“Seasonal incidence of major insect pests of maize *(Zea mays* L.*)* and their management through new insecticides”

THESIS

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Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

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

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In

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(ENTOMOLOGY)

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CERTIFICATE - I

This is to certify that the thesis entitled, **“Seasonal incidence of major insect pests of maize *(Zea mays* L.*)* and their management through new insecticides”**submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Ag) in Agriculture (Entomology)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. RAVINDRA CHOUDHARY** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.

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

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Date: **Dr. Mahendra Kumar Nayak**
(Chairman of the Advisory Committee)

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Member	**(Dr. R. S. Marabi)**	----------------------------
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CERTIFICATE - II

This is to certify that the thesis entitled **"Seasonal incidence of major insect pests of maize *(Zea mays* L.*)* and their management through new insecticides"**submitted by **Mr. RAVINDRA CHOUDHARY** to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in Agriculture** in the **Department of Entomology** has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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I, RAVINDRA CHOUDHARY s/o Shri. RADHESHYAM CHOUDHARY certify the work embodied in thesis entitled, “seasonal incidence of major insect pests of maize (zea mays L.) And their management through new insecticides” is my own first hand bonafide work carried out by me under the guidance of Dr. M. K. NAYAK at Department of Plant Entomology, College of Agriculture, Tikamgarh (MP) during 2018-19.

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

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Place: Tikamgarh
Dated: / 05 /2019 Ravindra Choudhary

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LIST OF SYMBOLS & ABBREVIATION

Symbol	Abbreviation	Stand for
@		At the rate of
:		Colon
,		Coma
^0C		Degree centigrade
.		Full stop
-		Hyphen
()		Parenthesis
%		Percentage
±		Plus or minus
/		Slash/oblique/virgule
	a.i.	Active ingredient
	ANOVA	Analysis of variance
	CD	Critical difference
	Cm	Centimeter
	D.F.	Degree of freedom
	DAS	Day after sowing
	DAS**	Day after spray
	DAT	Day after treatments
	DBS#	Day before spray
	E	East
	EC	Emulsifiable concentrate
	Ha	Hectare
	Hr.	Hour
	i.e.	In reference to; that is
	K	Potassium
	Kg	Kilogram

	Mg	Milligram
	Ml	Milliliter
	Mm	Millimeter
	Mrl	Meter row length
	MSS	Mean sum of square
	N	Nitrogen
	N	North
	NS	Non-significant
	P	Phosphorus
	PROC	Percent of reduction over control
	Q	Quintal
	R	Correlation
	RBD	Randomized Block Design
	RH	Relative humidity
	S	South
	SC	Soluble concentration
	SEm ±	Standard error of mean
	SG	Soluble granule
	SL	Soluble liquid
	SMW	Standard Meteorology Week
	SS	Sum of square
	Temp	Temperature
	Viz.	Videlicet (namely)
	W	West
	WG	Wettable granules
	WP	Wettable powder

Introduction

Maize *(Zea mays* L.*)*, belonging to family Poaceae, is one of the most important cereal crops of the world and contributes to food security in most of the developing countries. In India, maize is emerging as the third most important crop after rice and wheat. Its importance lies in the fact that it is not only used as human food and animal feed but at the same time it is also widely used in corn starch industry, corn oil production, and as baby corn in different recipes (Singh, 2014).

Maize, being a C_4 plant, has a greater yield potential as compared to other cereals, but attack of insect pests infesting this crop at various crop growth stages from sowing to maturity poses serious limitation in full manifestation of yield potential during different seasons Maize grain contains about 70 per cent carbohydrates, 10.5 per cent protein, 4 per cent oil, 2.3 per cent crude fiber and 1.4 per cent ash. Due to its nutritional property, maize is consumed as human food (23%), poultry feed (51%), animal feed (12%), industrial starch products (12%), beverages and seed (1%) in India (Anonymous, 2014).

Maize is cultivated on 177 million hectare in more than 150 countries, having wide variations in soil, climate, biodiversity and management practices. The total production of maize in the world is 967 million tonnes with a yield of 5.2 tonnes/ha. More than 40 per cent of the maize grain is produced in the USA, followed by China (20%), Brazil (6.3%), Mexico (2.5%), Indonesia (2.2%) and India (2.0%). The United States of America is the largest producer of maize and contributes nearly 35 per cent of the total production in the world. In India it is grown in 9.2 million ha area with production 24.17 million tonnes and average yield 2560 kg/ ha (Anonymous, 2015) while in Madhya Pradesh maize is cultivated in 1.13 million ha area with production of 2.062 million tonnes the average yield of maize in the state is 1790 kg /ha (Anonymous, 2015).

Maize crop is attacked by as many as 24 insect pests. Among these, stem borer (*Chilo partellus* Swin.), cob borer (*Stenachroia elongella* Hamp.) and shoot fly (*Atherigona soccata* Rond.) were found to be as major pests, seventeen insects as minor pest and others considered as stray pests. Crop damaged by major pests were estimated at 8.5 and 21.75 per cent by shoot fly, 15.67 and 13.45 per cent by stem borer and 11.95 and 6.5 per cent by cob borer during 2010 and 2011, respectively. *Patra et al.* (2013) Prakash *et al*. (2017) Nearly 139 species of insect pests have been observed to cause infestation to maize in India. Out of them, the major one is stem borer, *Chilo partellus* causing 90-95 per cent of the total damage in *Kharif* season. Natural enemies including seven coccinellid beetles, two predatory bugs and thirteen spider species have also been reported on maize

The detrimental effect of insecticides on the environment and human is also a matter of concern. Indiscriminate use of chemical insecticide creates many serious problems in maize like environmental contamination by way of pesticide residues, development of resistance in pests, danger for diseases, effect on wild life and pest resurgence etc. The new molecules are less toxic to mammals, birds and fish along with high insecticidal potency and checking the pest resistance in additive.

Keeping the above facts, in view the present study was carried out with the following objectives

1. To study on the population dynamics of major insect pests of maize and their correlation with weather parameters.
2. To study the efficacy of different insecticides against maize stem borer, *Chilo partellus*.
3. To work out the economics of different treatments of major insect pests of maize.

REVIEW OF LITERATURE

2.1 **To study on the population dynamics of major insect pests of maize and their correlation with weather parameter**

Dharmasena (2002) correlated the temporal distribution of *Chilo partellus* on maize with humidity, temperature, wind velocity and rainfall and reported that per cent stem damage was negatively correlated with minimum humidity and maximum temperature. Minimum humidity between 43.9 to 59 % and maximum temperature of 32°C prevailed at the second and third weeks after emergence of the maize crop resulted in the increase of maize stem borer population and percentage stem damage seven weeks after emergence. No relationship of wind velocity and rainfall was found with either per cent stem borer damage or the stem borer population.

Kandalkar *et al*. (2000) reported that mean temperature showed significant correlation with stem borer leaf injury with an r-value of -0.1734. The maximum temperature, morning and evening relative humidity and rainfall did not show significant effect on stem borer infestation.

Naz *et al*. (2003) reported that maize stem borer, *C. partellus* was found as serious pest with 24.5 per cent plant infestation followed by maize aphid, *Rhopalosiphum maidis* with 15 per cent plant infestation at tasseling stage.

According to Kandalkar and Men (2004) minimum temperature showed a significant and negative correlation with stem borer *C. partellus*, incidence.

Radha (2005) observed maximum population of *C. partellus* on maize during the first week of January *i.e.* at 35 days after germination (knee height stage) and continued up to the end of the tasseling stage. she also correlates the weather parameters with *C. partellus* population and found that none of the weather parameters could significantly influence the population of *C. partellus*

Saha (2006) reported that *C. partellus* infestation on sorghum was maximum (27% dead hearts) during the third week of February and minimum (3% dead hearts) during second fortnight of April. Among the abiotic factors minimum temperature (r = -0.2877), morning relative humidity and wind velocity (r = -0.1197) were negatively correlated but non-significant while maximum temperature was positively correlated (r = 0.3000) with the spotted stem borer population, but was non-significant.

