relatively safer to natural enemies.

Ahuja *et al.,* (1998) tested nine insecticides under field and laboratory conditions with castor cultivar, Aruna to determine the effective and suitable insecticides for the management of *A. janata* and it was revealed that phosalone was more effective among all the insecticides tested followed by fenitrothion.

Swarna Dhingra (1998) reported that the relative toxicity of emulsions of various pyrethroids and non-pyrethroid insecticides on castor leaves indicated that lambda – cyhalothrin was 4.1 times more toxic than endosulfan, malathion and lindane against *A. janata* larvae.

2.2.3 Efficacy of test chemicals in different host crops

Literature regarding the efficacy of test insecticides *viz*., endosulfan, phosalone, lambda-cyhalothrin, thiodicarb, emamectin benzoate, indoxacarb and flubendiamide against castor capsule borer (*Conogethes punctiferalis* Guen) of castor is meager. Hence literature of the chemicals on other crops is reviewed below.

2.2.3.1 Endosulfan

Viswanathan and Abdul Kareem (1983) reported that endosulfan 0.05% was very effective against leafhoppers on cotton.

Patel *et al.,* (1992) revealed that two need based applications of endosulfan 0.035% at 5 aphids or leafhoppers per leaf were effective and recorded the highest cost benefit ratio (1: 15.93) for the management of sucking pests on bhendi.

2.2.3.2 Phosalone

Mali *et al.,* (2006) tested insecticides like phosalone at 0.05%, carbaryl at 0.2%, lambda-cyhalothrin and endosulfan both at 0.06% which revealed that all chemical treatments were significantly superior over the untreated control against gram pod borer, *Helicoverpa armigera* on chickpea.

2.2.3.3 Lambda-cyhalothrin

Young *et al.,* (1997) reported that lambda-cyhalothrin provided the best level of control (> 97%) of *Helicoverpa zea* in cotton.

2.2.3.4 Thiodicarb

Durant and Moore (1989) opined that standard treatment (Chlordimeform 0.1%) exhibited good ovo-larvicidal efficacy against *Heliothis* spp. in cotton as compared to other treatments of thiodicarb (0.14%), profenofos (0.28%) and lambda- cyhalothrin + fenoxycarb (0.002 % +0.14%).

Clement Peter *et al.,* (1990) evaluated thiodicarb (Larvin 375 F) at three dosage levels with a new formulation of carbaryl (Sevin XLR Plus) and two standards viz., carbaryl 50 WP and fenvalerate 20 EC against *H. armigera* in cotton at Theni village of Madurai district. The results indicated that Sevin XLR and Larvin 375 F @ 2.5 l/ha were superior to Sevin

50 WP and fenvalerate 20EC both in terms of reduced infestation level as well as higher yields.

Siddiqui *et al.,* (1994) compared insecticides i.e. thiodicarb (Larvin), *Bt* sub spp. *kurstaki* (Thuricide WP) and monocrotophos (Nuvacron 40 EC) for the control of cotton bollworms Viz., *Earias vitella* (Fabricius) and *E. insulana* (Boisduval) at Tandojam (Pakistan) and results suggested that thiodicarb was the most effective treatment.

Mann *et al.,* (1995) reported that the thiodicarb was the most effective alternative for synthetic pyrethroids against *H. zea* (Boddie) and *H. virescens* (Fabricius) on cotton.

Xia-Jingyvan *et al.,* (1996) stated that Larvin (thiodicarb) had a good ovicidal effect, high stomach poisoning activity, rapid action and long residual persistence (7–10 days) and this suggested that thiodicarb was an ideal substitute for pyrethroids in cotton.

Kuwazawa (1999) reported that carbamate insecticides had relatively high activity against both eggs and larvae of *H. armigera* in cotton and among them thiodicarb was the most effective agent.

Khalid Ahmed *et al.,* (2000) reported that thiodicarb was the most effective and significantly superior to rest of the treatments in chilli, with highest larval mortality of *S. exigua* (94.4%) at 72 hrs.

2.2.3.5 Emamectin benzoate

Udikeri *et al.,* (2004) assessed the bio-efficacy of new insecticide, emamectin benzoate 5SG against bollworms and its safety to natural enemies in Cotton ecosystem during 2002 and 2003 (Kharif) at Agricultural Research Station, Dharwad farm under rainfed situation. Significantly lowest boll worm population (0.01 larva/plant) was noticed in emamectin benzoate 5 SG used at 11 g ai./ha and was at par with spinosad 48 SC @ 50 g ai/ha (0.14 larva/plant) and indoxacarb 15 SC @ 75 g ai/ha (0.16 larva/plant).

Akhilesh Kumar and Parasnath (2005) tested different insecticides in the field against pod borer [*Helicoverpa armigera* (Hb)] infesting pigeon pea cultivar Bahar at the Agriculture Research Farm, Banaras Hindu University, Varanasi during 1994-95 and 1995-96. The efficacy of insecticides against pod borer was in the descending order of endosulfan > fenvalenrate > cypermethrin > deltamethrin > monocrotophos > carbaryl > malathion.

Trials of Suganya Kanna *et al.,* (2005) indicated that the new formulation of emamectin 5 SG against cabbage diamondback moth, *Plutella xylostella* at 10.0g a.i., ha^{-1} and 8.75g ai./ha was more effective against the pest as compared to profenofos 50 EC @ 750 G a.i ha^{-1} and lambda-cyhalothrin 5 EC @30 g ai. ha^{-1}.

Murugaraj *et al.,* (2006) evaluated the efficacy of emamectin benzoate (Proclaim 05 SG) against the tomato fruit borer, *H. armigera* and concluded that emamectin benzoate 05 SG @ 11 g ai./ha was highly effective in reducing the larval population and fruit damage as well in increasing the yield.

Proclaim 5% SG was tested against brinjal shoot and fruit borer during 2002-2003 and 2003-2004 and results indicated that application of Proclaim 5 SG @ 200 g/ha was found to be effective in reducing dead hearts and also fruit damage in brinjal (Prasad Kumar and Devappa 2006).

Emamectin 5 SG offered effective control against cotton bollworm, *Helicoverpa armigera* when compared to standard check profenofos 50 EC @ 750 g a.i. ha^{-1}, λ-cyhalothrin 5 EC 15 g a.i ha^{-1}, indoxacarb 14.5 SC @ 100g a.i ha^{-1} and spinosad 1 SC@ 60g a.i ha^{-1} (Duraimurugan *et al.*, 2007).

Stanley *et al.*, (2007) concluded that emamectin (5 SG) applied @ 10, and 8.75 g a.i. ha^{-1} were more effective against brinjal fruit borer as compared to the standard checks and emamectin @ 7.5g a.i. ha^{-1} was found to be on par with profenofos 50 EC (750g a.i., ha^{-1}) and λ- cyhalothrin 5 EC (30 g a.i ha^{-1}).

2.2.3.6 Indoxacarb

Holloway and Forrester (1998) stated that indoxacarb, spinosad, chlorfenpyr and avermerctins can be used for the control of *Helicoverpa* spp. on cotton.

Indoxacarb 15% SC @75 gm ai./ha recorded significantly lowest bollworm incidence, maximum number of good opened bolls, maximum number of good opened bolls, per plant and higher seed cotton yield (Bheemanna and Patil, 1999).

Kharboutti *et al.,* (1999) reported that indoxacarb, spinosad and cyfluthrin effectively controlled activity of cotton bollworm.

Pawar *et al.,* (2006) documented that the efficacy of indoxacarb 15.5 SC @ 500 ml/ha was found optimum with cotton boll damage (22.425) and locule damage (11.35%) as compared to 45.80 damaged bolls and (22.64%) of locule damage in untreated control .

Kay (2007) evaluated new insecticides for the control of *Helicoverpa* spp. (Lepidoptera: Noctuiidae) on Capsicum and reported that indoxacarb, methoxyfenozide, spinosad and emamectin benzoate registered least per cent damaged fruits.

Akhilesh kumar *et al.,* (2007) reported that indoxacarb 15 SC @ 25 and 30 g ai./ha were found effective in controlling the diamond back moth on cabbage.

According to Shivalinga Swamy *et al.,* (2008) indoxacarb 15 SC recorded significantly less fruit damage in all the test doses and also was associated with highest yield of tomato.

2.2.7 Flubendiamide

Javaregowda (2005) revealed that flubendiamide 20 WDG at 25 g a.i/ha was promising for the effective management of rice stem borer.

According to Sekh *et al.,* (2007) flubendiamide 480 SC @ 24 and 30 gm a.i./ha provided effective control of stem borer and leaf folder of rice as compared to phosphamidon, hostathion and chlorphyriphos.

Vinodh Kumar *et al.,* (2007) observed that flubendamide 480 SC at 24 g a.i. ha^{-1} recorded lowest population of *P. xylostella* in cabbage than other treatments.

Ameta and Bunker (2008) reported that NN10001 (Flubendiamide) 480 SC @ 50 ml/ha caused significantly high reduction in the *P. xylostella* on cabbage than other treatments during experimentation.

Kubendran *et al.,* (2008) concluded that flubendiamide 480 SC @ 125 ml ha^{-1} was superior to all other treatments and registered highest per cent larval reduction of *H. armigera* in tomato through out the study period (80.71 to 99.95%) with nil fruit damage after treatment.

Patil *et al.,* (2008) reported that the minimum survival larval population of 1.13 and 0.05 larvae/5 plants in blackgram was recorded with the treatment of flubendiamide 480 SC @ 48 g a.i/ha followed by indoxacarb 14.5 SC @ 75 g a.i/ha. The lowest pod damage of 9.98% was recorded in flubendiamide 480 sc g.a.i/ha followed by indoxacarb (10.22%).

2.3 SCREENING OF CERTAIN CASTOR GENOTYPES FOR THEIR REACTION TO LEAFHOPPERS AND DEFOLIATORS

2.3.1 Screening of genotypes of castor, *Ricinus communis* L. to leafhoppers

Painter (1951) reported that thickness of waxy coating on all plant parts of castor as a factor favouring preference by insects.

Jassid incidence was more on GCH-4 at ARS, Mandor, Rajasthan (0.1 to 10.7 Jassids /leaf) and at Dantiwada, Gujarat (0.52 to 8.95 Jassids/3 leaves) during 1993-1994 (DOR Annual progress report, 1993).

Seshadri and Seshu (1956) classified the pest injury in to five clearly distinguishable grades *viz.*, highly susceptible, susceptible, partially susceptible, resistant and highly resistant. They also observed that castor varieties with waxy bloom were comparatively more resistant to jassids. The degree of resistance was found to increase with the intensity of the bloom.

Dorairaj *et al.,* (1963) observed that, there was a relationship of the leafhopper population with varied type of waxy bloom coating and stem colour of the castor genotypes.

Kranti variety of castor suffered a damage of 5 per cent during December, 1998 in Mahaboob Nagar, Andhra Pradesh (DOR Annual Progress Report, 1998).

Srinvasa Rao *et al.,* (2000) reported that leafhopper population was high on zero and single bloom entries resulting in high degree of hopper burn. Most of the triple bloom entries though recorded moderate leafhopper infestation exhibited only low hopper burn symptoms.

Vijaya Lakshmi (2003) reported that the hybrid GCH 4 had waxy coating in all the parts (triple bloom) which offered leafhopper resistance, whereas the DCH 177 had waxy coating only on stem (Single bloom). The other cultivars viz., Kranthi, Jyothi and Kiran are double bloom types.

According to Lakshmi *et al.,* (2003) , DCH 177 was classified as highly susceptible and Jyothi, Kranthi and Kiran as moderately susceptible and GCH 4 resistant genotypes of castor, against *E. flavescens*.

Lakshminarayana (2003) observed that among different morphological attributes, bloom character was the most important in imparting resistance against the sucking pests. Most of the germplasm accessions with zero and single bloom were susceptible to leafhopper. Majority of the double and triple bloom entries harboured only moderate leafhopper infestation.

2.3.2 Screening of castor genotypes, *Ricinus communis* L. to defoliators

Sarma *et al.,* (2005) determined the resistance of different castor cultivars against the semilopper (*Achaea janata*) at Imphal, Manipur, India in 2001 and 2002. The results revealed that the cultivar 48-1 was the most resistant followed by local red (powdery) and the least resistant one was local green (non-powdery).

CHAPTER III

MATERIALS AND METHODS

Incidence of insect pest complex on popular genotype of castor, evaluation of efficacy of selected insecticides against shoot and capsule borer (*Conogethes punctiferalis* Guen) besides screening of certain castor genotypes for their reaction to leafhoppers and defoliators were the main themes of the study. Field experiments were conducted at the insectary, Department of Entomology, Sri Venkateswara Agricultural college, Tirupati, Andhra Pradesh during *rabi* 2008. Materials and methods employed in the present investigations are as follows:

3.1 SEASONAL INCIDENCE OF INSECT PEST COMPLEX ON POPULAR GENOTYPES OF CASTOR

3.1.1 Cultivation Aspects

Preparatory cultivation: The field was ploughed thrice and farmyard manure @ 2 tonnes per acre was spread uniformly in the field before third ploughing and was leveled properly.

Variety: A popular variety “Jyothi” was selected for the experiment and the seed material was procured from Directorate of oilseeds Research, Rajendranagar, Hyderabad.

Sowing: Sowing was undertaken on 20-12-2008 with a spacing of 90cm between the rows and 60cm within the row. The plot measured 4 m x 30 m. the sowing was done in a field of 120 m^2 (30m x 4 m). The seeds were sown @ 2 seeds per hill. Gap filling was done a week after sowing and thinning was completed 10 days after sowing leaving one healthy seedling per hill. Similarly two more sowings were undertaken at fortnight intervals i.e. on 5/01/09 and 20/01/09.

Fertilizer Application: The recommended package of practices were adopted in managing crop with recommended fertilizer dose of NPK.

Inter-cultivation operations: Hand weeding was done periodically as and when required so as to keep the crop free from weeds.

3.1.2 Seasonal Incidence and Assessment of Insect Infestation

The incidence of major pests of castor was recorded starting from 15 days after germination (DAG) at weekly intervals.

Ten plants at random in each plot, per every sowing were selected and tagged to assess the incidence of insect pests during the course of crop growth.

Leafhoppers (*Empoasca (Empoasca) kerri* Pruthi): Nymphal and adult population of leafhoppers were recorded on nine leaves in each plant i.e. 3 leaves each from top, middle and bottom. Thus a total of 90 leaves from the 10 randomly selected plants were observed in each sowing at weekly interval.

Whitefly (*Trialeurodes ricini* Mishra): Adult population of whiteflies was recorded on nine leaves in each plant i.e. 3 leaves each from top, middle and bottom portion of the plant.

Thrips (*Thrips tabaci* Lind.): Nympal and adult population of thrips was recorded on nine leaves in each plant i.e. 3 leaves each from top, middle and bottom portion of the plant.

Leaf Miner (*Liriomyza trifolii* Burgees): The number of fresh mines was recorded on nine leaves in each plant i.e. 3 leaves each from top, middle and bottom portion of the plant.

Castor butterfly (*Ergolis merione* Cram.): The larval counts of castor butterfly were taken on 10 randomly selected plants in each sowing at weekly intervals during the crop growth period till the harvest.

Red spider mites (*Tertranychus cinnabarians* Boisd.): The mite population was recorded on nine leaves in each plant i.e. 3 leaves each from top, middle and bottom portion of the plant.

Shoot and capsule borer (*Conogethes punctiferalis* Guen.): The extent of incidence of the pest was recorded by counting the number infested capsules to the total number of capsules on the 10 randomly selected plants at weekly intervals and expressed as percentage with the following formula.

$$\text{Per cent infestation of capsules} = \frac{\text{No of capsules infested}}{\text{Total No of capsules (including infested ones)}} \times 100$$

Meteorological data: Data on weather parameters like temperature, relative humidity, rainfall and bright sunshine hours were collected from the Meteorological observatory, Dry land farm of S.V. Agricultural College, Tirupati to relate the influence of the abiotic factors on incidence of pests of castor.