Gaurav (2006) observed the incidence and damage caused by stem borer, *C. partellus*, in Nawanshahr district, Punjab, India. The leaf injury damage due to the *C. partellus* was maximum (21.74%) in crops sown on 5 June, where as dead heart formation was maximum (11.45%) in crops sown on 15 June. The borer caused maximum total infestation (29.37%) in crops sown on 5 June where as (26.35%) infestation was recorded in crops sown on 15 June

Farid *et al*. (2007) reported that maize stem borer damage varied from 10 to 50 per cent in Peshawar valley during 2003. Most of the borer damage occurred when the crop was in early vegetative stage and by the time it reached teaseling, no further increase in damage was observed.

Divya *et al.* (2009) took observations on the population dynamics of egg masses, larvae, pupae, number of plants damaged and parasitic interactions of natural enemies with larvae and pupae of *C. partellus* at weekly intervals at Dharwad (Karnataka). The stem borer population was significantly higher in *kharif* than in *rabi*-summer crop.

Zulfiqar *et al*. (2010) observed that minimum infestation up to16 per cent was found at the temperature of 36.5^{o}C and relative humidity 68 per cent. However, maximum infestation was found to be 45 per cent at temperature of 32.5^{0}C and relative humidity 50%

Biradar *et al*. (2011) conducted a field experiment at the Agricultural Research Station, Bagalkot and observed that the maximum dead hearts by stem borer were caused in the month of July (62%), and the minimum damage was noticed in the month of June (32%), December (32%) and January (32%).

Ahad *et al*. (2012) observed the seasonal incidence of stem borer, *C. partellus* in Jammu and Kashmir, India. Population densities of *C. partellus* were positively correlated with maximum temperature, minimum temperature and relative humidity. The adult stem borer was present throughout the growing season and its population peaked at 49 and 47 adults per trap.

Mallapur *et al*. (2012) reported about he the survey of incidence of stem borer, *C. partellus* in maize carried out in 12 districts of Karnataka. The survey data indicated that stem borer *C. partellus* incidence was quite prominent in all the places surveyed and the infestation ranged from 6.31 to 20.01 percent in different districts. The highest infestation was recorded in the month of August followed by July and September months.

Kore *et al.* (2013) observed that the seasonal incidence of stem borer, *C. partellus* occurred from 3rd week of August to 3rd week of October. The correlation studies indicated that the impact of rainfall and evening relative humidity were negative and bright sunshine was positively significant with stem borer infestation in terms of dead hearts.

Patra *et al*. (2013) recorded total 24 insect pests and some natural enemies including seven coccinellid beetles and two predatory bugs and thirteen spider species in maize crop. Among these, stem borer (*C. partellus*.), cob borer (*Stenachroia elongella*.) and shoot fly (*Atherigona soccata*) were found to be as major pests, seventeen insects as minor pest and others considered as stray pests. Crop damaged by major pests were estimated at 8.5 and 21.75 per cent by shoot fly, 15.67 and 13.45 per cent by stem borer and 11.95 and 6.5 per cent by cob borer during 2010 and 2011, respectively

Gowda *et al.* (2013) observed the seasonal incidence of stem borer, *C. partellus* during *Kharif* in Karnataka. The stem borer incidence was higher in July 2nd fortnight with 4.0-22.8 pinholes per plant and 2.14 percent dead hearts, while, the least incidence was observed during June

1st fortnight with 0.3 to 13.0 pinholes per plant and 1.03 percent dead hearts

Singh and Singh (2013) carried out a research at Rajmata Vijyaraje Scindia Krishi Vigyan Kendra, Zonal Agriculture Research Station, Morena, M.P during the year 2011-2012 in *Kharif* season on four varieties PEHM-2, Maharaja, NK-6240, NK-30 and found that the infestation of Stem borer *(C. partellus*) was highest at the temperature of 29.5 °C and at relative humidity 85% and lowest infestation at the temperature of 31.2 °C and at relative humidity 75 per cent respectively. The overall results of research work presented that the temperature, relative humidity are very responsible factors of the infestation of insect pest population in maize crop in *Kharif* season in Morena district

Meti *et al*. (2014) carried out a field experiment during *Rabi* / summer 2012-13 at the Agriculture College Farm, Bheemarayanagudi, University of Agricultural Sciences, Raichur and found that the stem borer incidence was found to be higher in zero tillage with mulch as compared to zero tillage without mulch and farmer's practice. In Zero tillage with mulch, the per cent dead heart by stem borers showed highly significant and positive correlation with rainfall and maximum and minimum temperature. Rainfall had highly significant positive correlation per cent dead heart by stem borers while, relative humidity showed positive correlation in zero tillage without mulch. In farmer's practice also minimum temperature had highly significant positive correlation with per cent dead heart by stem borers whereas, rainfall and relative humidity showed positive correlation.

Pawar *et al*. (2015) reported that the shoot fly, *A. soccata* showed peak incidence (dead hearts) in the month of August. Minimum temperature, relative humidity morning and evening showed significant and positive effect while maximum temperature had significant and negative effect on the incidence of shoot fly.

Kumar *et al.* (2015) observed seasonal incidence of shoot fly, *A. soccata* in *Kharif* season. Correlation study revealed that, rainfall found an important weather parameter which was having negative association with the egg population, while the effect of higher maximum temperature, minimum temperature, relative humidity in morning as well as in evening found positive.

Kumar *et al.* (2016) recorded eleven insect species attacking on different growth stage of maize crop, out of these stem borer, *C. partellus* (Swinhoe) and shoot fly, *A. soccata* (Rondani) as major pests, two insect *Rhopalosiphum maidis* and *Pyrilla perpusilla* as stray pests while other seven insects were appeared as minor insects to this region. The peak number of eggs laid by shoot fly (2.27) and (2.37 eggs/plant) were recorded at end week of March (13^{th} SMW) during the years, 2013 and 2014, respectively. The peak dead heart caused by shoot fly 26.18 and 26.40 per cent was recorded at first week of April (14^{th} SMW) during the both years of experimentation i.e. 2013 and 2014, respectively. In case of shoot fly incidence among the weather factors, only morning and evening relative humidity showed positive correlation while others had negative correlation

Kumar *et al*. (2016) showed that the stem borer infestation started from second week of August (33^{rd} SMW) with 4.61 percent dead heart and 6.29 per cent leaf injury rating of 1.4 and continued up to second week of September (37^{th} SMW). The infestation gradually increased and peak of 16.53 per cent dead heart and 15.56 percent leaf injury rating of 7.2 in first week of September (36^{th} SMW).

Patel *et al.* (2016) conducted a research at Krishi Vigyan Kendra, S.D. Agricultural University, Khedbrahma during *kharif* 2007 and 2008 entitled population dynamics of *C. partellus* on maize and found that the incidence of the *C. partellus* began from 3^{rd} week of July and continued up to 3^{rd} week of September with a peak activity in August. Rainfall had significantly negative association with *C. partellus* and damage was significantly negatively correlated with minimum temperature (2008), and significantly positively correlated with maximum temperature (2007)

Deole *et al.* (2017) studied on the population dynamics of pink stem borer during spring seasons for the year 2013-14 and 2014-15 at the

Research cum Instructional Farm, IGKV, Raipur (C.G.). The interactions between the larval population and weather parameters revealed non-significant correlation with maximum temperature (r = - 0.6519 and - 0.4964), while the interactions with morning and evening relative humidity was positively significant (r = 0.610 and 0.649) respectively.

Kumar *et al.* (2017) reported that the incidence of maize stem borer, *C. partellus* (Swinhoe) started from 2nd week of August and continued upto 4th week of October.

Keerthi *et al.* (2017) conducted field experiment during the cropping season of 2015- 16 at MARS, Raichur to characterize relationship of various meteorological parameters with shoot fly, incidence in terms of egg load and dead heart. The oviposition by shoot fly reached peak (3.10 eggs/ plant) during 35th SMW and also it was almost equal (2.9 eggs/ plant) during 33rd SMW. Similar trend was observed with respect to dead hearts, where it gradually increased and reached peaks (96.12 and 94.32%) during 33rd and 35th SMW. In all the correlated weeks, maximum had non-significant negative association with dead heart, but rainfall had significant positive association on dead heart during second and third week lead time.

Singh *et al.* (2018) conducted field experiment during *Kharif*- 2012 at Crop Research Centre (Chirori farm) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP) to characterize relationship of various meteorological parameters with sorghum shoot fly and stem borer incidence. In the experiment, maximum dead hearts due to *C. partellus* (Rondani) were recorded during crop season from 20th to 26th August (34th standard weeks). The shoot fly and stem borer incidence in the form of dead hearts was correlated with the meteorological parameters corresponding to the period of observations

kumar *et al.* (2018) carried out investigation at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during two consecutive year *kharif*, 2016 and *Kharif*, season 2017. The peak infestation caused by pink stem borer of 27.85 and 29.50 percent was recorded in the last week of August (34^{th} SMW) during *kharif* season 2016 and 2017, respectively. The data revealed that the correlation between percent infestation of *Sesamia inferens* was found positively significant with minimum (r=0.53) temperature, morning (r=0.45) and evening relative humidity (r=0.72) respectively. While rainfall had positive non-significant correlation (r=0.38) with percent infestation during *kharif*, 2016.

2.2 To Study the efficacy of different insecticides against maize stem boer, *Chilo partellus*

Sohail *et al.* (2003) reported that carbofuran 3 G (11kg/acre), cypermethrin 10 EC (150 ml/acre) and fipronil 10 G (220 ml/acre) were effective against *C. partellus* on maize.

Singh and Sharma (2009) conducted a field experiment during *Kharif* season of 2006 and 2007 on medium clay loam soil at Zonal Agricultural Research Station, Chandangaon, Chhindwara to know the effectiveness of Cypermethrin 25 EC, Monocrotophos 36 SC, Chlorpyriphos 20 EC, Carbofuron 3G, Phorate 10G with control plot against maize stem borer and concluded that application of Carbofuron 3G (15 kg/ha) was found to be effective in controlling of *C. partellus* and resulted in higher grain yield of maize.

Shahzad *et al*. (2010) evaluated the efficacy of Flubendiamide 48%, Emamection benzoate 1.9 EC, Spinosad 240 EC, Carbofuran 3 G, Indoxacarb 150 SC, Alpha Cypermethrine 20 EC against maize shoot fly (*A. soccata* Rondani) and maize stem borer, *C. Partellus* during. 2005-2006 and they manage the maize stem borer population below ETL

Ahmad *et al*. (2011) studied the relative efficacy of different insecticides as seed dressers, granules and foliar formulations against maize stem borer *(C. partellus)* in maize crop. The results of both the field experiments were similar Seed dressers (Confidor and Actara) were found considerably more effective as compared to granules and foliar sprays. As a whole the insecticides treatments resulted in 50 per cent reduction of MSB infestation as compared to control. Confidor was the most effective among the treatments causing 97.30 per cent reduction in *Chilo partellus* infestation. This was followed by Actara with 88 per cent infestation reduction as compared to control

Anuradha (2012) conducted field experiment to evaluate the different doses of Thiamethoxam 30 FS as seed treatment chemical for controlling maize stem borers, *C. partellus* (Swinhoe) and *Sesamia inferens* (Walker). Among the doses tested, higher dose of thiamethoxam 30 FS (8 9 ml/kg) proved superior resulting in 0.38 per cent dead hearts during *kharif* and 6.43 per cent dead hearts during *rabi* compared to 0.79 per cent and 14.76 per cent in untreated check.

Lamare *et al.* (2012) revealed that amongst the management trials with different pesticides, botanicals and synthetic insecticides, Imidacloprid 17.8 SL (0.25 ml/l) was the most effective against maize stem borer, followed by Flubendiamide where as, amongst the botanicals, Karanjin (2%) was found to be better than Anonin (1%) followed by neem oil (0.3%). Among all the pesticides, Imidacloprid was most effective in controlling the maize stem borer at the same time provided highest Kernel yield followed by Flubendiamide

Ramesh *et al.* (2012) conducted field experiments to evaluate the bioefficay of botanical pesticides, entomogenous microbes, insect growth regulators and natural insecticides in the management of stem borer, *C. partellus* in maize. Foliar application of Spinosad (0.002%) and Emamectin benzoate (0.002%) significantly reduced damage of *C.partellus* and the bioefficacy of these natural pesticides were found to be at par with that of Monocrotophos @ 0.05%. The marginal increase in maize grain yield was in the order of 38.66 and 31.93 per cent, respectively for the treatments Spinosad (0.002%) and Emamectin benzoate (0.002%) over untreated check.

Mallapur and Manjunath (2014) evaluated the efficacy of different insecticides against maize stem borer, *C. partellus* and found that Carbofuran 3 G at 7.5 kg/ha, Emamectin benzoate 5 SG at 0.2 gm/l, Spinosad 45 SC at 0.02 ml/l, Flubendiamide 480 SC at 0.2 ml/l were found effective in reducing the maize stem borer population, leaf injury rating and dead heart formation compared to control.

Zahid and Fayyaz (2014) studied the efficacy of different insecticides as granules and foliar formulations against *C. partellus* on maize crop. Two granular insecticides Carbofuran 3G @ 8 kg acre^{-1} Fipronil 4G @ 12 kg/ha and two foliar insecticides; Abamectin @ 10 ml/20 lit. and Profenophos 40% EC @ 500 g/l. were used the results revealed that Carbofuron 3G was recorded the most effective followed by Fipronil 4G. Average dead hearts count for Carbofuron 3G were 3.16 followed by 4.4 for Fipronil 4G.

Sneha *et al*. (2015) evaluated the bio-efficacy of ten insecticides *viz*., Dichlorvos 76 EC, Dimethoate 30 EC, Acephate 75 WP, Chlorofluzuron 25 EC, Fipronil 5 SC, Chlorantraniliprole 20 SC, Phorate 10 G, Neemazal 1.2%, Carbofuran 3 G and Emamectin benzoate 5 SG against maize stem borers*, C. partellus* and S. inferens during *kharif* 2013. The observed on the basis on leaf injury, pest infestation, stem tunneling and grain yield revealed that whorl application of Carbofuran 3 G at 7.5 kg/ha and phorate 10 G at 7.5 kg/ha proved the best and all other insecticides were superior compared to control

Kulkarni *et al*. (2015) studied the bio-efficacy of ten insecticides *viz*., Dichlorvos 76 EC, Dimethoate 30 EC, Acephate 75 WP, Chlorofluzuron 25 EC, Fipronil 5 SC, Chlorantaniliprole 20 SC, Phorate 10 G, Neemazal 11.2%, Carbofuron 3G, and Emamectin benzoate 5 SG against maize stem borers, *C. partellus* and *S. inferens* was evaluated during *Kharif* 2013. The observations based on leaf injury, pest infestation, stem tunneling and grain yield revealed that whorl application of Carbofuron 3G @ 7.5 kg/ha and Phorate 10 G @ 7.5 kg/ha proved to be the best followed by Emamectin benzoate 5 SG @ 0.2 g/l which performed highly effective and economical in reducing the stem borers damage in maize

Kumar *et al*. 2015 reported that the seed treatment with Chlorantraniliprole 18.5 SC @ 4 ml/kg seed and one spray @ 350 ml/ha was performed best with minimum infestation (4.5 per cent at 25 DAS and

7.42 per cent at 40 DAS), minimum number of dead hearts (2.33 per cent at 25 DAS and 1.66 per cent at 40 DAS) and minimum tunnel length (1.94 cm) followed by Fipronil 5 SC @ 4ml/kg seed and 625 ml/ha with infestation (7.84 and 10.27 per cent at 25 and 40 DAS), dead hearts (2.66 per cent at 25 DAS and 2.33 per cent at 40 DAS) and tunnel length (2.41 cm). The maximum infestation (30.45 per cent at 25 DAS and 31.30 per cent at 40 DAS), maximum number of dead hearts (7.33 per cent 25 DAS and 6.33 per cent at 40 DAS) and maximum tunnel length (11.07 cm) per plant was recorded with untreated control during the study. The maximum grain yield of 73.33 q/ha and net profit of Rs. 32714/ha obtained from the treatment of Chlorantraniliprole and followed by Fipronil. The minimum grain yield of 37.78 q/ha was recorded in untreated control.