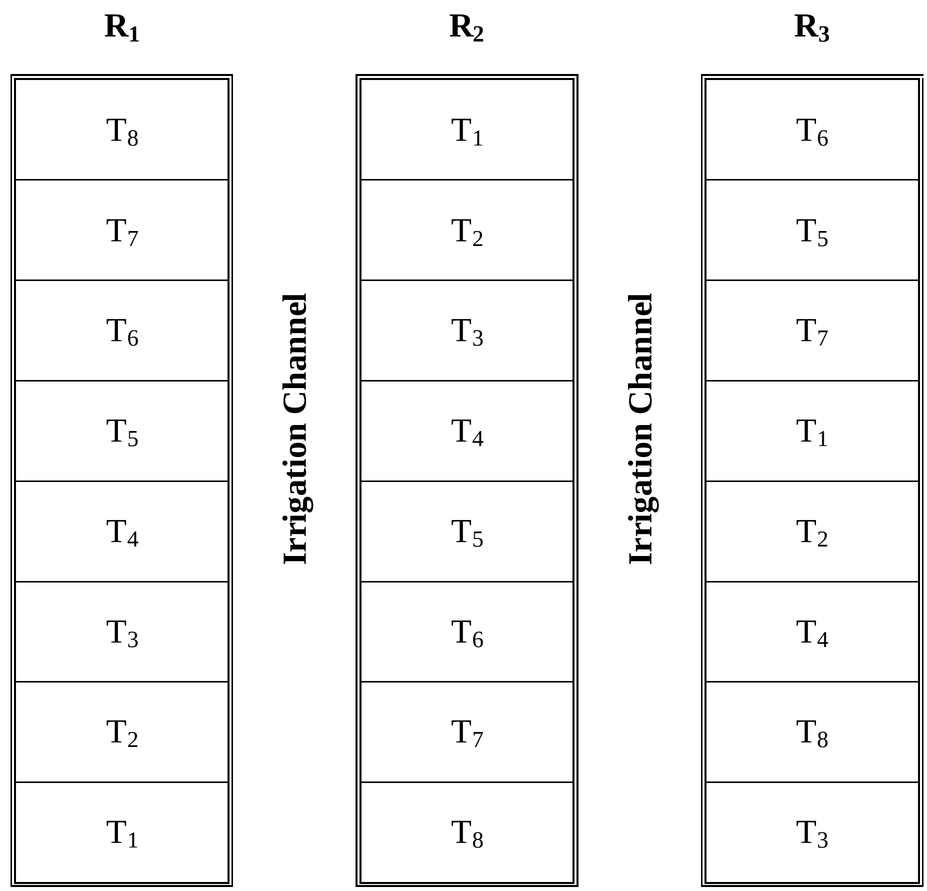
3.2 MANAGEMENT OF INSECT PEST OF CASTOR, SHOOT AND CAPSULE BORER, *Conogethes punctiferalis* Guen. WITH NEW CHEMICAL MOLECULES

A field experiment was conducted at the insectary, Department of Entomology, Sri Venkateswara Agricultural College, Tirupati to evaluate the efficacy of selected insecticides against shoot and capsule borer.

3.2.1 Lay out:

The experiment was laid out in a randomized block design with eight treatments including untreated control, replicated thrice as shown in Fig. 1. Each individual plot measured 3.6 m x 4.8 m. The spacing of 90 cm between the rows and 60 cm within the row were maintained . The recommended dose of fertilizers of 80 N, 40 P_2O_5, 30 K_2O Kg ha^{-1} were applied in the form of urea, single super phosphate, and muriate of potash. Half of the dose of nitrogen, entire dose of phosphorous and potash were applied as basal dose and remaining nitrogen was applied one month after sowing.

Fig. 1: Lay out plan of the experimental field for management of castor shoot and capsule borer



Design	: RBD	Replications	: 3
Treatments	: 8	Plot size	: 3.6 m x 4.8 m
Spacing	: 90 x 60 cm	Variety	: Jyothi

3.2.2 Sowing and agronomic practices

"Jyothi", a popular castor variety was sown on 20th December, 2008. Two seeds per hill were sown by dibbling. Gap filling was done a week after germination and thinning was completed 10 days after sowing leaving one healthy seedling per hill.

The experimental plot was irrigated at weekly intervals and operations like weeding was done so as to keep the crop free from weeds.

3.2.3 Test insecticides

Details of insecticides used in the experiment are given in Table 1.

Table 1: Particulars of treatments used

Sl. No	Common Name	Formulation	Trade name	Conc. of Spray fluid	Source of supply
1.	Endosulfan	35% EC	Thiodan	0.07%	Bayer crop science Ltd., Mumbai
2.	Phosalone	35% EC	Zolone	0.07%	Cheminova India Ltd., Gujarat
3.	Lambda – Cyhalothrin	5% EC	Karate	0.003%	Syngenta crop protection private Ltd., Mumbai
4.	Thiodicarb	75% WP	Larvin	0.075%	Bayer crop Science Ltd., Mumbai
5.	Emamectin benzoate	5% SG	Proclaim	0.003%	Syngenta crop protection private Ltd., Mumbai
6.	Indoxacarb	14.5% SC	Avaunt	0.015%	E.I. dupont India Private Ltd., Gujarat.
7.	Flubendiamide	480 SC	Fame	0.1%	Bayer crop science Ltd., Mumbai

3.2.4 Preparation of Spray Fluid

Measured quantity of the insecticide formulation was mixed with required quantity of water and stirred well to obtain the desired concentration of spray fluid. In case of wettable powders and suspension concentrates, required quantities were mixed with a little quantity of water and then the remaining quantity of water was added to obtain desired concentration and stirred well.

3.2.5 Insecticidal application

Insecticide treatments included in this experiment were applied with high volume foliar sprayer. One spraying was given during morning hours with care to prevent the drift of the spray fluid reaching the adjacent plots by keeping a screen in between the plots. The plants were covered with the spray fluid thoroughly and the sprayer was cleaned with water before changing the insecticide. The treatments were randomized in a block, before imposing treatments.

3.2.6 Field observation of shoot and capsule borer (*Conogethes punctiferalis*)

Infestation of capsule borer was assessed by recording the number of total and affected capsules on each of the five randomly selected plants per treatment and fresh per cent infestation of capsules for each plant was calculated by using formula:

$$\text{Pre treatment calculation} = \frac{\text{No of capsules infested}}{\text{Total No of capsules}} \times 100$$

STATISTICAL ANALYSIS:

Efficacy of treatments with reference to infestation in different treatments were calculated by using formula

$$\text{Per cent efficacy of treatments} = \frac{\text{Infestation \% in untreated check} - \text{Infestation \% in treatment}}{\text{Infestation \% in untreated check}}$$

The per cent values were transformed in to angular values which were subjected to statistical analysis to observe the effect of the treatments.

3.3 SCREENING OF CERTAIN CASTOR GENOTYPES FOR THEIR REACTION TO LEAFHOPPERS AND DEFOLIATORS

An experiment was conducted at the field located in the insectary, Department of Entomology, Sri Venkateswara Agricultural college, Tirupati to screen selected castor genotypes to assess their relative reaction to leafhopper (*Empoasca (Empoasca) kerri*) and defoliators (grasshopper (*Neorthacris acuticeps*) and castor butterfly *Ergolis merione*).

3.3.1 Layout

The experiment was laid out in a randomized block design with 19 genotypes of castor and replicated thrice.

3.3.2 Seed material

A total of 19 varieties were involved in screening trial (Table 2).

Table 2: Different genotypes employed in field trail

Sl. No.	Name of the Variety
1.	GCH 4
2.	DCS 78
3.	PCS 170
4.	UP 1
5.	M 574
6.	PCS 171
7.	PCS 90
8.	Kiran
9.	Jyothi (DCS 9)
10.	PCS 122
11.	PCS 95
12.	Jwala
13.	PCH 222
14.	PCS 137
15.	PCH 111
16.	DPC 9
17.	BCS 87
18.	Haritha (PCS 124)
19.	Kranthi (PCS 4)

Sowing: Sowing was done on 20-01-2009 with a spacing of 90 cm between the rows and 60 cm within the row. The seeds were sown @ 2 seeds per hill. Gap filling was done a week after sowing and thinning was completed 10 days after sowing leaving one healthy seedling per hill.

Fertilizer application: The recommended package of practices were adopted in managing crop with the recommended fertilizers dose of NPK acre was applied in the form of urea, single super phosphate and muriate of potash.

Irrigation: The plots were irrigated at weekly intervals.

Inter cultivation operations: Hand weeding was done periodically as and when required so as to keep the crop free from weeds.

3.3.3 Assessment of pest injury/damage:

The leafhopper and defoliator damages were visually scored and recorded from 1st week of March (30 days after germination) which continued at fortnightly intervals till 1st week of May. The leafhopper and defoliator injury grades were scored on 1 to 9 scale. The description of grades for leafhopper injury and defoliator damage are furnished in Table 3 and 4, respectively.

3.3.3.1 Leafhopper injury index: $\frac{G_1La + G_3Lb + G_5Lc + G_7Ld + G_9Le}{La + Lb + Lc + Ld + Le}$

where La to Le are the number of leaves with the leafhopper injury grades G1 to G9 respectively. The mean leafhopper index was based on observations recorded at fortnightly intervals, where as the last observation reflected the final leafhopper injury index.

3.3.3.2 Defoliator damage index: $\frac{G_1La + G_3Lb + G_5Lc + G_7Ld + G_9Le}{La + Lb + Lc + Ld + Le}$

where La to Le are the number of leaves with the defoliator damage grades G1 to G9, respectively. The mean defoliator index was based on observations recorded at fortnightly intervals, where as the last observation reflected the final defoliator damage index.

Table 3: Different grades for leafhopper injury (Mahal, 1978)

Grade	Damage	Description
1	No	Entire leaf green; showing no hopper burn at all
3	Low	About 1-25 percent leaf area showing hopper burn; yellowing at leaf margins
5	Medium	About 26-50 percent leaf area showing hopper burn; slight cupping and yellowing of leaf margins
7	High	About 51-75 percent leaf area showing hopper burn; severe cupping and bronzing of leaves
9	Severe	Maximum leaf area 75-100 percent showing hopper burn;

Table 4: Different grades for Defoliator damage: (Foahan, 1969)

Grade	Damage	Description
1	No	Entire leaf can be seen
3	Low	Less than 10% damage: holes on the leaves are observed
5	Medium	20-50% damage: leaf eaten partly up to 50%
7	High	50-75% damage is maximum portion of leaf is eaten
9	Severe	75-100% damage of leaf

CHAPTER – IV

RESULTS

The results pertaining to seasonal incidence of major pests of castor, management of major pest shoot and capsule borer (*Conogethes punctiferalis*) with certain insecticides and screening of certain castor genotypes for their reaction to leafhoppers and defoliators are presented in this chapter.

4.1 SEASONAL INCIDENCE OF INSECT PEST COMPLEX ON POPULAR GENOTYPES OF CASTOR

Seasonal incidence of castor insect pests *viz*., leafhoppers, *Empoasca (Empoasca) kerri* Pruthi; whitefly, *Trialeurodes ricini* Mishra; thrips, *Thrips tabaci* Lind. ; leaf miner, *Liriomyza trifolii* (Burgees) ; shoot and capsule borer, *Conogethes punctiferalis* Guen.; red spider mites, *Tetranychus cinnabarians* (Boisd.) and castor butterfly *Ergolis merione* were observed during 2008 rabi season.

4.1.1 Seasonal Incidence of leaf hopper (Table 5 and Fig 2)

1st Sowing (20th December, 2008)

The first incidence of leafhoppers was observed on 15 days after germination (DAG) with a mean population of 3 leafhoppers/plant. The incidence gradually increased from 15 DAG and reached its peak level (39.80 leafhoppers/plant) by 78 DAG. Thereafter, the population gradually decreased (27.20 leafhoppers/plant) which coincided with the maturity phase of the crop (99 DAG).

2nd Sowing (5th January, 2009)

In the second sowing, leafhopper incidence started from 15 DAG with a mean population of 2.8 leafhoppers/plant and continued to increase reaching peak (40.20 leafhoppers/plant) at 71 DAG. Thereafter from 78 DAG the population gradually decreased to 20.00 leafhoppers/plant at 99 DAG of the crop.

3rd Sowing (20th January, 2009)

Incidence of leafhopper was noticed from 15 DAG onwards with a mean population 2.50 leafhoppers/plant at 15 DAG onwards and the population increased with the age of the crop and reached high (36.70 leafhoppers/plant) during 64 DAG. A decrease in incidence with advance in age of crop was observed similar to that observed in 1st and 2nd sowings.

Table 5: Seasonal incidence of leafhopper, *Empoasca kerri* on castor during *Rabi* 2008

Observations (DAG)	Mean number of leafhoppers/plant*		
	1st sowing (December 20th)	2nd sowing (January 5th)	3rd sowing (January 20th)
15	3.00	2.80	2.50
22	4.50	4.10	3.90
29	6.20	7.70	6.80
36	8.10	9.00	7.20
43	12.10	14.20	13.10
50	15.40	17.90	18.10
57	19.70	25.50	27.20
64	27.90	32.40	36.70
71	37.40	40.20	30.90
78	39.80	35.00	26.70
85	31.40	34.50	24.40
92	28.60	30.20	22.00
99	27.20	26.00	17.40

* Average numbers over duplicate plots

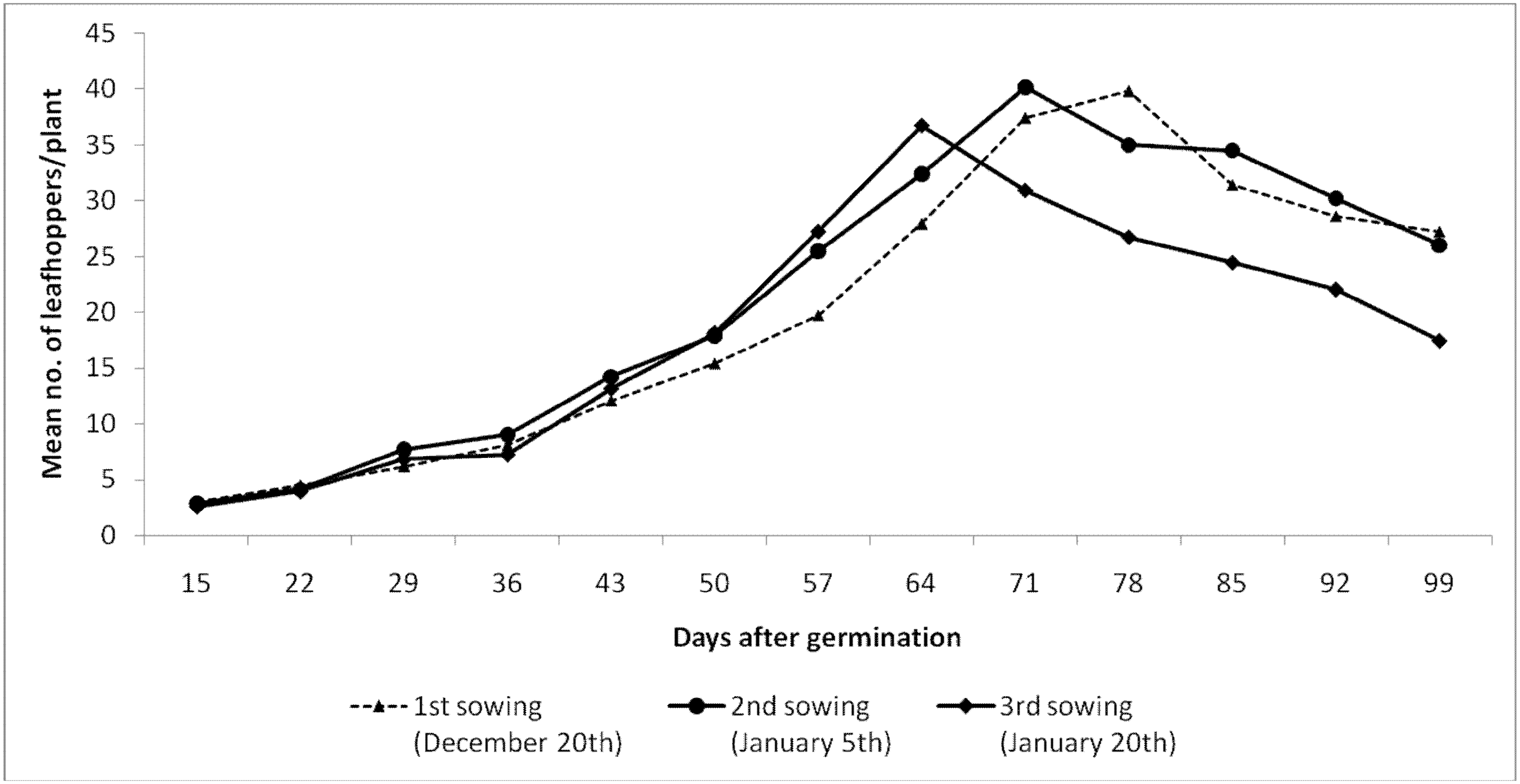


Fig 2: Seasonal incidence of leafhopper, *Empoasca kerri* on castor during *Rabi* 2008.