Neupane *et al.* (2016) reported that use of pesticides had significant effect on percent damage and crop yield over control. In 2015, the lower percent damage (5.3%) with higher crop yield 4.52 t ha^{-1} and lowest insect score (1.00) was observed in plot sprayed with Spinosad 45% EC at 0.5 ml L^{-1} of water followed by plot treated with Chloropyriphos 50%EC+Cypermethrin 5%EC @1.5ml L^{-1} of water with percent damage of 6.60%, crop yield (4.23 t ha^{-1}) and insect score of 1.60. Almost similar trend of insect incidence along with damage percentage and yield data were observed in 2016. The higher percent damage control (79.06%) was observed at the plot sprayed after Spinosad 45% EC at 0.5 ml L^{-1} of water with higher crop yield (4.58 t $ha^{-1}$and lowest insect score (1.00) followed by the plot treated with Imidacloprid 17.8% @ 0.5 ml L^{-1} of water with percent damage control of 73.10 %, crop yield (3.38 t ha^{-1}) and insect sore 1.50. The highest percent damage (20.63%) was observed in the control plot with lower yield (0.95 tonne ha^{-1}) and highest insect score (6.00). Over the years, Spinosad 45% EC at 0.5 ml L^{-1} of water was effective bio-pesticide to control maize stem borer damage and also increase the yield

Bhanu *et al.* (2016) revealed that as a whole the insecticide treatments resulted in more than 50 per cent reduction of maize stem borer infestation as compared to untreated control. Among the insecticides, Imidacloprid 48 FS as seed dresser were found to be more effective as compared to granules and foliar sprays reduced considerably the infestation and recorded superior cob yields in both the seasons. This was followed by Flubendiamide 48 FS as foliar spray at 20 days after sowing.

Kumar *et al.* (2017) revealed that all the treatments were significantly superior over control among all the treatments Carbofuran recorded highest reduction of *C. partellus* (Swinhoe) population i.e. (7.70%) which was significantly superior over control followed by followed by Cypermethrin (9.86%) and Fipronil (13.38%) are at par with each other, followed by Indoxacarb (14.44%), Cartap recorded (15.37%), Profenophos (17.63%) then the treatment Imidacloprid (19.47%) was least effective among all the treatments.

Kumar *et al.* (2017) reported that the minimum leaf injury rating was recorded with Flubendiamide (3.23) followed by Thiamethoxam (3.43), Emamectin benzoate (3.57), Rynaxypyr (4.03) and Cartap hydrochloride (4.17) treated plots. Flubendiamide 20 WG was recorded the best effective treatment with the minimum dead heart percent per plant (13.33%), which was followed by Emamectin benzoate 5 SG (20.0%) Thiamethoxam 25 WG (20.0%), and Rynaxypyr 0.4G (20.0%), respectively.

Devananda *et al.* (2018) revealed that Flubendiamide 480 SC@ 0.016, and Cartap hydrochloride 4G@0.75 kg a.i./ha were found highly effective in reducing the larval population and dead heart and found on par to each other. Rest of the treatments Flubendiamide was superior over control in reducing stem borer incidence.

2.3 To work out the economics of different treatments of major insect Pests of maize

Chouraddi and Mallapur (2017) evaluated the different newer molecules of insecticides and found that Emamectin benzoate 5SG @ 0.2 g/l or Spinosad 45SC @ 0.2 ml/l at 25 DAS as well as whorl application of Carbofuran 3G @ 7.5 kg/ha being on par with each other proved superior over untreated control. Maximum net profit was recorded in Carbofuran and Endosulfan treatments (37851.00 and 37197.90 Rs./ha, respectively). The lower net profit was found in Imidacloprid and Thiomethoxam. the lower IBC ratio was recorded in Flubendiamide (5.07) and Thiomethoxam (6.72).

Kumar *et al.* (2017) reported that the highest grain yield was recorded in Flubendiamide 20 WG (34.00qha^{-1}), which was followed by Emamectin benzoate 5SG (31.92 q ha-1) and Rynaxypyr 0.4 G (30.6 qha-1) The grain yields was also significantly highly influenced by Flubendiamide 20 WG, followed by Emamectin benzoate 5 SG and Rynaxypyr 0.4% G and Fipronil 0.3% G. Among different insecticides tested, the highest net return was found in Flubendiamide 20WG (Rs.21496.2)

Reddy *et al*. (2018) showed that based on leaf injury rating, grain yield and cost benefit ratio, Flubendiamide 480 SC @ 0.1ml followed by Flubendiamide 480 SC @ 0.2 ml and Deltamethrin 2.8 EC @ 0.8 ml/l of water proved highly effective and economical in reducing the *C. partellus* damage.

Shahid *et al*. (2018) evaluated the efficacy of Fipronil 0.3G, Caorbofuran 3G and Cartal 10G @ 19.76, 19.76 and 4.94 kg/ha were tested against *Chilo partellus* (Swinhoe) on maize and it was observed that Fipronil proved to be the best resulted in the maximum CBR *i.e*., 1:24 as compared to 1:15 and 1:13 in Carbofuran and Cartal respectively

MATERIALS AND METHODS

Description of materials used and methods adopted during the course of investigation in order to conduct the experiment and record scheduled observations, on the present investigation entitled **“Seasonal incidence of major insect pests of maize *(Zea mays* L.*)* and their management through new insecticides”** carried out in the research field of JNKVV, College of Agriculture Tikamgarh (MP) during *kharif* 2018-19., are present in this chapter.

Geographical location

The field experiment was conducted at the Research Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Tikamgarh (M.P.) which is situated at 24' 430 North latitude and 78' 490 East longitude at an altitude of 358 meters mean sea level.

Climate

Tikamgarh district lies in the Bundelkhand Zone (Agro-climatic Zone-VIII). It is situated in the north-eastern part of Madhya Pradesh at 24' 430 North latitude and 78' 490 East longitude at an altitude of 358 meters mean sea level. It has sub-tropical climate characterized by hot dry summers and cool dry winter. The average maximum temperature during the month of May–June varies between 43.0 to 45.0 °C, while the average minimum temperature varies between 3.0 to 4.5 °C during December-January, which is the coldest months of the year.

Rainfall

The average annual rainfall of this region is about 1000 mm which is mostly received between June to September and a little rainfall (90 mm) is also obtained during October to May. The average humidity of the tract is about 70 per cent.

Soil

Soil of the experimental site was medium in organic carbon and nitrogen, high in phosphorus, medium in potassium and neutral in the action. (Bhati, 2015)

Meteorological observations:

The meteorological data prevailed during crop season (*Kharif* 2018-19) was recorded at the Meteorological Observatory located at College of Agriculture, Tikamgarh (M.P.) and presented in **Table 3.1** and depicted in **Fig-3.1**

During the course of conducting research, following objectives were undertaken:

1. To study on the population dynamics of major insect pests of maize and their correlation with weather parameters.
2. To study the efficacy of different insecticides against maize stem borer, *Chilo partellus*.
3. To work out the economics of different treatments of major insect pests of maize.