4.1.2 Seasonal incidence of whiteflies, *Trialeurodes ricini* (Table 6 and Fig 3)

1st Sowing (20th December, 2008)

The initial incidence of *T. ricini* started from 22 DAG with 0.5 whiteflies/plant. The whitefly population continued to increase reaching peak at 71 DAG with a pest load of 2.5 whiteflies/plant. The whitefly population gradually increased from 22 DAG to 71 DAG (2.5 whiteflies/plant). Thereafter a gradual decrease was observed at 99 DAG (1.8 whiteflies/plant).

2nd Sowing (5th January, 2009)

In second sowing, whitefly incidence started from 22 DAG with a mean population of 0.3 whiteflies/plant and continued to increase reaching peak at 99 DAG with mean population of 3.1 whiteflies/plant. The increase of the whiteflies population observed was coincided with advance in age of the crop.

3rd Sowing (20th January, 2009)

In third sowing, the whitefly population was noticed from 29 DAG with a mean population of 0.5 whiteflies/plant. An increase incidence with advance in age of crop was observed with peak population of 4.0 whiteflies/plant during 99 DAG similar to that observed in 2nd sowing.

Table 6: Seasonal incidence of whiteflies, *Trialeurodes ricini* on castor during *Rab*i 2008

Observations (DAG)	Mean number of whiteflies/plant*		
	1st sowing (December 20th)	2nd sowing (January 5th)	3rd sowing (January 20th)
15	0.0	0.0	0.0
22	0.5	0.3	0.0
29	0.9	1.0	0.5
36	1.2	0.7	1.1
43	1.4	0.6	0.9
50	1.1	0.6	1.5
57	1.9	1.1	2.1
64	2.2	1.5	2.7
71	2.5	1.8	3.4
78	2.3	2.4	3.2
85	2.4	2.2	3.8
92	2.0	2.8	3.7
99	1.8	3.1	4.0

* Average numbers over duplicate plots

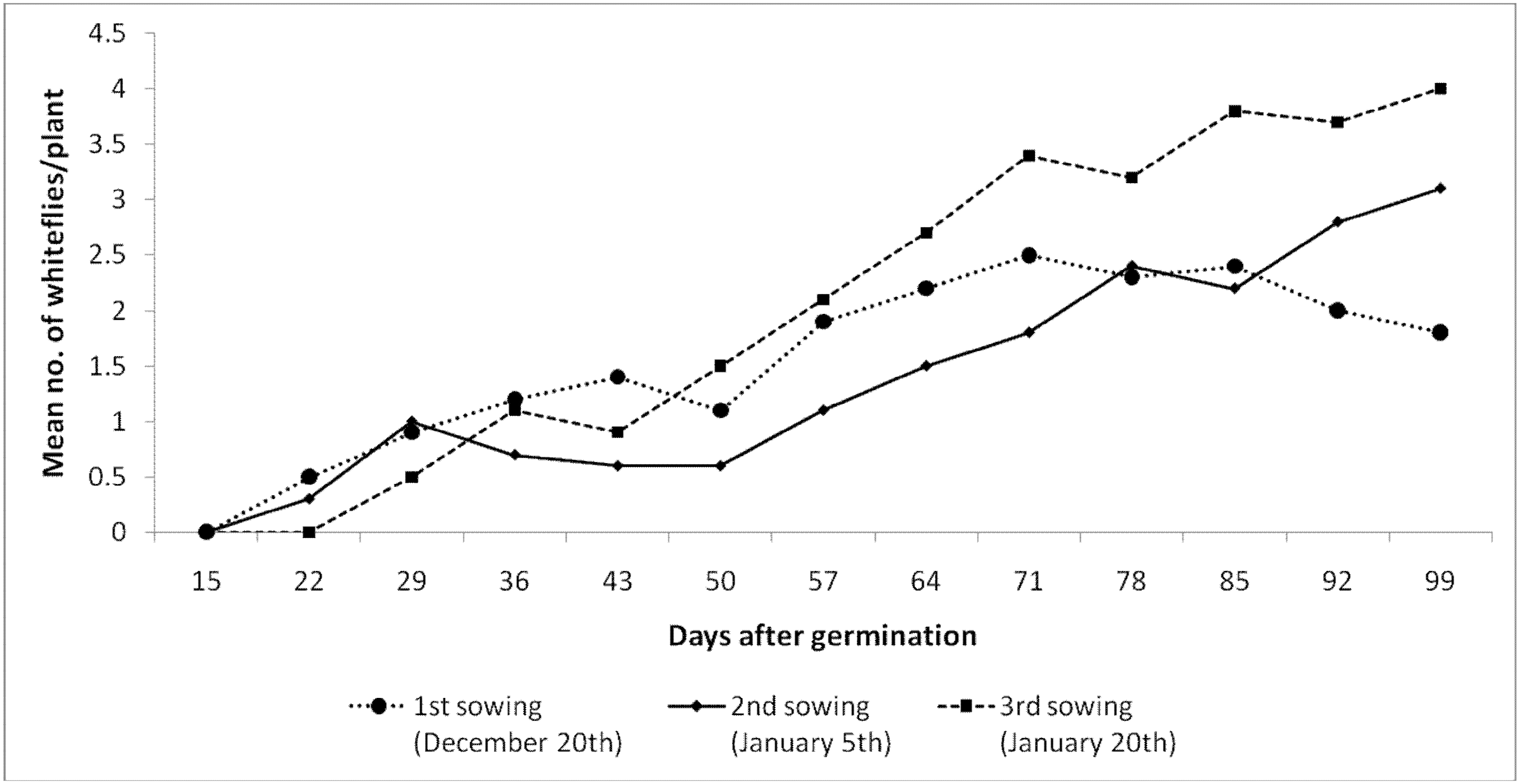


Fig 3: Seasonal incidence of whiteflies *Trialeurodes ricini* on castor during *Rabi* 2008

4.1.3 Seasonal incidence of thrips, *Thrips tabaci* (Table 7 and Fig 4)

1st Sowing (20th December, 2008)

The incidence of thrips was noticed from 15 DAG onwards with a mean population of 9 thrips per plant. Thereafter, the increase in incidence with advance age of crop was observed reaching peak level (41 thrips/plant) during 99 DAG.

2nd Sowing (5th January, 2009)

In the second sowing, thrips incidence started from 15 DAG with a mean population of 10.20 thrips per plant. The population increased gradually and attained its peak (38 thrips/plant) during 92 DAG which coincided with the maturity phase of the crop.

3rd Sowing (20th January, 2009)

In 3rd sowing, the thrips population was noticed from 15 DAG onwards with mean population of 12.10 thrips/plant. The population of thrips increased with the age of the crop and reached high (36.70 thrips/plant) during 99 DAG. Increase of thrips incidence with advance in age of crop was observed similar to that observed in 1st and 2nd sowing.

Table 7: Seasonal incidence of thrips, *Thrips tabaci* on castor during *Rabi* 2008

Observations (DAG)	Mean number of thrips/plant*		
	1st sowing (December 20th)	2nd sowing (January 5th)	3rd sowing (January 20th)
15	9.00	10.20	12.10
22	12.10	13.60	11.60
29	17.40	12.40	13.00
36	16.20	14.00	14.10
43	15.90	16.50	12.90
50	18.10	20.20	14.30
57	21.00	25.60	17.90
64	24.50	29.10	21.20
71	28.20	31.50	24.10
78	32.60	36.40	26.40
85	40.30	35.20	28.80
92	38.50	38.00	34.20
99	41.00	31.50	36.70

* Average numbers over duplicate plots

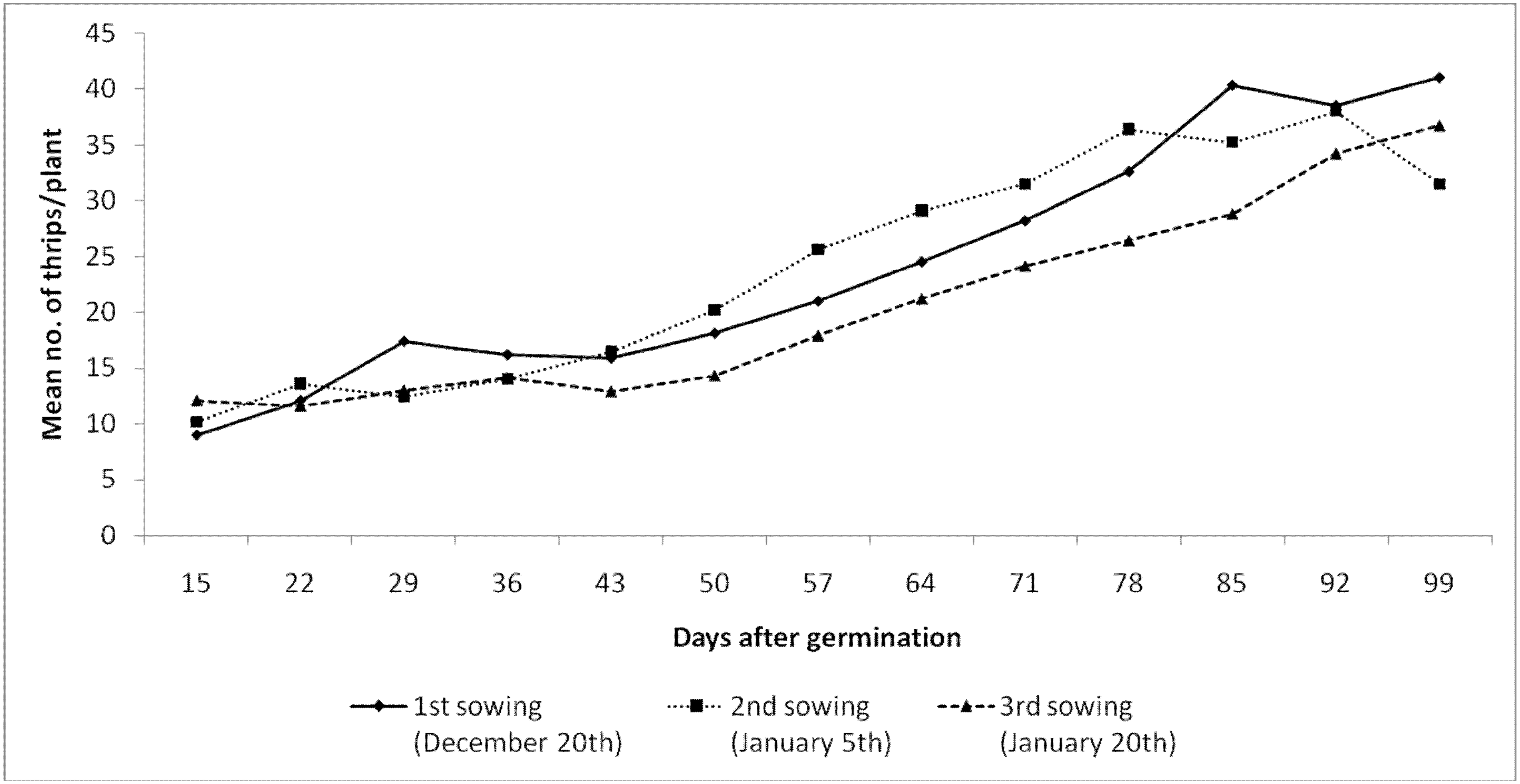


Fig 4: Seasonal incidence of thrips, *Thrips tabaci* on castor during *Rabi* 2008

4.1.4 Seasonal incidence of leaf miner, *Liriomyza trifolii* (Table 8 and Fig. 5)

1st Sowing (20th December, 2008)

The initial occurrence of leaf miner was observed on 15 DAG onwards with a low mean leaf mines of 2.2 per plant. The leaf mines gradually increased and reached a peak level (46.2 leaf mines per plant) at 64 DAG. Thereafter the severity of the attack decreased (20.00 leaf mines/plant) on 99 DAG as the crop growth progressed.

2nd Sowing (5th January, 2009)

In second sowing, the incidence of leaf miner started from 15 DAG with 3.10 leaf mines per plant. It was observed that the trend of raise of pest occurrence, which reached peak (36.60 leaf mines/plant) by 50 DAG thereafter the extent of damage decreased (18.80 leaf mines/plant) at 99 DAG as the crop growth progressed.

3rd Sowing (20th January, 2009)

In 3rd sowing, the leaf miner incidence was noticed from 15 DAG onwards with a mean population of 2.30 leaf mines/plant. The leaf mines increased with the age of the crop and reached high (38.30 leaf mines/plant) on 64 DAG. A decrease in incidence with advance age of crop was observed similar to that observed in 1st and 2nd sowing.

Table 8: Seasonal incidence of leaf miner, *Liriomyza trifolii* on castor during *Rabi* 2008

Observations (DAG)	Mean number of leaf mines/plant*		
	1st sowing (December 20th)	2nd sowing (January 5th)	3rd sowing (January 20th)
15	2.20	3.10	2.30
22	5.60	4.80	3.20
29	8.10	12.60	10.90
36	16.70	17.50	17.00
43	26.10	29.10	23.90
50	35.90	36.60	28.90
57	42.20	35.40	36.10
64	46.10	34.20	38.30
71	37.10	35.60	32.20
78	32.50	31.40	29.10
85	27.90	27.10	25.20
92	21.80	20.50	19.10
99	20.80	18.80	17.50

* Average numbers over duplicate plots

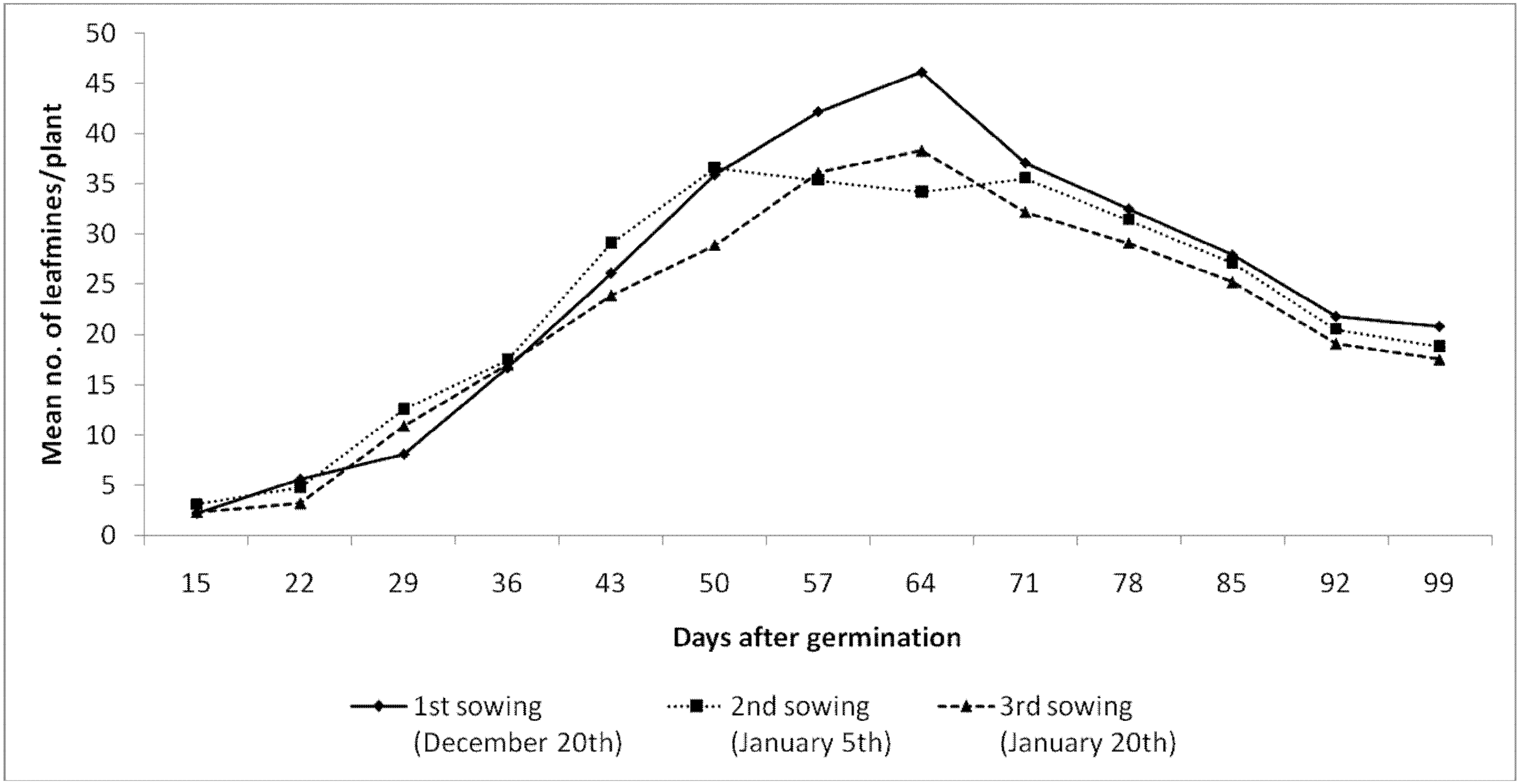


Fig 5: Seasonal incidence of leaf miner, *Liriomyza trifolii* on castor during *Rabi* 2008

4.1.5 Seasonal incidence of shoot and capsule borer, *Conogethes punctiferalis* (Table 9 and Fig 6)

1st Sowing (20th December, 2008)

The initial infestation of capsule by *C. punctiferalis* commenced from 43 DAG with a mean infestation of 1.50% per plant and the infestation started to increase progressively attaining its peak (13.12% infestation/plant) on 64 DAG. Thereafter, a sudden decrease (2.83% infestation/plant) was observed at 71 DAG continued with a gradual increase reaching 6.85% infestation/ plant by 92 DAG.

2nd Sowing (5th January, 2009)

In the second sowing, the per cent infestation of capsules due to *C. punctiferalis,* was found to be high, when compared to first sowing. Initial infestation of capsule was observed on 43 DAG with mean per cent of 4.76 infestation per plant and continued its infestation attaining its peak 34.95% per plant at 85 DAG.

3rd Sowing (20th January, 2009)

The capsule infestation was observed at 50 DAG with mean per cent of 8.57 while the peak infestation (19.04 per cent) was recorded on 64 DAG.

Table 9: Seasonal incidence of shoot and capsule borer, *Conogethes punctiferalis* on castor during *Rab*i 2008

Observations (DAG)	Mean per cent of capsule infestation/plant*		
	1st sowing (December 20th)	2nd sowing (January 5th)	3rd sowing (January 20th)
15	0.00	0.00	0.00
22	0.00	0.00	0.00
29	0.00	0.00	0.00
36	0.00	0.00	0.00
43	1.50	4.76	0.00
50	4.96	13.00	8.57
57	10.20	14.88	12.85
64	13.12	10.21	19.04
71	2.83	11.42	4.30
78	5.84	24.35	11.08
85	6.85	34.95	13.73
92	3.62	12.56	5.92
99	0.00	3.69	3.21

* Average numbers over duplicate plots

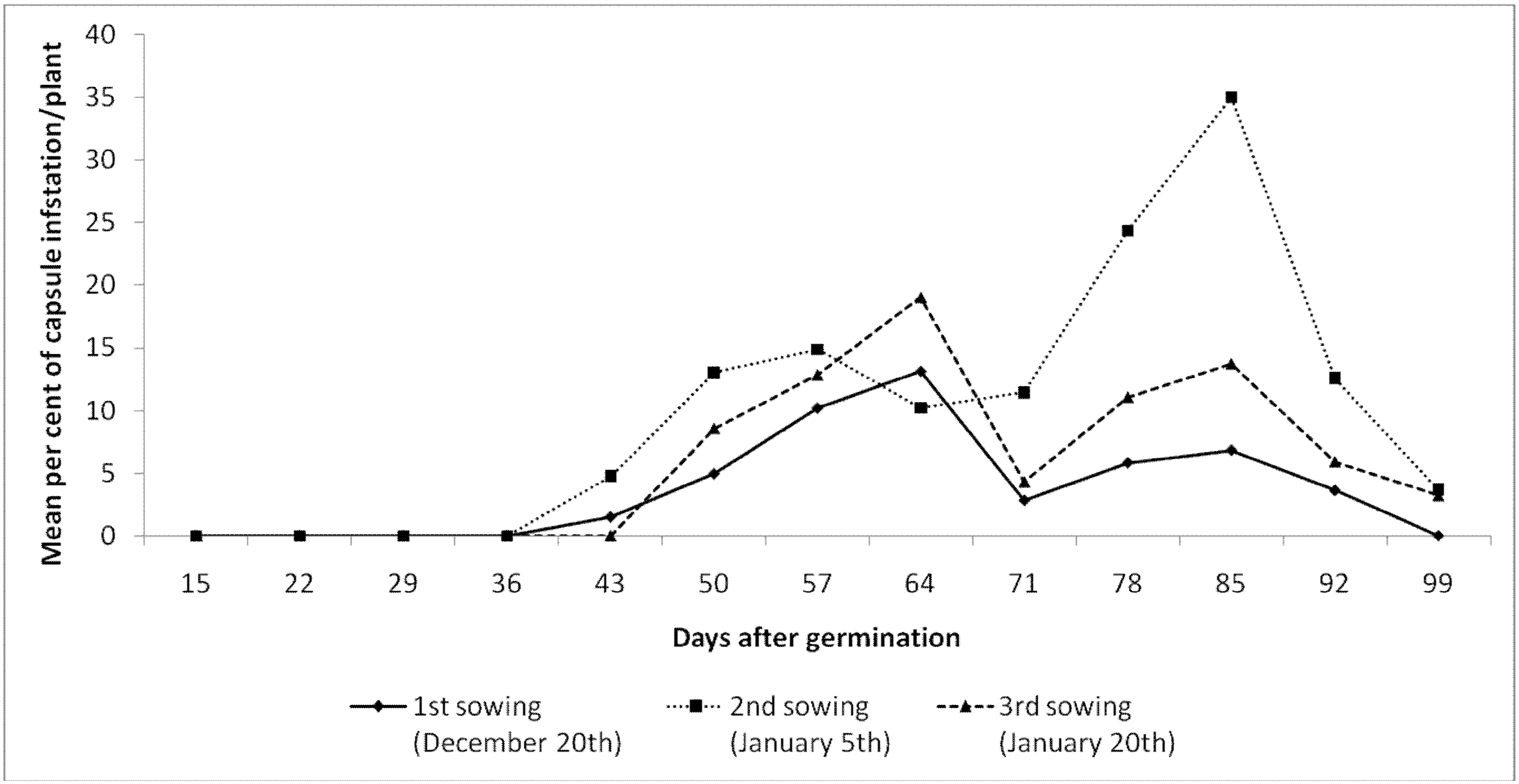


Fig 6: Seasonal incidence of shoot and capsule borer, *Conogethes punctiferalis* on castor during *Rabi* 2008

4.1.6 Seasonal incidence of castor butterfly, *Ergolis merione* (Table 10 and Fig 7)

1st Sowing (20th December, 2008)

The incidence of castor butterfly larvae was first observed at 29 DAG with 0.5 larva per plant. Increase of larval population was noticed attaining peak of 1.4 larva per plant on 43 DAG. Thereafter the larval population gradually decreased to a very low of 0.2 per plant at 92 DAG.

2nd Sowing (5th January, 2009)

In the second sowing, the initial incidence of *E. merione* started from 15 DAG with mean population of 0.1 larva/plant, which reached a peak level (0.7 larva/plant) at 43 DAG. Decrease in incidence of 0.1 larva/plant was observed by 99 DAG was observed.

3rd Sowing (20th January, 2009)

In 3rd sowing, the larval incidence was first noticed from 22 DAG onwards with a mean population of 0.3 larva/plant. The population reached its peak 0.7 larva/plant at 29 DAG. Thereafter, a decrease in incidence with age of crop was observed similar to that observed in 1st and 2nd sowing.

Table 10: Seasonal incidence of castor butterfly, *Ergolis merione* on castor during *Rab*i 2008

Observations (DAG)	Mean number of larva/plant*		
	1st sowing (December 20th)	2nd sowing (January 5th)	3rd sowing (January 20th)
15	0	0.1	0
22	0	0.1	0.3
29	0.5	0.2	0.7
36	0.9	0.3	0.5
43	1.4	0.7	0.4
50	0.9	0.5	0.3
57	0.6	0.5	0.1
64	0.3	0.3	0.2
71	0.3	0.2	0.2
78	0.3	0.2	0.2
85	0.4	0.1	0
92	0.2	0	0.2
99	0	0	0

* Average numbers over duplicate plots

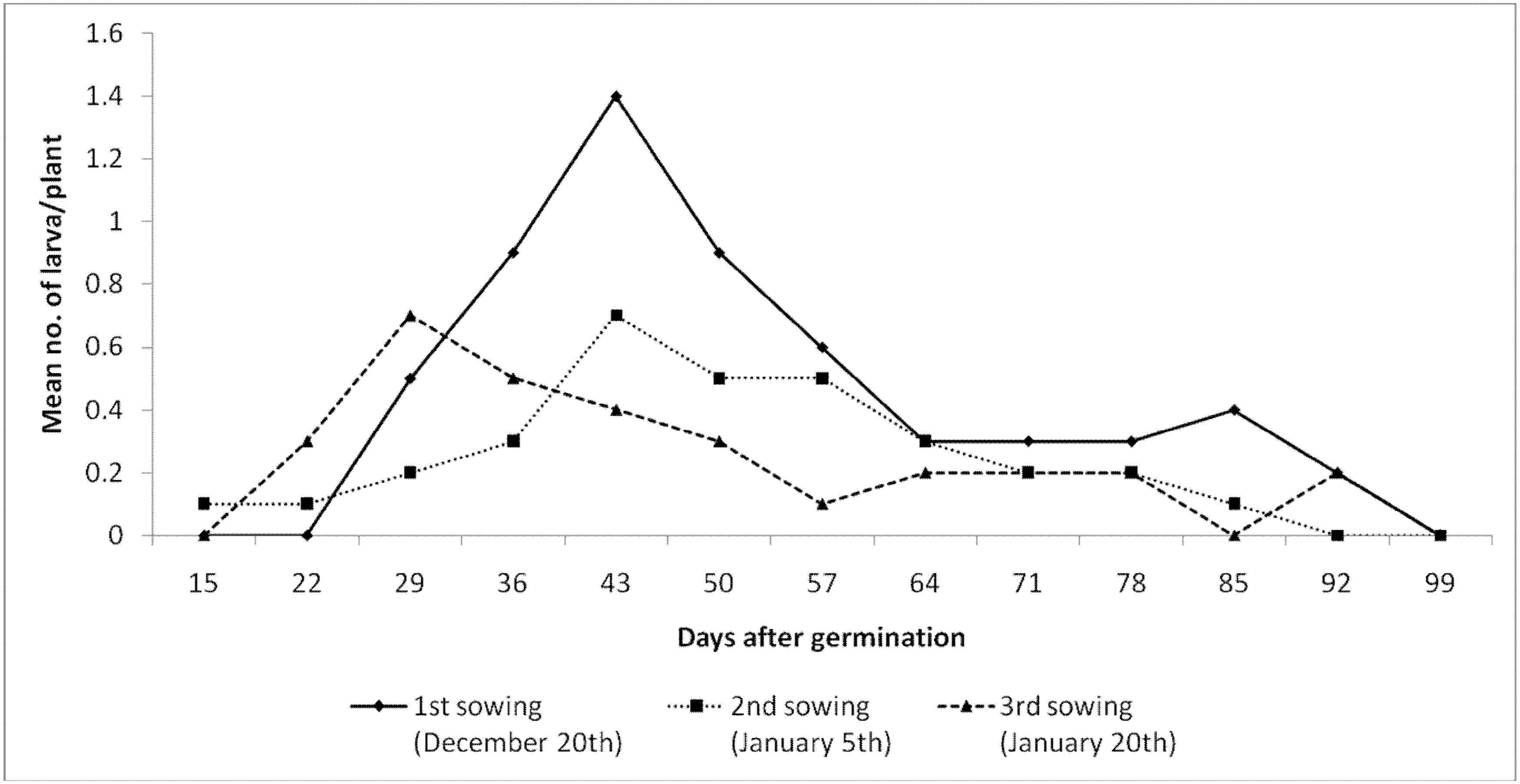


Fig 7: Seasonal incidence of castor butterfly, *Ergolis merione* on castor during *Rabi* 2008

4.1.7 Seasonal incidence of red spider mites *Tetranychus cinnabarians* (Boisd.) (Table 11 and Fig 8)

1st Sowing (20th December, 2008)

The initial incidence of red spider mites was observed from 29 DAG onwards with a mean population of 2.9 mites/plant. The population increased progressively and peak of 18.1 mites/plant was attained by 85 DAG.

2nd Sowing (5th January, 2009)

In the second sowing, mite incidence appeared from 43 DAG with a mean population of 2.5 mites/plant. The population of mite gradually increased with increase in age of crop reaching its peak on 92 DAG with mean population of 15.8 mites/plant

3rd Sowing (20th January, 2009)

In third sowing, the mite incidence was noticed from 36 DAG onwards with a mean population of 1.7 mites/plant. The population increased with the age of the crop and reached high (12.0 mites/plant) by 85 DAG. An increased incidence with advance age of crop was observed similar to that in 1st and 2nd sowing.

Table 11: Seasonal incidence of red spider mite, *Tetranychus cinnabarians* on castor during *Rab*i 2008

Observations (DAG)	Mean number of mites/plant*		
	1st sowing (December 20th)	2nd sowing (January 5th)	3rd sowing (January 20th)
15	0.0	0.0	0.0
22	0.0	0.0	0.0
29	2.9	0.0	0.0
36	4.1	0.0	1.7
43	3.2	2.5	2.5
50	3.9	4.0	2.2
57	6.6	6.2	4.1
64	11.4	9.1	7.9
71	15.8	8.4	9.3
78	14.6	9.6	9.9
85	18.1	13.7	12.0
92	16.3	15.8	10.6
99	12.1	14.7	8.8

* Average numbers over duplicate plots

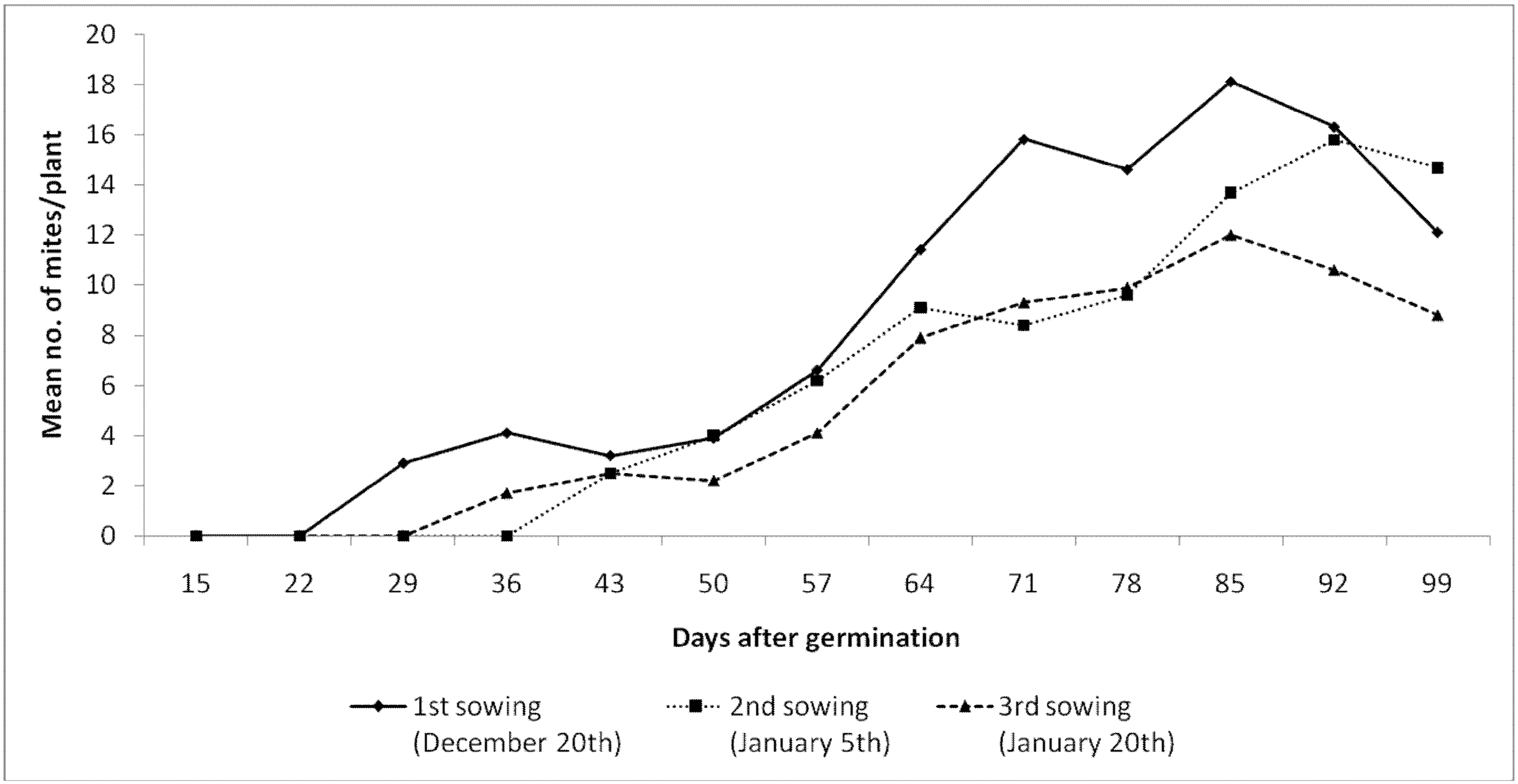


Fig 8: Seasonal incidence of red spider mite, *Tetranychus neocaledonicus* on castor during *Rabi* 2008

4.2 INFLUENCE OF WEATHER PARAMETERS ON INCIDENCE OF INSECT PESTS OF CASTOR DURING *RABI* 2008

The results on the incidence of different pests of castor indicated that pest abundance varied with time of sowing. Of the insect pests observed population of leafhoppers, leaf miner and shoot and capsule borer were at appreciable numbers, while incidence of thrips, whiteflies, butterfly and mites occurred at less population levels. Influence of weather parameters *viz*., maximum and minimum temperature, mean relative humidity, rainfall and sunshine hours on incidence of different pests was subjected to correlation analysis.