Table 3.1 Weekly meteorological data during the experimentation period i.e. (1st week of August 2018 to 2nd week of November 2018) at Tikamgarh

SMW	Date	Temperature		Relative humidity (%)		Rainfall	Evap
		Max.^{0}C	Min.^{0}C	Morning	Evening	Mm	Mm
31	30 to 5 Aug	41.6	36.2	88.40	68.9	5.90	2.5
32	06 to 12 Aug	31.8	24.5	92.14	71.3	5.37	3.2
33	13 to 19 Aug	31.5	25.1	94.85	76.6	9.65	2.9
34	20 to 26 Aug	29.1	24.1	98.14	84.0	11.40	2.1
35	27 to 2 Sep	29.4	23.4	97.85	86.4	24.06	2.1
36	03 to 9 Sep	26.5	22.4	97.00	90.6	13.80	1.6
37	10 to 16 Sep	29.6	20.5	94.28	67.6	1.10	2.0
38	17 to 23 Sep	31.9	22.4	86.57	58.7	0.34	3.0
39	24 to 30 Sep	34.0	21.1	86.71	40.3	0.00	3.4
40	01 to 7 Oct	36.5	19.6	74.71	30.3	0.00	3.9
41	08 to 14 Oct	34.6	18.4	80.00	41.3	0.00	3.9
42	15 to 21 Oct	35.2	17.2	68.14	33.3	0.00	4.2
43	22 to 28 Oct	33.0	15.2	75.57	31.0	0.00	3.5
44	29 to 4 Nov	31.6	15.1	70.42	47.0	0.00	3.5
45	05 to 11 Nov	29.3	10.7	77.14	31.3	0.00	2.9

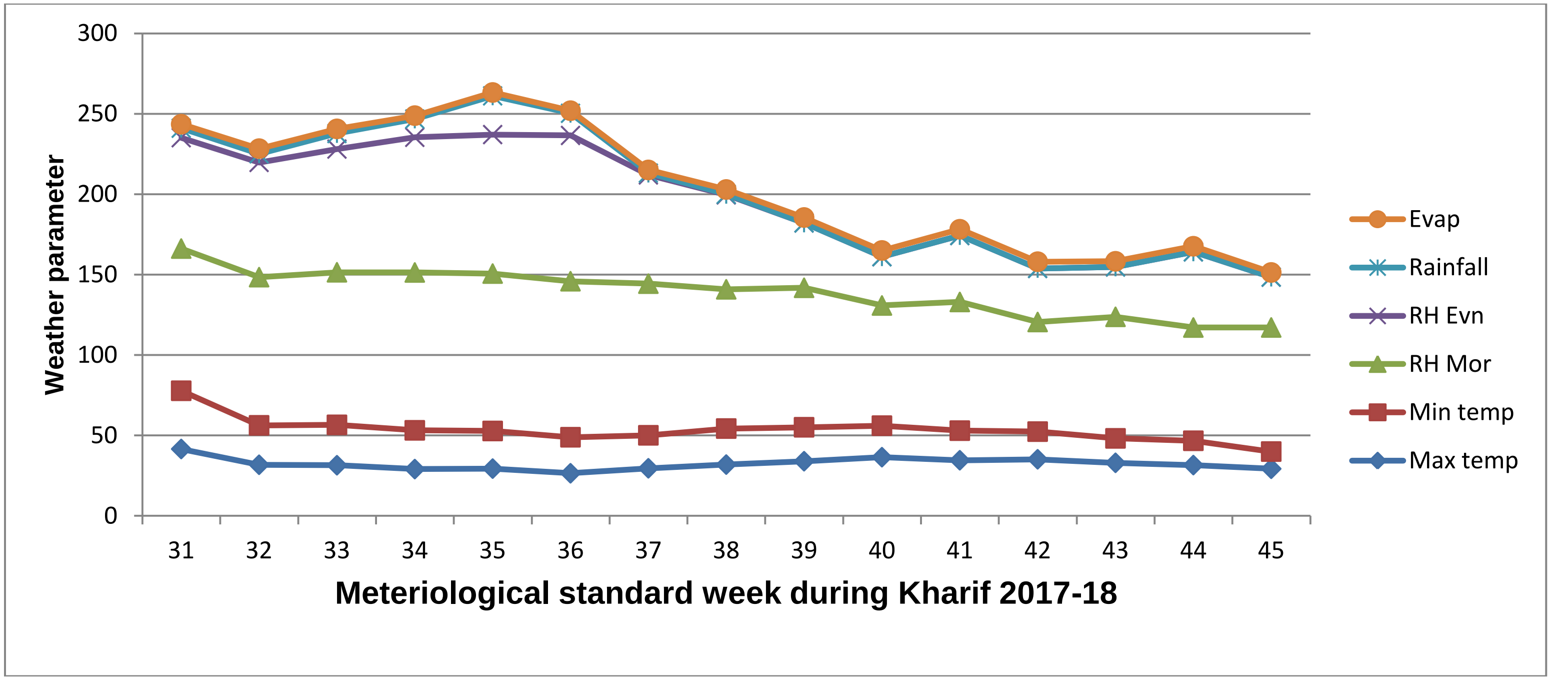


Fig.3.1 Weekly meteorological data during the experimentation period i.e. (2nd week of August 2018 to 4th week of January 2019) at Tikamgarh

3.1 To study on the population dynamics of major insect pests of maize and their correlation with weather parameters

3.1.1 Experimental details

The crop was grown during *kharif* season 2018-2019 with the following details:

Details of experiment layout:

1	Season	:	*Kharif*
2	Crop	:	Maize
3	Variety	:	Nath samrat 1144
4	Spacing	:	60 cm x 20 cm
5	Plot size	:	15 m. x 6 m.
6.	No. of rows	:	10
7.	Date of sowing	:	20/07/2018

3.1.2 Method of observations

Observations on seasonal incidence of major insect pests were recorded at weekly interval on randomly selected 10 plants starting from germination to harvesting of the crop.

The observation will be recorded with the following approach.

- Appearance of insect
- Stage of crop
- Peak period of activity
- Disappearance of insect

For the case of analysis and findings, meteorological data were pooled out at weekly interval. The data on infestation of various insects were correlated with prevailing temperature, relative humidity, evaporation and rainfall obtained from observatory of the college and similarly correlated with insect pest population.

3.1.3 Statistical analysis:

The seasonal incidence of pests and their natural enemies with abiotic factors were correlated on the basis of following formula.

$$r = \frac{\sum XY - n\overline{x}\overline{y}}{\sqrt{\sum \bar{X}^2 - n\bar{X}^2} \text{ x } \sqrt{\sum \bar{Y}^2 - n\bar{Y}^2}}$$

Where,

X= Mean of first factor

Y= Mean of second factor

n = Total no. of observations

r = Correlation coefficient

After correlating significant and non-significant findings, t-test value (n-2) degrees of freedom were calculated on the following formula:

$$\mathbf{t = r\sqrt{\frac{n-2}{1-r^2}}}$$

Where,

'n' is the number of observation and 'r' is the correlation coefficient, the value of 't' is based on (n-2) degree of freedom.

3.2 To study the efficacy of different insecticides against maize stem borer, *Chilo partellus*

Different insecticides namely Imidacloprid 17.8 SL Flubendiamide 39.5 SC, Emamectin Benzoate 5 SG, Fipronil 5 SC, Thiamethoxam 25 WG, Rynaxpyr 18.5 Ec, Phorate 10G were purchased from local market. The details of the experiments are as under.

3.2.1 Experimental details:

1	Design	:	Randomized Block Design
2	Season	:	*Kharif*
3	Crop	:	Maize
4	Variety	:	Nath samrat-1144
5	Seed rate	:	15-20 kg/ha
6	No. of replication	:	3
7	No. of treatment	:	8
8	Total No. of plots	:	24
9	Plot size	:	4.0 m x 3.0 m
10	Spacing	:	60 cm x 20 cm
11	Distance between replications	:	1 m.
12	Distance between plots	:	0.5 m.
13	No. of row / plots	:	7
14	Fertilizer application Half-N, full-P, full-K (Basal) Half N- Top dressing (45 DAS)	:	150:75:75 N.P.K. kg/ha
15	Date of sowing	:	20/07/2018

3.2.2 Treatment detail -

Treatment	Name of Insecticides	Doses gm or ml/ha
T_1	Imidacloprid 17.8 SL	110 ml
T_2	Flubendiamide 39.5 SC	150 ml
T_3	Emamectin benzoate 5 SG	200gm
T_4	Fipronil 5 SC	350 ml
T_5	Thiamethoxam 25 WG	100gm
T_6	Rynaxpyr 18.5 EC	160 ml
T_7	Phorate 10G	10 kg
T_8	Untreated	-

Spray schedule:

(1) 1st spray: After initiation of incidence of insect pests at ETL level.

(2) 2nd spray: 15 days after 1st spray.

Observations:

1. Pre treatment observation on incidence of *Chilo partellus* of maize was recorded one day before treatment.

2 Post treatment observations were recorded at 5, 10 and 15 day after the application of insecticides.

2. Observation on stem borer, *Chilo partellus* was recorded on following parameters *viz*.
   - Number of dead heart/10 plant
   - Leaf injury level/10 plant
   - Yield/ plot

3.2.3 Statistical analysis:

The data on pest population were transformed to square root (√x+0.5). The data thus transformed were subjected to statistical analysis for knowing the significance of different treatments; similarly, data on grain yield were also subjected to statistical analysis.

The data obtained from a set of observation for each character was tabulated and analysis by the method of "Analysis of variance" as suggested by Fisher and Yates, 1938.in Table 3.2.3.

Table 3.2.3. - The skeleton of analysis of variance for randomized block design

Sources of variance	D.f.	SS	MSS	$F_{Cal.}$	$F_{tab.}$	SEm ±	CD 5%
Replication	(r-1)	SSR	VR	VR/VE			
Treatments	(t-1)	SST	VT	VT/VE			
Error	(r-1) (t-1)	SSE	VE	-	-		
Total	(rt-1)	-	-	-	-		

The following formulae were used for standard error, critical difference and coefficient of variance estimations.

(a) $$\textbf{SEm} \pm = \sqrt{\frac{EMS}{R}}$$

(b) $$\textbf{C.D.} = \sqrt{\frac{2EMS}{R}} \times t(D.f.\,at\ 5\%)$$

Where,

R = Number of Replications, D.F = Degrees of Freedom

T = Number of Treatments, S.S. = Sum of Square

C.D. = Critical Difference, GM = Grand Mean

MSS= Mean Sum of Square, EMS = Error Mean Square

SEm ± = Standard Error of means

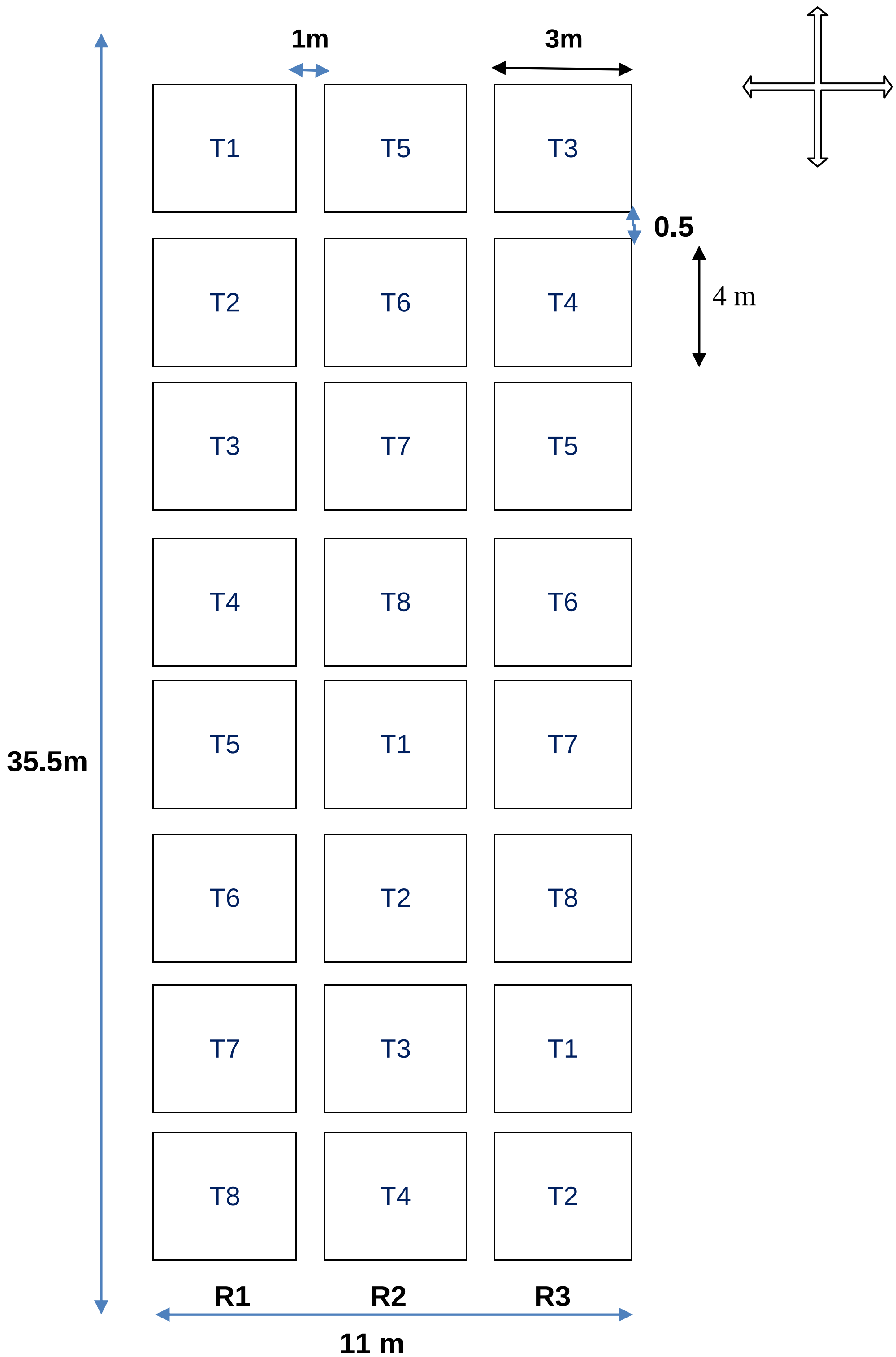
3.3 To work out the economics of different treatments of major insect pests of maize.

Economics of different treatments were worked out in comparison to control plot. Yield data was also analyzed and yield differences among different treatments were calculated. While comparing the yield from different treatments, the per cent increase in yield over control was calculated using the following formula (Pradhan, 1969)

$$\text{Increase in yield over control (\%)} = \frac{(T - C)}{C} \times 100$$

Where, T=Yield from treated plot.

C=Yield from control plot



Layout of experiment field

RESULTS

The Present study entitled **"Seasonal incidence of major insect pests of maize *(Zea mays* L.*)* and their management through new insecticides"** was conducted in *kharif season 2018*-19 at Research Farm, JNKVV, College of Agriculture, Tikamgarh (M.P.). Results of experiments were critically evaluated and statistically analyzed as per method suggested by Snedecor and Cochran (1967) as given in this chapter.

The present investigation was undertaken with the following objectives:

4. To study on the population dynamics of major insect pests of maize and their correlation with weather parameters.
5. To study the efficacy of different insecticides against maize stem borer, *Chilo partellus*.
6. To work out the economics of different treatments of major insect pests of maize.