4.2.1 Influence of weather parameters on incidence of leafhoppers

A significant positive correlation existed between maximum temperature (r = 0.72), minimum temperature (r = 0.84) and leafhopper population and negative correlation was observed between mean relative humidity % (r = -0.365), sunshine hours (-0.495) and leafhopper population (Table 12).

Multiple linear regression analysis of incidence of leafhoppers and weather parameters lead to the following equation (Table 13).

$$Y = -100.39 + 1.459\ X_1 + 2.508\ X_2 + 0.473\ X_3 – 2.809\ X_4 – 1.063\ X_5$$

Table 12: Simple correlations between weather parameters and leafhoppers on castor during Rabi 2008

Weather parameter	Correlation coefficients (r)
Maximum temperature	0.727**
Minimum temperature	0.840**
Relative humidity	-0.365*
Rainfall	0.185NS
Sunshine hours	-0.495**

** Correlation is significant at the 0.1 level (2-tailed)

* Correlation is significant at the 0.5 level (2-tailed)

NS = Not significant

Table 13: Multiple linear regression between weather parameters and incidence of leafhopper on castor during Rabi, 2008-09

Variable	Regression coefficient	Standard error	t-value
X_1 – Maximum temperature	1.459	2.111	0.691 NS
X_2 – Minimum temperature	2.508	1.445	1.735 NS
X_3 – Relative humidity	0.473	0.587	0.807 NS
X_4 – Rainfall	-2.809	1.621	-1.733 NS
X_5 –Sunshine hours	-1.063	1.478	-0.719 NS

NS = Not significant

4.2.2 Influence of weather parameters on whiteflies (Table 14)

The results indicated that the relation between the maximum temperature, minimum temperature, rainfall and whitefly population were significant and positive (r = 0.785), (r = 0.855) and (0.430) respectively. Influence of relative humidity, sunshine hours and whitefly population was found to be significant and negative with (r = -0.44) and (r = -0.506) respectively.

The multiple linear regression analysis revealed the following equation (Table 15).

$$Y = -10.312 + 0.219\ X_1 + 0.114\ X_2 + 0.053\ X_3 + 0.144\ X_4 - 0.140\ X_5$$

It was indicated that regression coefficients were not significant.

Table 14: Simple correlations between weather parameters and whitefly on castor during Rabi 2008

Weather parameter	Correlation coefficients (r)
Maximum temperature	0.785**
Minimum temperature	0.855**
Relative humidity	-0.440**
Rainfall	0.430**
Sunshine hours	-0.506**

** Correlation is significant at the 0.1 level (2-tailed)

Table 15: Multiple linear regression between weather parameters and incidence of whitefly on castor during Rabi, 2008

Variable	Regression coefficient	Standard error	t-value
X_1 – Maximum Temperature	0.219	0.173	1.265 NS
X_2 – Minimum Temperature	0.114	0.118	0.959 NS
X_3 – Relative Humidity	0.053	0.048	1.092 NS
X_4 – Rainfall	0.144	0.133	1.080 NS
X_5 –Sunshine hours	-0.140	0.121	-1.158 NS

NS = Not significant

4.2.3 Influence of weather parameters on thrips (Table 16)

The thrips population was significantly influenced by maximum temperature / minimum temperature with positive effect (r = 0.698 and 0.763, respectively) whereas negative correlation was observed between mean relative humidity % (r = -0.356) sunshine hours (-0.407) and thrips population.

The multiple linear regression analysis indicated following equation (Table 17) .

$$Y = -93.741 + 2.106 X_1 + 0.876 X_2 + 0.549 X_3 – 0.373 X_4 – 0.867 X_5$$

The equation revealed that significant influence between weather parameters and thrips population, could not be established.

Table 16: Simple correlations between weather parameters and thrips on castor during Rabi 2008

Weather parameter	Correlation coefficients (r)
Maximum temperature	0.698**
Minimum temperature	0.763**
Relative Humidity	-0.356*
Rainfall	0.281 NS
Sunshine hours	-0.407*

** Correlation is significant at the 0.1 level (2-tailed)

* Correlation is significant at the 0.5 level (2-tailed)

NS = Not significant

Table 17: Multiple linear regression between weather parameters and incidence of thrips on castor during Rabi, 2008

Variable	Regression coefficient	Standard error	t-value
X_1 – Maximum Temperature	2.106	1.927	1.093 NS
X_2 – Minimum Temperature	0.876	1.319	0.664 NS
X_3 – Relative Humidity	0.549	0.536	1.024 NS
X_4 – Rainfall	-0.373	1.480	-0.252 NS
X_5 –Sunshine hours	-0.867	1.349	-0.642 NS

NS = Not significant

4.2.4 Influence of weather parameters on leaf miner (Table 18)

The relationship between the leaf mines caused by leaf miner and the weather parameters of maximum temperature, minimum temperature (r = 0.449) and (r = 0.414) respectively were significant and positive. The correlation was negative and significant with mean relative humidity (r = -0.431). The relationship between leaf mines on rainfall and sunshine hours (r = -0.092 and -0.40 respectively), were negative and non significant.

The derived multiple linear regression equation (Table 19) was $Y = 105.268 – 2.323 X_1 + 3.011 X_2 – 1.439 X_3 – 5.032 X_4 + 2.112 X_5$

The equation revealed that influence of weather parameters on leaf mines, was not significant

Table 18: Simple correlations between weather parameters and leaf mines on castor during Rabi 2008

Weather parameter	Correlation coefficients (r)
Maximum temperature	0.449**
Minimum temperature	0.414**
Relative Humidity	-0.431**
Rainfall	-0.092 NS
Sunshine hours	-0.210 NS

** Correlation is significant at the 0.1 level (2-tailed)

NS = Non significant

Table 19: Multiple linear regression between weather parameters and incidence of leaf mines on castor during Rabi, 2008

Variable	Regression coefficient	Standard error	t-value
X_1 – Maximum Temperature	-2.323	3.016	-0.770 NS
X_2 – Minimum Temperature	3.011	2.065	1.458 NS
X_3 – Relative Humidity	-1.439	0.838	-1.716 NS
X_4 – Rainfall	-5.032	2.316	-2.172 NS
X_5 –Sunshine hours	2.112	2.112	1.000 NS

NS = Non significant

4.2.5 Influence of weather parameters on shoot and capsule borer (Table 20)

The relationship between the maximum temperature, minimum temperature and capsule infestation (Table 20) indicated that correlation was significant and positive for per cent infestation of capsules with coefficients of 0.409, 0.360 respectively while negative and significant relation was found between per cent infestation and relative humidity (r = -0.384).

The multiple linear regression equation was (Table 21).
$Y = 84.67 – 2.545 X_1 + 2.474 X_2 – 1.125 X_3 + 2.792 X_5$

The equation revealed that influence of the weather parameters on incidence of shoot and capsule borer was not significant.

Table 20: Simple correlations between weather parameters and shoot and capsule borer on castor during Rabi 2008

Weather parameter	Correlation coefficients (r)
Maximum temperature	0.409**
Minimum temperature	0.360*
Relative Humidity	-0.384*
Rainfall	0.0a
Sunshine hours	0.009 NS

** Correlation is significant at the 0.1 level (2-tailed)

* Correlation is significant at the 0.5 level (2-tailed)

a Could not be computed

NS = Non significant

Table 21: Multiple linear regression between weather parameters and incidence of shoot and capsule borer on castor during Rabi, 2008

Variable	Regression coefficient	Standard error	t-value
X_1 – Maximum Temperature	-2.545	2.007	-1.268 NS
X_2 – Minimum Temperature	2.474	1.405	1.760 NS
X_3 – Relative Humidity	-1.125	0.590	-1.908 NS
X_4 – Rainfall	-	-	-
X_5 – Bright Sunshine hours	2.792	1.505	1.856 NS

NS = Non significant

4.2.6 Influence of weather parameters on castor butterfly during *Rabi* 2008 (Table 22)

The results indicated that the relation between maximum temperature, relative humidity, rainfall and sunshine hours and butterfly larval population was negative and not significant with (r = -0.229, -0.049 and -0.137 respectively) while the correlation between minimum temperature and larval population was negative and significant (r = -0.414).

The multiple linear regression equation (Table 23) revealed that influence of the weather parameters on incidence of castor butterfly larva was not significant.

$$Y = 1.631 + 0.017 X_1 - 0.056 X_2 - 0.018 X_3 - 0.009 X_4 + 0.025 X_5$$

Table 22: Simple correlations between weather parameters and castor butterfly larva on castor during Rabi 2008

Weather parameter	Correlation coefficients (r)
Maximum temperature	-0.229NS
Minimum temperature	-0.414**
Relative Humidity	-0.049 NS
Rainfall	-0.137 NS
Sunshine hours	0.295 NS

** Correlation is significant at the 0.1 level (2-tailed)

NS = Non significant

Table 23: Multiple linear regression between weather parameters and incidence of castor butterfly Larva on castor during Rabi, 2008

Variable	Regression coefficient	Standard error	t-value
X_1 – Maximum Temperature	0.017	0.083	0.207 NS
X_2 – Minimum Temperature	-0.056	0.057	0.981 NS
X_3 – Relative Humidity	-0.018	0.023	-0.769 NS
X_4 – Rainfall	-0.009	0.064	-0.145 NS
X_5 – Sunshine hours	0.025	0.058	0.430 NS

NS = Non significant

4.3 MANAGEMENT OF INSECT PEST OF CASTOR SHOOT AND CAPSULE BORER, *Conogethes punctiferalis* WITH NEW CHEMICAL MOLECULES

Data on the efficacy of treatments against *C. punctiferalis* are presented in the Table 24 and Figure 9.

Pretreatment

The differences in per cent infestation of capsule borer before application of treatments were not significant which indicated the uniform distribution of pest in the crop. The per cent infestation of capsules ranged between from 19.06 to 23.97 in different treatments.

Differences among the treatments were significant for efficacy of chemicals against infestation of capsules over untreated control at all the days after treatment (DAT). All chemical treatments were superior and effective in reducing the incidence of capsule borers.

Three days after treatment:

The highest efficacy was in flubendiamide @ 0.1% (31.83%), emamectin benzoate @ 0.003% (29.41%) and phosalone @ 0.07% (29.09%) treatments were on par with each other, while, lambda-cyhalothrin @ 0.003% registered comparatively less efficacy of 19.15%.

The descending order for efficacy of different treatment is as follows:

$$T_7 > T_5 > T_2 > T_6 > T_1 > T_4 > T_3$$

Five days after treatment:

The efficacy of treatments against capsule borer with reference to untreated control ranged from 24.50 – 35.34% and the differences among the chemical treatments were not significant. The highest efficacy was recorded in emamectin benzoate @ 0.003% (35.34%) and was on par with flubendiamide @ 0.1% (33.37%) and indoxacarb @ 0.015% (32.14%) while less efficacy was recorded in thiodicarb @ 0.075% (24.57%).

The descending order for efficacy of different treatments is as follows:

$$T_5>T_7>T_6>T_2>T_1>T_3>T_4$$

Seven days after treatment:

The highest efficacy of reduction in infestation was recorded in flubendiamide @ 0.1% (39.03%), emamectin benzoate @ 0.003% (39.04%) followed by indoxacarb @ 0.015% (36.00%) were on par with each other. The less efficacy was recorded in lambda-cyhalothrin @ 0.003% (27.50%). The differences among the chemical treatments were not statistically significant.

The descending order for efficacy of different treatments is as follows:

$$T_5>T_7>T_6>T_2>T_4>T_1>T_3$$

Overall efficacy:

The highest efficacy cumulative of test chemicals was recorded in flubendiamide @ 0.1% (34.74%) followed by emamectin benzoate @ 0.003% (34.51%), indoxacarb @ 0.1% (31.57%) were on par with each other, while lambda-cyhalothrin @0.003% registered less efficacy of 23.71%.

The descending order for efficacy of different treatment is as follows:

$$T_7 > T_5 > T_6 > T_2 > T_1 > T_4 > T_3$$

Table 24: Efficacy of test insecticidal treatments on reduction in per cent infestation of capsules by shoot and capsule borer *Conogethes punctiferalis* during *Rabi* 2008

Treatments	Conc. %	Per cent capsule infestation before treatment	Efficacy of test chemicals			Cumulative efficacy
			3 DAT	5 DAT	7 DAT	
T1 – Endosulfan	0.07	20.00	23.2 (28.59)	25.85 (30.46)	27.80 (31.70)	25.61 (30.25)
T2 – Phosalone	0.07	19.24	29.09 (31.95)	32.10 (33.94)	33.82 (35.25)	31.67 (33.71)
T3 – Lambda-cyhalothrin	0.003	20.32	19.15 (25.90)	24.50 (29.6)	27.50 (31.56)	23.71 (29.02)
T4 – Thiodicarb	0.075	21.49	22.35 (28.13)	24.57 (29.55)	28.96 (32.45)	25.29 (30.14)
T5 – Emamectin benzoate	0.003	20.44	29.15 (32.41)	35.34 (36.35)	39.04 (38.59)	34.51 (35.95)
T6 – Indoxacarb	0.015	19.06	26.57 (31.03)	32.14 (34.51)	36.00 (36.85)	31.57 (34.21)
T7 – Flubendiamide	0.1	19.83	31.83 (34.24)	33.37 (35.19)	39.03 (38.59)	34.74 (36.16)
T8 – Control	-	23.97	0 (0.58)	0 (0.58)	0 (0.58)	0 (0.58)
F – test		1.24	20.57**	29.60**	43.58**	31.72**
SED (±)		2.00	3.48	3.09	2.72	3.01
CD (P = 0.01)		NS	10.45	9.26	8.15	9.13
CD (P = 0.05)		NS	7.48	6.63	5.83	6.49

** F test - Significant at 0.05 – Indicated figures are per cent reduction of population of *C. punctiferalis* with reference to those on untreated control

Figures in parenthesis are angular transformed values.

NS = Non significant

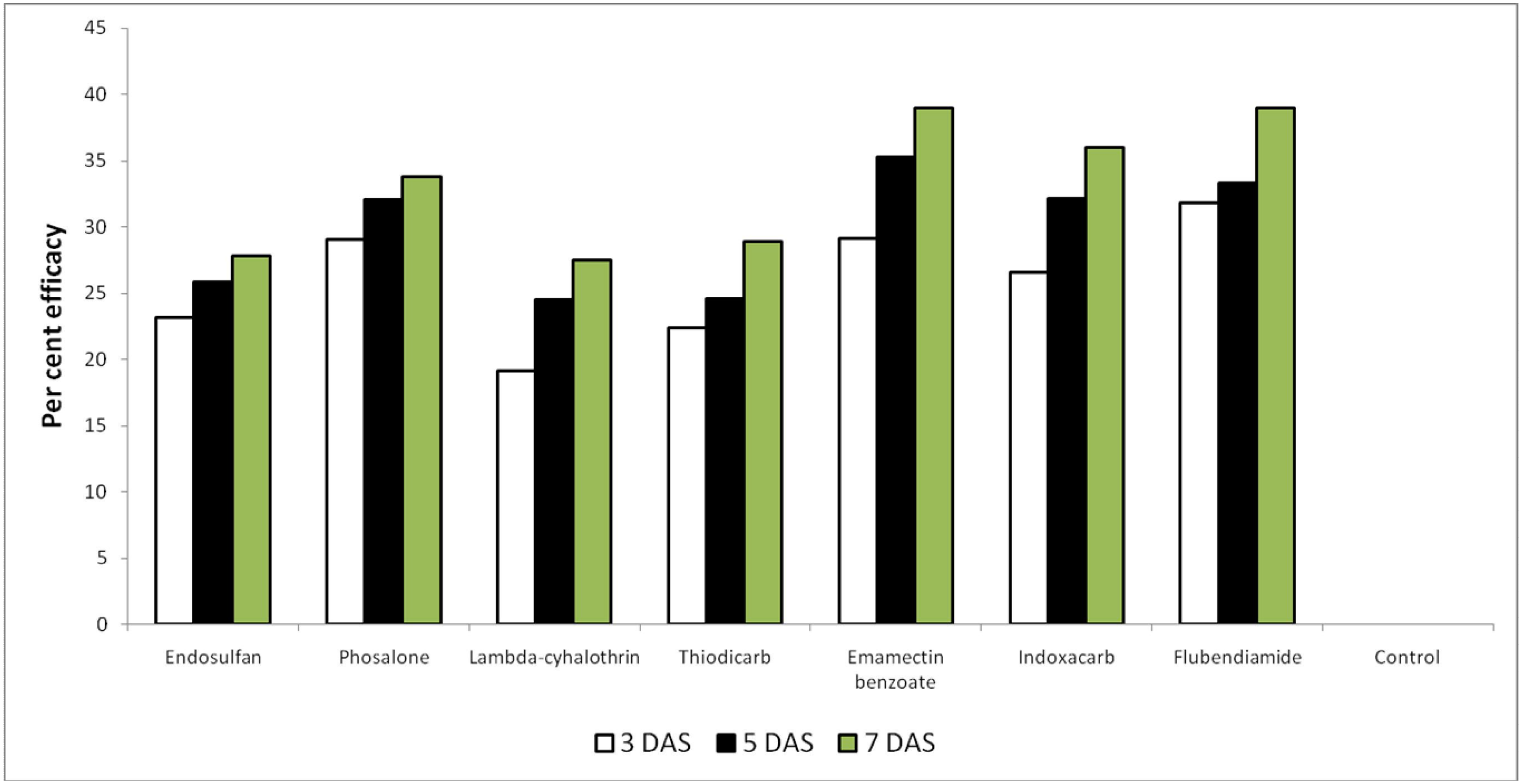


Fig. 9: Efficacy of insecticidal treatments against castor shoot and capsule borer *Conogethes punctiferalis* at different days after treatment (DAT)

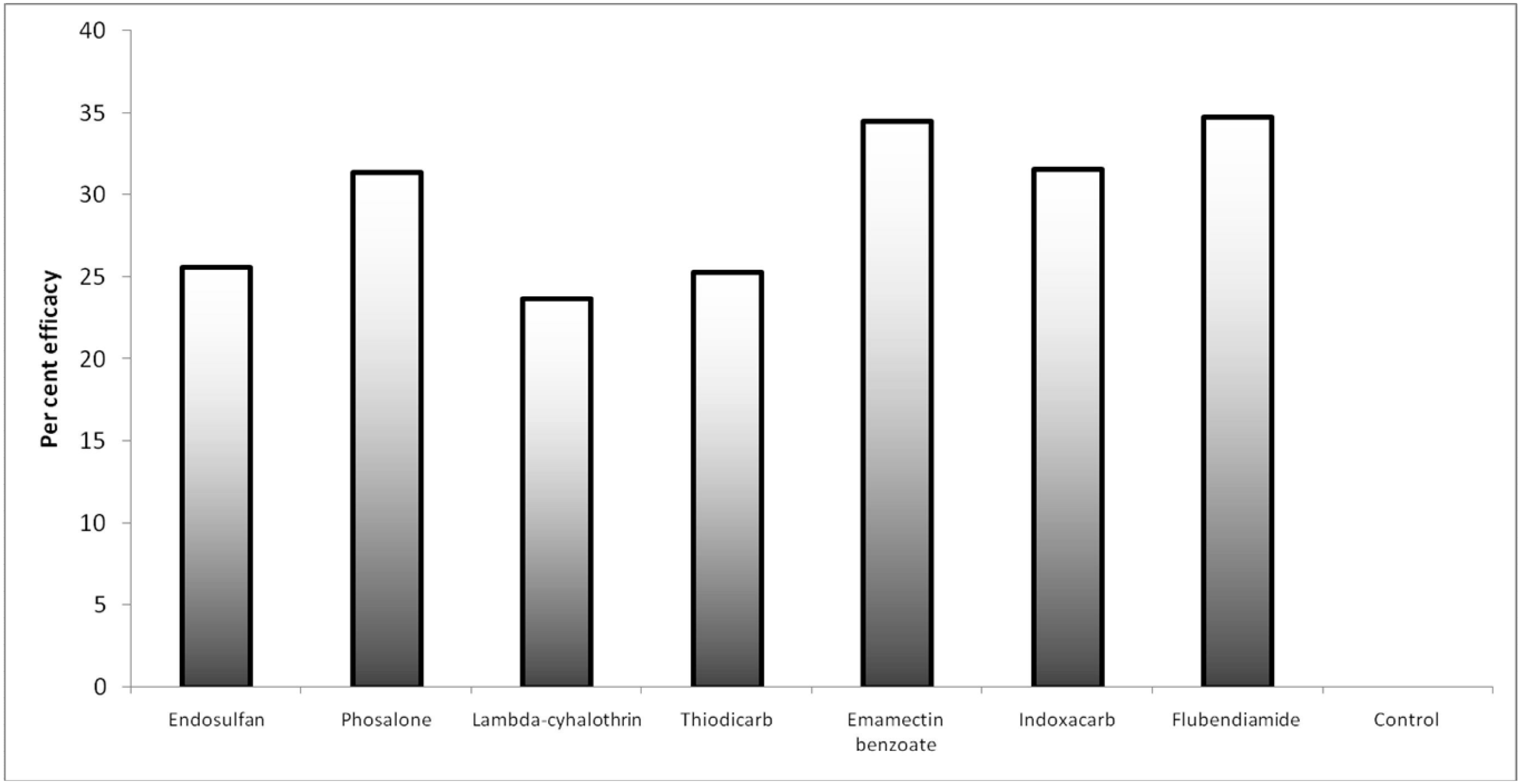


Fig. 10: Cumulative efficacy of treatments against castor shoot and capsule borer, *Conogethes punctiferalis* during *Rabi* 2008

4.4 SCREENING OF CERTAIN CASTOR GENOTYPES FOR THEIR REACTION TO LEAFHOPPERS AND DEFOLIATORS (Table 25 and Fig 11)

4.4.1 Reaction to leafhoppers (*E. kerri*)

30 DAG

On 30 DAG, the cultivar DPC 9, exhibited hopper burn injury (>1) of (score 1.66) followed by Jyothi (DCS 9) (1.33), PCS 90 (1.33) and PCS 70 (1.33), while rest of the genotypes recorded hopper injury of score 1.

45 DAG

The genotype DPC 9 continued to exhibit the high score (3.00) followed by the genotypes Jyothi (DCS 9) (score 2) and genotypes PCS 170, PCS 90, PCS 122, PCS 87 and Haritha (PCS 124) recorded score 1.66 while GCH-4, PCS 171 and PCH 222 recorded score less than 1.

60 DAG

The high score of hopper burn injury was recorded with the cultivar Jyothi (DCS 9) (score 5.66) followed by DPC 9 (score 5), while the genotypes GCH 4, PCS 171, PCH 222 recorded less scores of 1.33, 1.33 and 1.66, respectively.

75 DAG

The cultivars Jyothi (DCS 9) and DPC 9 exhibited highest hopper burn injury with score of 7.33 and 5.66, respectively while cultivars GCH 4, PCS 171 and PCH 222 recorded score 1.33, 1.66 and 2.33, respectively.

90 DAG

On 90 DAG, the hopper burn score of 8.33 was exhibited by the cultivar Jyothi (DCS 9) followed by the genotype DPC 9 with score 7.66, while cultivars GCH 4 and PCS 171 registered less scores of 1.66 and 2.33, respectively.

Based on performance at 90 DAG, genotypes were categorized into 4 groups.

Groups	Scores		No. of Entries with details
1	< 3	⟶	2 (GCH 4, PCS 171)
2	3 – 5	⟶	8 (M 574, PCS 90, Kiran, Jwala, PCH 22, PCS 87, Haritha (PCS 124), Kranthi (PCS 4)
3	5.1 – 7	⟶	7 (DCS 78, PCS170, UP 1, PCS 122, PCS 95, PCS 137, PCH 117)
4	7.1 – 9	⟶	2 (Jyothi (DCS 9), DPC 9)

Thus, it is apparent that two genotypes Jyothi (DCS 9) and DPC 9 were highly susceptible to leafhopper with high score of hopper burn; while GCH 4 and PCS 171 were relatively less susceptible to leafhopper injury.

Table 25: Mean scores/grades to leafhopper injury of different genotypes of castor

Sl. No.	Name of the Variety	Scores/grades				
		Days after germination				
		30	45	60	75	90
1.	GCH 4	1.00	1.00	1.33	1.33	1.66
2.	DCS 78	1.00	1.33	3.66	5.33	5.66
3.	PCS 170	1.33	1.66	3.33	4.00	5.33
4.	UP 1	1.00	1.33	3.00	5.00	5.33
5.	M 574	1.00	1.33	2.66	3.00	4.00
6.	PCS 171	1.00	1.00	1.33	1.66	2.33
7.	PCS 90	1.33	1.66	3.33	4.00	5.00
8.	Kiran	1.00	1.33	2.66	4.33	4.66
9.	Jyothi (DCS 9)	1.23	2.00	5.66	7.33	8.33
10.	PCS 122	1.00	1.66	3.33	5.00	6.33
11.	PCS 95	1.00	1.33	2.66	4.33	6.00
12.	Jwala	1.00	1.00	2.33	3.00	4.33
13.	PCH 222	1.00	1.00	1.66	2.33	3.66
14.	PCS 137	1.00	1.33	3.00	4.00	6.33
15.	PCH 111	1.00	1.33	2.33	4.33	5.66
16.	DPC 9	1.66	3.00	5.00	5.66	7.66
17.	PCS 87	1.00	1.66	2.66	3.00	4.33
18.	Haritha (PCS 124)	1.00	1.66	2.33	4.00	5.00
19.	Kranti (PCS 4)	1.00	1.33	2.66	3.00	4.33

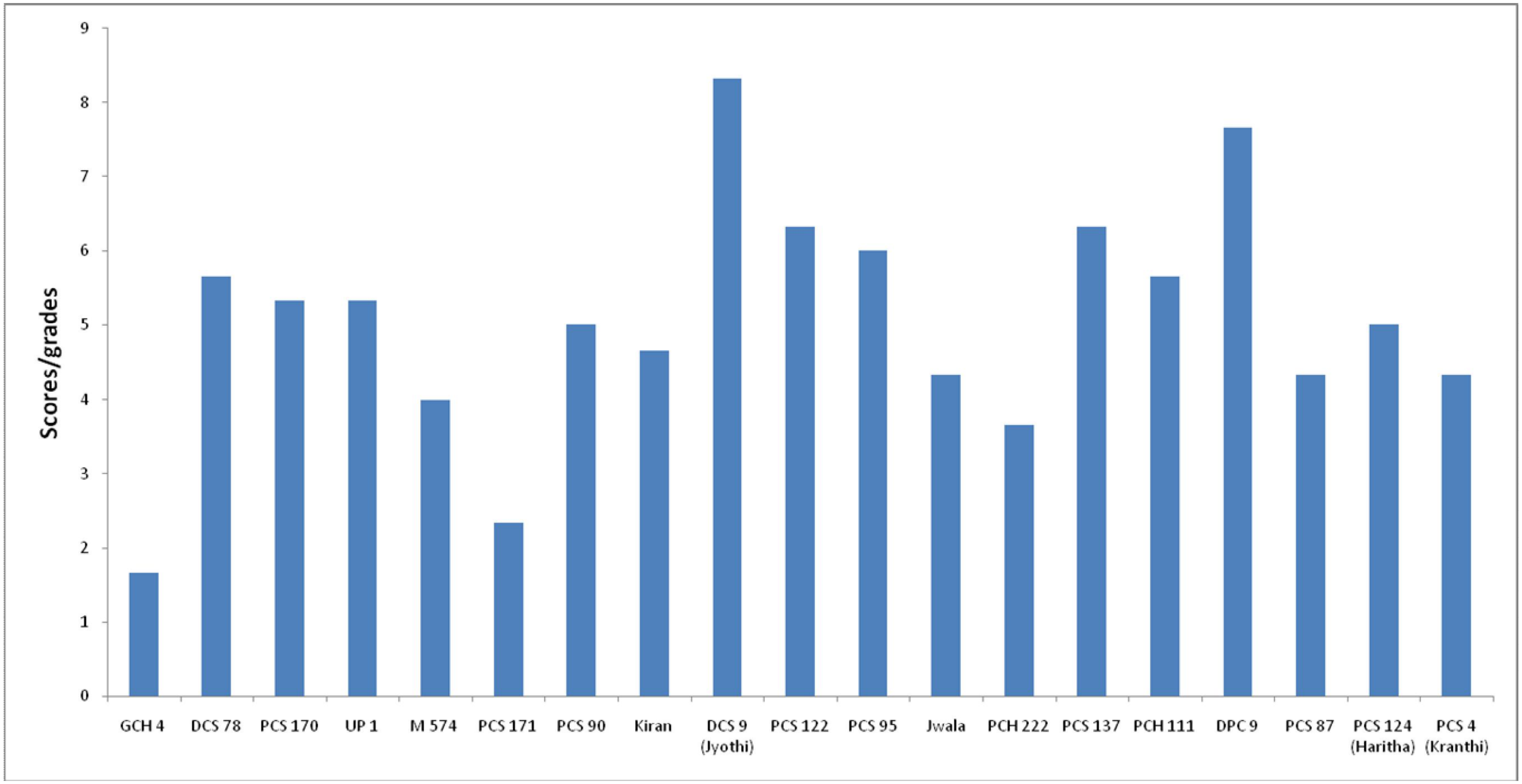


Fig. 11: Leafhopper (*E. kerri*) injury in different genotypes of castor at 90 DAG

4.4.2 Reaction to defoliators (Table 26 and Fig 12)

During period of investigation, insect of defoliators *viz*., grasshoppers (*Neorthacris acuticeps*) and castor butterfly (*E. merione*) were noticed.

30 DAG

On 30 DAG, all genotypes recorded defoliator damage scores of 1 with no damage to leaves.

45 DAG

The genotype, Haritha (PCS 124) exhibited high defoliator damage with (score 2.00) followed by PCS 137 (score 1.33), PCH 111 (score 1.33), DPC 9 (score 1.33) and PCS 170 (score 1.33) while the remaining all genotypes recorded defoliator damage of score 1.

60 DAG

The highest score of defoliator damage was recorded with the cultivar PCS 170 (score 4.33) followed by PCS 122 (score 3.33), PCS 137 (score 3.33) and Haritha (PCS 124) (score 3.33) while PCH 222 registered very less damage of score 1.00 and all the four genotypes GCH 4, M574, PCS 95 and Jwala recorded same score of 1.33.

75 DAG

The cultivars PCS 170 and Haritha (PCS 124) exhibited highest defoliator damage with score of 5.33 and 5.00, respectively while the cultivars GCH 4, PCS 95, Jwala, PCH 222 and Kranthi (PCS 4) recorded less defoliator damage with scores of 1.66, 2.00, 1.66, 1.66 and 2.00 respectively.

90 DAG:

The highest defoliator damage score of 7.00 was exhibited in the cultivar PCS 170 followed by the genotypes Haritha (PCS 124), DCS 78 and Kiran with scores of 6.66, 5.66 and 5.66, respectively, while very less score was noticed in PCH 222 (score of 2.00).

Based on the performance at 90 DAG, genotypes were categorized into 3 groups.

Groups	**Scores**		**No. Entries with details**
1	< 3	→	4 (GCH 4, PCS 95, Jwala, PCH 222)
2	3 – 5	→	10 (UP 1, M 574, PCS 171, PCS 90, Jyothi (DCS 9), PCS 137, PCH 111, DPC 9, PCS 87, Kranthi (PCS 4))
3	5.1 – 7	→	5 (DCS 78, PCS170, UP 1, PCS 122, PCS 95, PCS 137, PCH 117)

Thus, it was indicated that genotypes PCS 170 (score of 7.00), Haritha (PCS 124) (score of 6.66) sustained high defoliator damage and were more susceptible than the rest of entries, while genotype, PCH 222 was promising and suffered moderately less damage.