4.1 To study the seasonal incidence of major insect pests of maize.

During the present investigation three major insect pests of maize *ie*. stem borer (*Chilo partellus* Swinhoe), pink stem borer (*Sesamia inferens* Walker), shoot fly (*Atherigona soccata* Rondani), were observed for their date of appearance, stages of crop attacked peak activity and disappearance of these insect as given in table below:

Table 4.1 Observations on major insect pests on maize crop

SN	Name of insect	Appearance of insect	Stages of crop	Peak period of activity	Disappearance of insect
1.	**Stem borer**	10 august	Knee stage Tasseling Grain filling stage	35 SMW (27 Aug to 2 Sep)	95 to 105 day old crop 45 SMW
2.	**Shoot fly**	10 august	Knee stage Tasseling Cob development	35 SMW (27 Aug to 2 Sep)	75 to 80 day old crop 42 SMW
3.	**Pink stem borer**	15 august	Knee stage Cob development Tasseling Grain maturing stage	36 SMW (3 Sep to 9 Sep)	105 to 110 old crop 45 SMW

4.1.1 Maize stem borer, (*Chilo partellus*)

The first appearance of maize stem borer, *C. partellus* was recorded during 32th SMW (06 Aug to 12 Aug) with the population 0.10 number of dead heart/10 plant. At that time the crop was 15 to 20 days old with 3 to 5 leaf stage of maize plant. thereafter, the population was observed in increasing trend up to 35th SMW and reached at its peak (0.70 number of dead heart/10 plant) during 35th SMW (27 Aug. to 02 Sep.), when the crop was 35 to 40 days old and 10 to 12 leaf tasseling stage of plant. After that the declined trend was observed and reached its lowest level with the population of (0.10 number of dead heart/10 plant) during 44th SMW after 95 to 105 days old crop and in grain filling stage. During the study period maximum and minimum temperature were 29.4 ^{0}C and 23.4 ^{0}C, and morning and evening relative humidity were 97.85% and 86.4% respectively, whereas the rainfall and evaporation were 24.06 mm and 2.1 mm respectively

Correlation studies:

The correlation studies between stem borer population and weather parameters revealed that stem borer population was highly significantly and positive correlated with minimum temperature, morning and evening relative humidity and rainfall (0.84,0.88,0.71 and 0.71).The relation between the stem borer and maximum temperature and evaporation was negatively correlated but statistically non-significant (0.05 and -0.51). respectively.

Table 4.1.1. Seasonal incidence of maize Stem borer at Tikamgarh during 2018-19.

SMW	Date	Temperature		Relative humidity (%)		Rainfall	Evap.	Stem borer number of dead heart/10 plant
		Max.^{0}C	**Min.^{0}C**	**Morning**	**Evening**	**mm**	**Mm**	
31	30 to 5 Aug	41.6	36.2	88.40	68.9	5.90	2.5	**0.00**
32	06 to 12 Aug	31.8	24.5	92.14	71.3	5.37	3.2	**0.10**
33	13 to 19 Aug	31.5	25.1	94.85	76.6	9.65	2.9	**0.30**
34	20 to 26 Aug	29.1	24.1	98.14	84.0	11.40	2.1	**0.50**
35	27 to 2 Sep	29.4	23.4	97.85	86.4	24.06	2.1	**0.70**
36	03 to 9 Sep	26.5	22.4	97.00	90.6	13.80	1.6	**0.60**
37	10 to 16 Sep	29.6	20.5	94.28	67.6	1.10	2.0	**0.60**
38	17 to 23 Sep	31.9	22.4	86.57	58.7	0.34	3.0	**0.50**
39	24 to 30 Sep	34.0	21.1	86.71	40.3	0.00	3.4	**0.40**
40	01 to 7 Oct	36.5	19.6	74.71	30.3	0.00	3.9	**0.30**
41	08 to 14 Oct	34.6	18.4	80.00	41.3	0.00	3.9	**0.30**
42	15 to 21 Oct	35.2	17.2	68.14	33.3	0.00	4.2	**0.10**
43	22 to 28 Oct	33.0	15.2	75.57	31.0	0.00	3.5	**0.30**
44	29 to 4 Nov	31.6	15.1	70.42	47.0	0.00	3.5	**0.10**
45	05 to 11 Nov	29.3	10.7	77.14	31.3	0.00	2.9	**0.00**
	Correlation studies	0.05	0.84**	0.88**	0.71**	0.71**	-0.51	

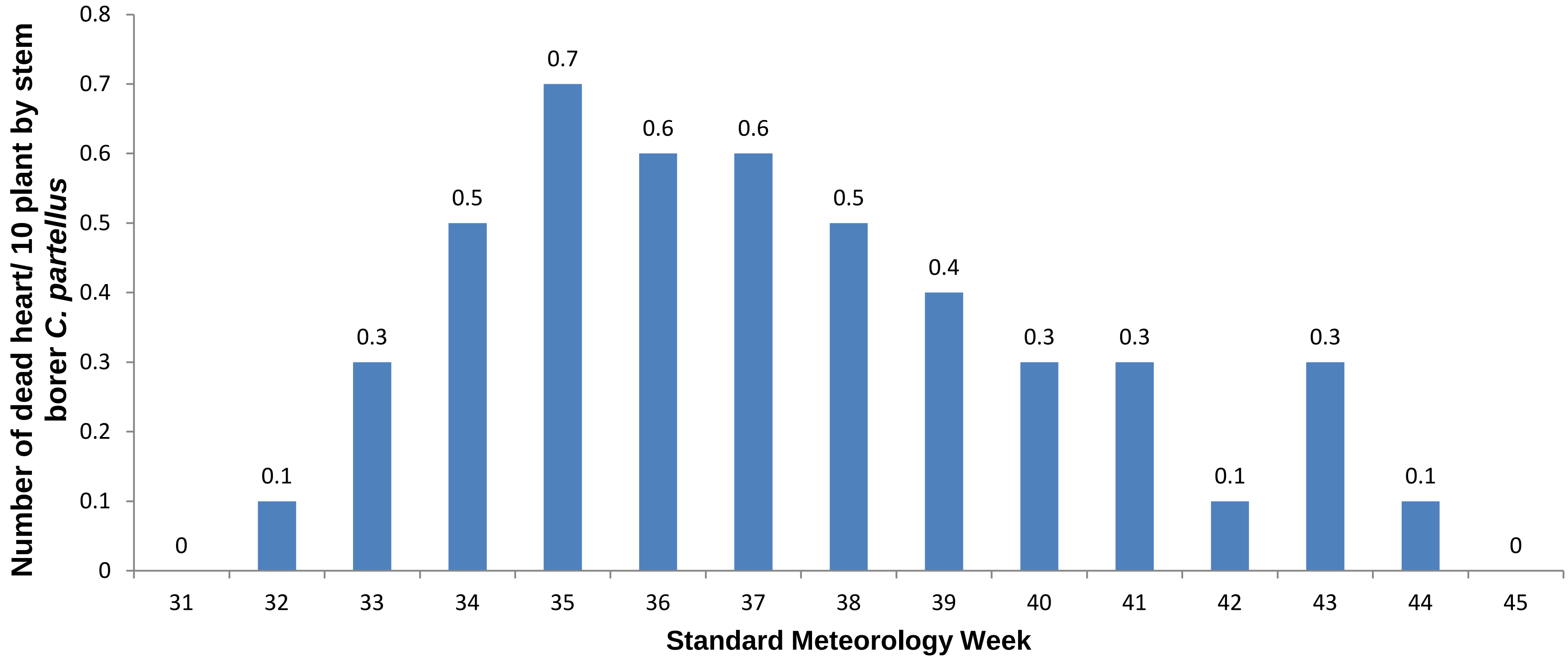


Fig 4.1.1 Seasonal incidence of maize Stem borer at Tikamgarh during 2018-19.

4.1.2 Maize shoot fly (*Atherigona soccata* Rondani)

The first appearance of maize shoot fly (*Atherigona soccata* Rondani) was recorded during 32^{th} SMW (06 Aug to 12 Aug.) with the population 0.10 Number of dead heart/10 plant when the crop was 15 to 20 days old and 3 to 5 leaf stage of maize plant Thereafter, the population was observed in increasing trend up to 35^{th} SMW and the population of maize shoot fly reached at its peak level (0.80 number of dead heart/10 plant) during 35^{th} SMW (27 Aug. to 02 Sep) when the crop was 35 to 40 days old and 10 to 12 leaf tasseling stage of plant after that, declined trend was observed and reached its lowest level with the population of (0.20 number of dead heart/10 plant) during 41^{th} SMW at that time the crop was 80 to 95 days old and in pollination stage. During the study period, maximum and minimum temperature were 29.4 ^{0}C and 23.4 ^{0}C, respectively and morning and evening relative humidity were 97.85% and 86.4% respectively, while rainfall and evaporation were 24.06 mm and 2.1 mm respectively

Correlation studies:

The correlation studies between maize shoot fly *(A. soccata* Rondani) population and weather parameters revealed that maize shoot fly *(A. soccata* Rondani) population was highly significantly and positively correlated with minimum temperature, morning and evening relative humidity and rainfall (0.79,0.91,0.75,0.77). The relation between shoot fly and maximum temperature (-0.14) was negative non-significant and with evaporation it was recorded to be negative and significantly correlated (-0.60).