Table 26 : Mean scores/grades for defoliator damage in different genotypes of castor

Sl. No.	Name of the Variety	Scores/grades				
		Days after germination				
		30	45	60	75	90
1.	GCH 4	1.00	1.00	1.33	1.66	2.33
2.	DCS 78	1.00	1.00	2.33	4.00	5.66
3.	PCS 170	1.00	1.33	4.33	5.33	7.00
4.	UP 1	1.00	1.00	2.00	3.33	3.06
5.	M 574	1.00	1.00	1.33	2.66	3.60
6.	PCS 171	1.00	1.00	1.66	2.33	3.00
7.	PCS 90	1.00	1.00	1.66	3.00	4.33
8.	Kiran	1.00	1.00	2.33	4.00	5.66
9.	Jyothi (DCS 9)	1.00	1.00	1.66	2.66	3.66
10.	PCS 122	1.00	1.00	3.33	4.66	5.66
11.	PCS 95	1.00	1.00	1.33	2.00	2.33
12.	Jwala	1.00	1.00	1.33	1.66	2.33
13.	PCH 222	1.00	1.00	1.00	1.66	2.00
14.	PCS 137	1.00	1.33	3.33	3.66	5.00
15.	PCH 111	1.00	1.33	1.66	2.33	3.66
16.	DPC 9	1.00	1.33	1.66	2.66	3.66
17.	PCS 87	1.00	1.00	1.66	2.33	3.66
18.	Haritha (PCS 124)	1.00	2.00	3.33	5.00	6.66
19.	Kranti (PCS 4)	1.00	1.00	1.66	2.00	3.00

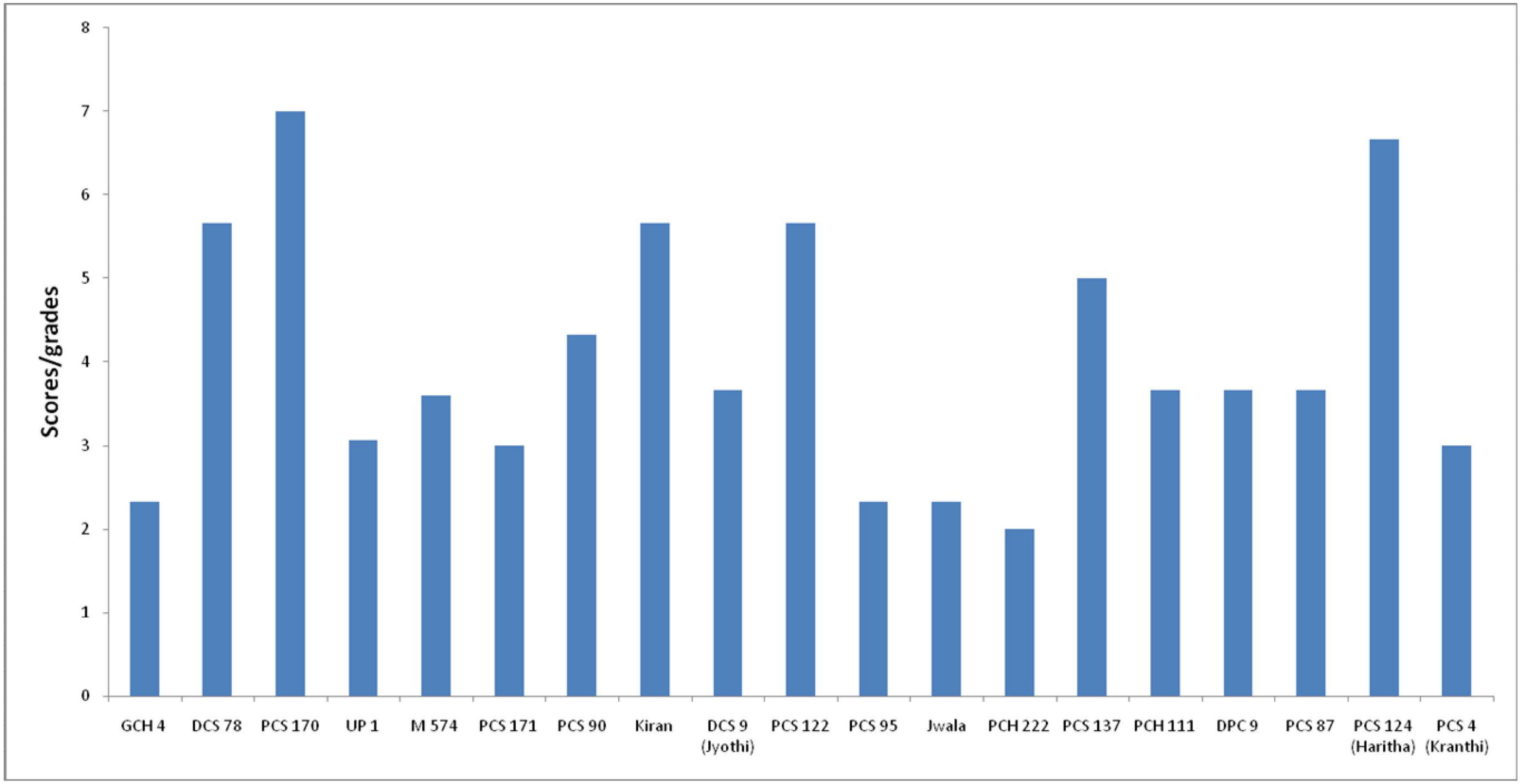


Fig. 12 : Defoliator damage in different genotypes of castor at 90 DAG

CHAPTER – V

DISCUSSION

Present investigation on seasonal incidence of insect pest complex on popular genotype of castor, management of insect pest of castor shoot and capsule borer, *Conogethes punctiferalis* with new chemical molecules and screening of certain castor genotypes against leafhoppers and defoliators was taken up at the Insectary, Department of Entomology, Sri Venkateswara Agricultural College, Tirupati during rabi, 2008. The results obtained are discussed hereunder in light of available literature.

5.1 SEASONAL INCIDENCE OF INSECT PEST COMPLEX ON POPULAR GENOTYPES OF CASTOR

Information on incidence of the different insect pests with reference to phenology of the crop growth suitable for feeding as well as breeding will give a definite clue about the period of peak occurrence and its low level of activity.

In the literature, leafhopper fauna associated with castor were *Empoasca flavescens*, *Amarasca bigutulla bigutulla* and *E. kerri*. In the present investigation, the leafhopper species was identified as *E. kerri* (Professor V. Ramasubbarao, Insect taxonomy, S.V. Agricultural College, Tirupati). Prevalence of the species on castor was in confirmity with reports of Singh *et al.,* (1991) and Sudha Jacob *et al.,* (2000). Though many workers reported occurrence of *E. flavenscens* in India, Sohi and Dworakowska, (1983) quoted that the leafhopper . *E. flavenscens* was not occurring on castor in India and referred it as mis-identify.

5.1.1 Incidence of leafhoppers, *Empoasca (Empoasca) kerri* Pruthi on castor

The studies on the seasonal incidence of leafhopper *E. kerri* as influenced by three different times of sowing *viz.*, December 20^{th}, January 5^{th} and January 20^{th} revealed that leafhopper population was first observed from 15 days after germination (DAG) onwards. The leafhopper incidence in 1^{st} sowing gradually increased and reached its peak level (39.80 leafhoppers/plant) by 78 DAG. There after the population gradually decreased (27.20 leafhoppers/plant) which coincided with maturity phase of the crop (99 DAG).

The leafhopper population in the crop in of 2^{nd} sowing (January 5^{th}) and 3^{rd} sowing (January 20^{th}) also followed a similar trend, gradually attaining a peak and thereafter the decline of population with advance in age of crop and details are furnished in Table 5 and Fig 2.

In the three sowings, the incidence of leafhoppers on castor during the months of February to April ranged from 2.50 to 40.20 jassids/plant.

According to DOR (1989) , *E. flavescens* on castor started building up from November and remained high during December 1988, February and March 1989 at Mandor, Rajasthan and similar situation was noticed in the present findings. DOR (1999) reported that germplasm lines sown on 08-10-1999 recorded a population range of 2-23.7 jassids/plant (three leaves) and maximum were noticed during January and February months in Andhra Pradesh.

In contrary to the present findings, DOR (1998) reported that maximum leafhoppers were recorded on castor during January month (51.0 jassids/plant), and by March population declined to low level at Hiryur, Karnataka. Thirupati Reddy (2002) and Madhuri (2005) also observed the peak level of population during January.

Influence of weather parameters on incidence of leafhopper during Rabi 2008 (Table 12)

The results revealed that mean maximum temperature influenced leafhopper population positively with a significant correlation (r = 0.727). Similar positive correlation with mean maximum temperature was also obtained by Men *et al.,* (1996) and Singh *et al.,* (2002).

Mean minimum temperature had significant and positive correlation (r = 0.840). The present results were in contrast with the observations made by Jayaraj and Basheer (1964) who reported significant negative correlation between minimum temperature and jassid population.

Mean relative humidity showed no significant effect but correlation was negative (-0.365) and is in agreement with Jayaraj and Basheer, (1964) who reported that relative humidity had no significant effect on jassid population, while significant and negative correlation was quoted by Men *et al.,* (1996).

5.1.2 Incidence of whitefly, *Trialeurodes ricini* on castor

Data on incidence of whitefly from 1st sowing (December 20th), 2nd sowing (January 5th) and 3rd sowing (January 20th) during rabi 2008 are given in Table 6 and Fig. 3.

In the first sowing, the whitefly population was recorded from 22 DAG with 0.5 whiteflies/plant. The whitefly population gradually increased from 22 DAG to 71 DAG (2.5 whiteflies/plant). The increase in whitefly population trend coincided with advance in age of crop. Similarly in 2nd (January 5th) and 3rd (January 20th) sowings too, the population of whiteflies increased from 22 DAG to 99 DAG. Among three times of sowings, crop of 3rd sowing (January 20th) suffered comparatively high incidence at 99 DAG with 4.0 whiteflies/plant. Peak level of population ranging from 2.00 to 4.00 whiteflies/plant were recorded during months of March-April in all the sowings.

David and Radha (1964) noticed that the peak level incidence of whiteflies from the month of March and continued up to June. Similar results were also evident from the studies of Vetten and Allen (1982) who reported a pronounced effect of season on the number of whiteflies emerging with maximum numbers recorded in April – May.

Influence of weather parameters on incidence of whiteflies (Table 14)

Significant and positive correlation existed between mean maximum temperature, minimum temperature and rainfall and whiteflies incidence (corresponding r values were 0.785, 0.855 and 0.430). Influence of relative humidity and sunshine hours on whitefly population was found to be significant and negative with -0.44 and -0.506 respectively. The present results are in agreement with Tirupati Reddy (2002) who reported positive correlation between whitefly population and maximum temperature/ minimum temperature and negative correlation with relative humidity.

5.1.3 Incidence of thrips, *Thrips tabaci* on castor

Data on incidence of thrips on castor during 1st (December 20th), 2nd sowing (January 5th) and 3rd sowing (January 20th) sowing (Rabi 2008) are given in Table 7 and Fig. 4.

The results of 1st sowing (December 20th) revealed that the incidence of thrips was noticed from 15 DAG onwards with a mean population of 9 thrips per plant. Thereafter, increase in incidence was observed reaching peak level (41 thrips/plant) by 99 DAG. Similar trend of increase in incidence of thrips population with advance in age of crop in 2nd (January 5th) and 3rd (January 20th) sown crop was also witnessed.

In all the three different sowings, the maximum incidence was recorded during April with population ranging 38.50 – 41.00 thrips/plant in 1st sowing; 35.20 – 38.00 thrips/plant in 2nd sowing and 26.40 – 34.20 thrips/plant in 3rd sowing. The present results are in conformity with the observations made by Jayadeb Ghosh Chatterjee and Senapathi (1999) in Okra crop where thrips were prevalent throughout the year, with the maximum number during April and the lowest numbers during the months of December – January.

Similar results of high infestation of thrips were noticed during the February and March by Chaudhuri *et al.,* (2001) and Salman *et al.,* (2001).

Influence of weather parameters on incidence of thrips (Table 16)

The results obtained from present investigation indicated that the thrips population was significantly influenced by maximum temperature/minimum temperature with positive effect (r = 0.698 and r = 0.763), respectively. Reddy *et al.,* (2001) and Khan *et al.,* (2008) reported that temperature played a significant and positive role for thrips in cotton.

A negative correlation between sunshine hours and thrips population was observed in the present investigation. Madhusudhan *et al.,* (1989) reported a negative correlation between sunshine hours and population density in rice crop.

Mean relative humidity had a negative correlation (r = -0.356) with thrips population.

The present findings are in agreement with Water House and Norris (1989) who reported significant and negative correlation between relative humidity and thrips population.

5.1.4 Incidence of leafminer, *Liriomyza trifolii* on castor

The studies on the seasonal incidence of leaf miner, *L.trifolii* during 1st (December 20th), 2nd (January 5th) and 3rd (January 20th) sowings (Rabi 2008-09) revealed that the leaf miner incidence was noticed from 15 DAG in 1st sowing with a low mean leaf mines of 2.2 per plant. The leaf miner incidence gradually increased from 15 DAG and reached its peak level (46.2 leaf mines/plant) at 64 DAG. Thereafter the severity of attack gradually decreased (20.00 leaf mines/plant) on 99 DAG as the crop growth progressed.

The leaf miner incidence in the crop during 2nd sowing (January 5th) and 3rd sowing (January 20th) also followed a similar trend attaining a peak and thereafter decline as crop growth progressed and details are furnished in Table 8 and Fig. 5.

The maximum number of leaf mines in three different sowings were recorded in 1st sowing (46.1 leaf mines/plant) at 64 DAG i.e. by second week of March, 2nd sowing (36.60 leaf mines/plant) at 50 DAG i.e. by second week of March and 3rd sowing (38.30 leaf mines/plant) at 64 DAG i.e. by first week of April. Kharpuse and Rakesh Bajpai (2006) reported peak incidence of leaf miner during second and last week of March in tomato crop. Similar high incidence of leaf miner in March and April was also quoted by Durairaj (2002), Chaudhuri and Senapati (2004) and Reddy and Kumar (2005).

Influence of weather parameters on incidence of leaf miner (Table 18)

The relationship between the leaf mines caused by *L. trifolii* and weather parameters of maximum temperature, minimum temperature (r = 0.45) and (r = 0.415) respectively were significant and positive. Mandal *et al.,* (2006) noticed a highly significant positive correlation with the maximum temperature and high positive correlation with minimum temperature.

Similar positive association of leaf miner incidence with maximum/minimum temperature were observed by Chauduri and Senapati (2004), Reddy and Kumar (2005) and Durairaj (2007). Negative correlation with relative humidity and positive correlation with sunshine hours were noticed by Choudhary and Rosaiah (2000) in tomato crop.

The correlation was negative and significant with mean relative humidity (r = -0.43188). The relationship between leaf mines and rainfall/sunshine hours were negative and non significant as represented by -0.092 and -0.40 of ‘r’ values respectively.

Bagmare *et al.*, (1995) documented negative correlation between the leaf miner incidence and relative humidity.

5.1.5 Incidence of castor shoot and capsule borer (Table 9 and Fig 6)

Shoot damage by *C. punctiferalis* in the early stages was very less. The results of 1st sowing (December 20th) revealed that the initial infestation of capsules commenced from 43 DAG with mean of 1.50% infestation and the peak infestation by capsule borer was observed at 64 DAG, which synchronized with population stage.

Data from 2nd sowing (January 5th) on per cent of capsule infestation due to *C. punciferalis* revealed that the initial infestation was observed on 43 DAG (mean per cent of 4.76) which attained its peak (34.95) by 85 DAG.

The initial infestation during 3rd sowing (January 20th) was observed at 50 DAG with mean percent of 8.57, while the peak percent infestation (19.04) was recorded on 64 DAG.

The peak activity recorded of shoot and capsule borer in three different dates of sowings, December 20th, January 5th and January 20th were at

64 DAG (6.85% by last week of March), 85 DAG (34.95% on second week of April) and 64 DAG (19.04%) on first week of April), respectively. Mishra and Teotia (1965) reported that the pest was generally active in main crop season with occurrence of all stages from March to April.

DOR (1999) reported that in rabi sown crop, the lowest incidence of pest was noticed in November and the highest incidence of 40% was by the end of the March at Palem, A.P.

Ashokan and Kempuchetty (2000) observed high infestation during January-February which extended upto March-April.

Similar results as that of present findings (peak infestation during last week of March to 2nd week of April, despite variation in sowing dates) were also quoted by Tirupati Reddy (2002) and Madhuri (2005) with the highest percentage of incidence during March.

Influence of weather parameters on incidence of castor shoot and capsule borer (Table 20)

The relationship between the maximum temperature, minimum temperature and capsule infestation indicated that relationship was significant and positive with (r = 0.409), (r = 0.360) respectively, while negative and significant relation was established between per cent infestation and humidity (r = -0.384).

Goel and Kumar (1990) quoted that maximum and minimum temperature influenced positively with significant effect on per cent infestation of capsule borer, *C. punctiferalis*.

Tirupati Reddy (2002), Virender Kaul Kesar (2003) and Madhuri (2005) have reported that the relationship between the weather parameters maximum temperature, minimum temperature and capsule infestation was significant, while negative and significant relation was found between per cent infestation and humidity.

5.1.6 Incidence of castor butterfly, *Ergolis merione*

Studies on the seasonal incidence of castor butterfly *E.merione* during 1st (December 20th), 2nd (January 5th) and 3rd (January 20th) sowings during Rabi 2008 revealed that larval incidence was noticed from 29 DAG in 1st sowing with a population of 0.5 larva/plant. Increase of larval population was noticed attaining its peak of 1.4 larva per plant on 43 DAG. Thereafter the larval population gradually decreased to a very low of 0.25 per plant at 92 DAG.

The incidence of castor butterfly larva in the crop of 2nd and 3rd sowing also followed a similar a peak and thereafter decline as crop growth progressed and details are furnished in Table 10 and Fig 7.

No parallel inferences could be drawn due to lack of related reports of seasonal incidence of castor butterfly larva. During the season *E. merione* was the only defoliator in this field trial, while occurrence of castor semilooper, *A. janata* or other lepidopterans were nil.

Influence of weather parameters in incidence of castor butterfly (Table 22)

The results revealed that the correlation between maximum temperature, humidity rainfall and butterfly larval population was negative and not significant with (r = -0.229), (r = -0.049) and (r = -0.137), respectively, while the correlation between maximum temperature and larval population was negative and significant (r = -0.414).

5.1.7 Incidence of red spider mites on castor

Data obtained from 1st (December 20th), 2nd sowing (January 5th) and 3rd sowing (January 20th) on incidence of redspider mite on castor are given in Table 11 and Fig 8.

The initial incidence of red spider mites in different sowings were recorded on, 29 DAG, 43 DAG and 36 DAG in 1st, 2nd and 3rd sowing respectively.

In 1st sowing, the mean population of 2.9 mites/plant was observed from 29 DAG onwards and thereafter population increased progressively and peak of 18.1 mites/plant was obtained by 25 DAG. Similarly in 2nd (January 5th) and 3rd (January 20th) sowings too, the population of mites increased gradually attaining their peaks by 92 DAG and 85 DAG, respectively.

Among three different sowings, the highest incidence of red spider mites was recorded in 1st sowing with population of 18.1 mites/plant (i.e. by 2nd week of March) on 85 DAG. Ahuja (1994) also reported that the populations of mite on castor reached peak in February and March.

During the period of experimentation (rabi 2008), the insect problems of leaf hoppers, leaf miner and capsule borer were present in relative abundance, as compared to thrips, whiteflies, butterfly and mites. Due to potential of damage, *E. kerri*, *L. trifolii* and *C. punctiferalis* can be reckoned as important insect problems of castor of this region. Fauna of leafhoppers, thrips, whiteflies, mites, leaf miners were found to attack crops in early vegetative stages, while at reproductive stages, capsule borer was prevalent.

Data on incidence of different insect and mite pests during the period under study revealed that sowing of castor, later than January, may invite more pest pressure and necessitate suppression measures; thus planting in the optimum time appears to be low cost input in the cultivation of castor.

5.2 MANAGEMENT OF INSECT PEST OF CASTOR, SHOOT AND CAPSULE BORER, *Conogethes punctiferalis* WITH NEW CHEMICAL MOLECULES

The results on the efficacy of the treatments against *C. punctiferalis* on 3, 5 and 7 days after treatment (DAT) and overall efficacy are present in Table 24 and Fig. 10.

It was indicated that the chemical treatments were highly effective in suppressing the capsule borer. The plots treated with flubendiamide @ 0.1% and emamectin benzoate @ 0.003% registered high reduction of infestation of capsules with 31.83% and 29.15%, respectively , while treatment of lambda-cyhalothrin @ 0.003% registered lowest efficacy of 19.15% at 3 DAT.

The efficacy of treatments against capsule borer with reference to untreated control ranged from 24.50 to 35.34%. Emamectin benzoate @0.003% and flubendiamide @0.1% registered high efficacy of 35.34% and 33.37%, respectively and thiodicarb @0.003% which registered lowest efficacy of 24.50% at 5 DAT.

Data on the efficacy of test treatments at 7 DAT revealed that flubendiamide @ 0.1% and emamectin benzoate @0.003% were highly effective with 39.03% and 39.04 per cent efficacy. Lambda-cyhalothrin treatment @0.003% with 27.50% efficacy was less effective.

The differences among the overall efficacy of treatments with reference to untreated control against *C. punctiferalis* were significant.

The highest cumulative efficacy of test chemicals was recorded in flubendiamide @ 0.1% (34.74%) and emamectin benzoate @ 0.003% (34.51%) and lambda-cyhalothrin @ 0.003% registered less efficacy of 23.71%.

The efficacy of flubendiamide at 0.1% @ 50 ml/ha was established by Ameta and Bunker (2008) with significantly high reduction of *Plutella xylostella* in cabbage than other treatments of experimentation.

Patil *et al.,* (2008) reported that the minimum survival of larval population (*Helicoverpa armigera*) of 1.13 and 0.05 larvae/5 plants in blackgram was recorded with the treatment of flubendiamide 480 SC @ 50 g a.i./ha followed by indoxacarb (10.22% larvae).

Kubendran *et al.,* (2008) concluded that flubendiamide 480 SC @ 125 ml ha^{-1} was superior to all other treatments against *H. armigera* in tomato and registered highest per cent larval reduction (80.71 to 99.95%) throughout the study period with nil percent fruit damage after treatment.

According to Duraimurugan *et al.,* (2007) emamectin 5 SC offered effective control against cotton bollworm, *H. armigera,* when compared to standard check of profenofos 50 EC @ 750 g a.i. ha^{-1}, λ-cyhalothrin 5 EC

@ 15 g a.i. ha^{-1}, indoxacarb 14.5 SC @ 100 g a.i. ha^{-1} and spinosad 1 SC @ 60 g a.i. ha^{-1}.

Efficacy of emamectin benzoate @ 0.003% in the present study is in confirmity with the report of Suganya Kanna *et al.*, (2005) who observed that emamectin 5 SG was more effective against cabbage diamond back moth, *Plutella xylostella* as compared to profenofos 50 EC @ 750 g a.i. ha^{-1} and lambda – cyhalothrin 5 EC @20 g a.i. ha^{-1}.

Of the seven test chemicals *viz.*, emamectin benzoate, flubendiamide, indoxacarb, lambda-cyhalothrin, thiodicarb, phosalone, endosulfan, the former three chemicals have different mode of action and new chemistries on insects. Emamectin benzoate belongs to a avermectin class of insecticide, effective on nervous system and acts as chloride channel activator. Flubendiamide is of benzenedicarboxamide class, which activates calcium release channel that contracts muscles and acts on ingestion. Indoxacarb, a oxadiazine insecticide is a voltage dependent sodium channel blocker and is effective on nervous system. These three chemicals were reported effective against insects such as *Helicoverpa armigera*, *Plutella xylostella* and other lepidopterans, which developed insecticide resistance and their effect on test insect, *Conogethes punctiferalis* with new chemistry of mode of action is very convincing.

Lambda-cyhalothrin, being synthetic pyrethroid it is less effective on tissue borers . Endosulfan, phosalone and thiodicarb have mode of action of traditional groups of insecticides belonging to cyclodienes, organophosphates and carbamate groups respectively. In view of the toxicity, all the test insecticides, exhibited effective control of *C. punctiferalis*, while flubendiamide and emamectin benzoate were superior to rest of the treatments. This forms a new report of efficacy of the new chemicals which can be employed in the eco-friendly integrated pest management of castor.

5.3 SCREENING OF CERTAIN CASTOR GENOTYPES FOR THEIR DEGREE OF REACTION TO LEAFHOPPERS AND DEFOLIATORS

5.3.1 Reaction to leafhoppers (*E. flavescens*)

Score of leafhopper injury at 30, 45, 60, 75 and 90 DAG are presented in the Table 25 and Fig. 11.

The incidence of leaf hopper was present throughout the crop growth period in all the genotypes under test.

The incidence and hopper burn injury was maximum in Jyothi (DCS 9) and DPC 9 with score of 8.33 and 7.66, respectively, which were designated as highly susceptible to leafhopper injury. The mean hopper burn injury of GCH 4 and PCS 171 was 1.66 and 2.33, respectively therefore, these two entries were designated as resistant genotypes. The present results pertaining to GCH 4 is in confirmity with the findings of Lakshmi *et al.*, (2005) who reported GCH 4 as a resistant variety, while Jyothi (DCS 9) was referred as susceptible genotype.

The susceptibility/resistance to leafhopper injury in the cultivars could be attributed to the morphological characters of the cultivars. In accordance with Painter (1951), Seshadri *et al.*, (1956), Dorairaj *et al.*, (1968), Lakshminarayana (1992) and Vijayalakshmi (2003), the genotype GCH 4 with waxy coating in all plant parts (triple bloom) was found resistant to leaf hoppers. The cultivars *viz.*, PCS 4 (Kranthi), PCS 124 (Haritha), PCS 90, M 574, Kiran, Jwala and PCS 87 were less susceptible to jassids injury.

Jayaraj (1967 and 1968) identified plant height, intensity of waxy bloom coating, petiole length, age of plant of flowering, number of nodes, internode length, petiole length, leaf sinus depth and number of lobes that were positively correlated with incidence of leafhoppers. However, details on wax coating could not be established in the present studies.

5.3.2 Reaction to defoliators

Nymphs of grasshopper (*Neorthacris acuticeps*) and larvae of castor butterfly (*E. merione*) were noticed as defoliators and data on score at 30, 45, 60, 75 and 90 DAG are given in the Table 26 and Fig 12.

The entries PCS 170 and Haritha (PCS 124) sustained high cumulative defoliator damage with score of 7.00 and 6.66, respectively at 90 DAG, and were designated as susceptible genotypes while, PCH 222, GCH 4, PCS 95 and Jwala suffered less defoliator damage with corresponding score of 2.00, 2.33, 2.33 and 2.33 respectively at 90 DAG were referred as resistant genotypes.

The leaf characters of okra typed fissured leaves were noticed in the susceptible entries PCS 170 and Haritha, while leaves of other entries under study were normal. No other visual characters to offer resistance or susceptibility to defoliator could be established. However, biochemical factors could be of much relevance than the morphological parameters in castor. Three lines of castor possessing multiple pest resistance such as RC 1006 against *C. punctiferalis* and *Tetranychus letarus;* RC 488 Egypt against *C. punctiferalis* and *Empoasca devastans* and Aruna against *C. punctiferalis* and *E. flavescens* were used in breeding of castor varieties resistant to pests of major economic significance (Jayaraj 1967 ; Singh *et al.*, 1977).

This investigation encompassing vital information on seasonal incidence of insect pests as influenced by dates of sowing, management of key insect pest *viz.*, *Conogethes punctiferalis* and basic screening programme of genotypes for their reaction to leafhoppers and defoliators forms a basic study to prepare a integrated insect pest management module of castor relevant to this location specific situation.

CHAPTER – VI

SUMMARY

Castor (*Ricinus communis* L.) is an important oilseed crop belonging to family Euphorbiaceae, grown mainly for oil purpose for manufacture of wide range of industrial products *viz*., dye, detergents, printing ink, ointment, polishes, surface paints etc.,

Investigation on seasonal incidence of insect pests of castor, evaluation of selected insecticides against shoot and capsule borer and screening of certain castor genotypes against leafhoppers and defoliators was taken up during rabi 2008.

To study the seasonal incidence, castor crop was sown thrice at fortnightly intervals starting from December 20th 2008 and population counts of different insect pests were taken at weekly intervals from 15 days after germination (DAG).

The population of different pests varied in different sowing of castor of infestation of pests *viz*., leafhopper, leaf miner and castor butterfly which increased gradually from first incidence up to certain stage of the crop and thereafter the population gradually declined which coincided with the maturing phase of the crop in all the sowings. Maximum incidence of

leafhoppers was recorded in 3rd week of March at 71 DAG on 2nd sowing (January 5th). High infestation of leaf miner (*L. trifolii*) was noticed in 2nd week of March at 64 DAG in 1st sowing (December 20th). Maximum incidence of thrips was recorded in 1st sowing at 99 DAG i.e. on 2nd week of April. High incidence of whitefly was noticed in first week of May at 99 DAG on 3rd sowing (January 20th). In case of shoot and capsule borer, peak per cent infestation was recorded in first week of April at 5 DAG in 2nd sowing (January 5th) and maximum incidence of red spider mites was recorded during first week of April for 1st sowing.

The study on influence of weather parameters on incidence of insect pests of castor during rabi 2008 revealed that insect pests *viz*., leafhoppers, whitefly, thrips, leaf miner, shoot and capsule borer exhibited significant and positive correlation with mean maximum temperature/ minimum temperature. The pest population of whitefly, thrips, leaf miner, shoot and capsule borer and castor butterfly exerted negative and significant effect with relative humidity , while , leafhoppers exhibited negative and significant correlation. Multiple linear regression equations obtained to check the influence of weather parameters on the incidence of insect pests have indicated that regression coefficients were not significant.

Results on efficacy of certain insecticides against *C. punctiferalis* revealed that the differences among the treatments for reduction of borer infestation of capsule borer were significant.

The highest efficacy in reduction of infestation of capsule was recorded in flubendiamide @ 0.1% and emamectin benzoate @ 0.003% while, lambda cyhalothrin @ 0.003% registered less efficacy.

Screening of castor genotypes against leafhoppers revealed that hopper burn injury was maximum in Jyothi (DCS 9) and DPC 9, which were designated as highly susceptible. The mean hopper injury in entries GCH 4 and PCS 171 was relatively less and these two entries were designated as resistant genotypes to leafhopper injury. Entries PCS 170 and Haritha (PCS 124) sustained high defoliator damage and were designated as susceptible genotypes while PCH 222, GCH 4, PCS 95 and Jwala suffered less defoliator damage and were referred as resistant genotypes.

From the field evaluations the following conclusions are drawn.

1. The insect problems on castor were leafhoppers, leaf miner and capsule borer with their relative abundance as compared to thrips, whiteflies, butterfly and mites. Due to potential damage. *E. kerri*, *L. trifolii* and *C. punctiferalis* can be reckoned as important insect problems of castor of this region.

2. The chemical treatments flubendiamide @ 0.1% and emamectin benzoate @ 0.003% were highly effective against infestation of capsules by *C. punctiferalis*.

3. The genotypes GCH 4 and PCS 171 were found to be highly resistant to leaf hopper injury while the genotypes Jyothi (DCS 9) and DPC 9 were highly susceptible. Genotypes PCH 222, GCH 4, PCS 95 and Jwala were designated as resistant to defoliator damage while entries PCS 170 and Haritha (PCS 124) were highly susceptible genotypes.

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Note: The Literature is cited as per the “Thesis Guidelines” prescribed by Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad.

APPENDIX - I

Standard Week	Date & Month	Temperature		Mean relative humidity (%)	Rain fall (mm)	Sun shine hours
		Max.	Min.			
51	17-23 Dec.	29.0	17.9	68.60	000.0	7.5
52	24-31 Dec.	29.4	15.3	67.75	000.0	8.4
1	01-07 Jan.	28.1	15.1	64.30	000.0	8.7
2	08-14 Jan.	28.3	18.1	69.50	000.0	6.7
3	15-21 Jan.	29.3	16.1	62.95	000.0	8.7
4	22-28 Jan.	30.7	16.1	63.85	000.0	9.0
5	29-04 Feb.	33.1	17.9	60.35	000.0	9.0
6	05-11 Feb.	32.1	15.9	58.05	000.0	9.0
7	12-18 Feb.	33.0	16.1	58.80	000.0	9.4
8	19-25 Feb.	33.4	18.4	58.70	000.0	9.3
9	26-04 Mar.	37.8	19.5	46.15	000.0	9.3
10	05-11 Mar.	36.2	20.2	45.25	000.0	6.8
11	12-18 Mar.	34.3	21.2	55.70	000.0	6.4
12	19-25 Mar.	36.0	23.2	57.90	000.0	7.8
13	26-01 Apr.	37.0	22.2	54.65	000.0	9.5
14	02-08 Apr.	38.2	23.5	53.95	000.0	9.7
15	09-15 Apr.	39.2	23.9	51.90	7.2	9.8
16	16-22 Apr.	39.8	26.1	52.40	5.4	9.2
17	23-29 Apr.	40.3	26.8	46.40	000.0	9.5
18	30-05 May	41.4	26.8	48.20	3.2	8.5
19	06-11 May	40.3	27.4	46.40	000.0	8.9

Max. : Maximum; Min: Minimum; mm: Millimeter