Table 4.1.2 Seasonal incidence of maize shoot fly *A. soccata* at Tikamgarh during 2018-19.

SMW	Date	Temperature		Relative humidity (%)		Rainfall	Evap	Shoot fly number of dead heart/10 plant
		Max.^{0}C	Min.^{0}C	Morning	Evening	mm	mm	
31	30 to 5 Aug	41.6	36.2	88.40	68.9	5.90	2.5	**0.00**
32	06 to 12 Aug	31.8	24.5	92.14	71.3	5.37	3.2	**0.10**
33	13 to 19 Aug	31.5	25.1	94.85	76.6	9.65	2.9	**0.50**
34	20 to 26 Aug	29.1	24.1	98.14	84.0	11.40	2.1	**0.50**
35	27 to 2 Sep	29.4	23.4	97.85	86.4	24.06	2.1	**0.80**
36	03 to 9 Sep	26.5	22.4	97.00	90.6	13.80	1.6	**0.40**
37	10 to 16 Sep	29.6	20.5	94.28	67.6	1.10	2.0	**0.50**
38	17 to 23 Sep	31.9	22.4	86.57	58.7	0.34	3.0	**0.30**
39	24 to 30 Sep	34.0	21.1	86.71	40.3	0.00	3.4	**0.30**
40	01 to 7 Oct	36.5	19.6	74.71	30.3	0.00	3.9	**0.20**
41	08 to 14 Oct	34.6	18.4	80.00	41.3	0.00	3.9	**0.20**
42	15 to 21 Oct	35.2	17.2	68.14	33.3	0.00	4.2	**0.00**
43	22 to 28 Oct	33.0	15.2	75.57	31.0	0.00	3.5	**0.00**
44	29 to 4 Nov	31.6	15.1	70.42	47.0	0.00	3.5	**0.00**
45	05 to 11 Nov	29.3	10.7	77.14	31.3	0.00	2.9	**0.00**
	Correlation studies	- 0.14	0.78**	0.91**	0.78**	0.71**	- 0.60	

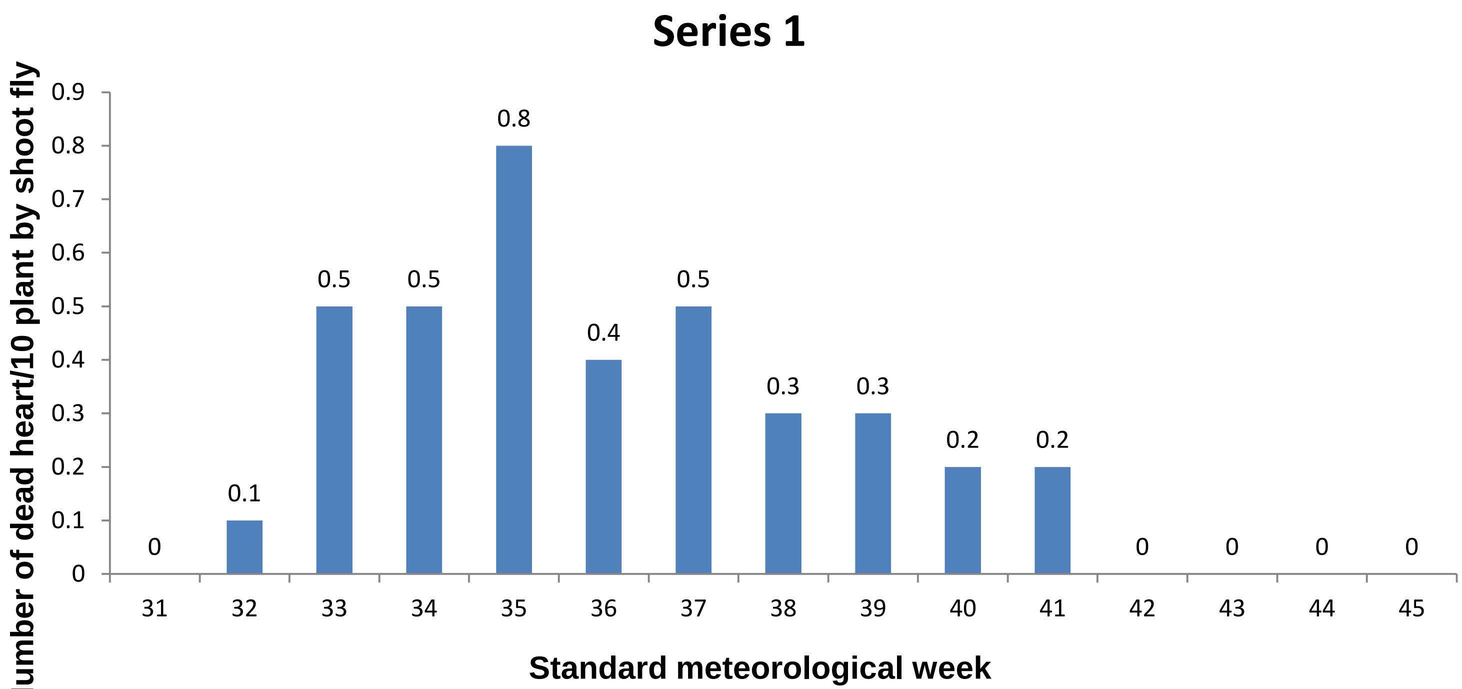


Fig 4.1.2 Seasonal incidence of maize shoot fly *A. soccata* at Tikamgarh during 2018-19

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4.1.3 Maize pink stem borer (*Sesamia inferens* Walker).

The first appearance of maize pink stem borer (*S. inferens* Walker) was recorded during 33rd SMW (13 Aug to 19 Aug) with the population 0.10 number of dead heart/10 plant when the crop was 20 days old and in 5 leaf stage. Thereafter, the population increased gradually up to 36th SMW and reached at its peak level (0.60 number of dead heart/10 plant) during 36th SMW (03 Sep. to 09 Sep.). After that the population was same in 37th and 38th SMW at that time the crop was 40 days old and 12 leaf cob development stage of plant. Thereafter the declined trend was observed and reached its lowest level with the population of (0.20 number of dead heart/10 plant) during 45th SMW. During the study period maximum and minimum temperature were 26.5 ^{0}C and 22.4 ^{0}C, respectively morning and evening relative humidity were 97% and 90.6% respectively. While rainfall and evaporation were 13.8 mm and 1.6 mm respectively.

Correlation studies:

The correlation studies between maize pink stem borer (*S. inferens* Walker) population and weather parameters revealed the population was highly significantly positive correlated with minimum temperature and morning relative humidity (0.87,0.62). The relation between pink stem borer and maximum temperature was found positive correlated but non significant (0.03) and relation with rainfall and evening relative humidity was positive and significant (0.61, 0.85) while with evaporation it was negative and non significantly correlated (-0.45).

Table 4.1.3 Seasonal incidence of maize pink stem borer at Tikamgarh during 2018-19.

SMW	Date	Temperature		Relative humidity (%)		Rainfall	Evap	Pink stem borer number of dead heart/10 plant
		Max.^{0}C	Min.^{0}C	Mor	Eve	Mm	mm	
31	30 to 5 Aug	41.6	36.2	88.40	68.9	5.90	2.5	**0.00**
32	06 to 12 Aug	31.8	24.5	92.14	71.3	5.37	3.2	**0.00**
33	13 to 19 Aug	31.5	25.1	94.85	76.6	9.65	2.9	**0.10**
34	20 to 26 Aug	29.1	24.1	98.14	84.0	11.40	2.1	**0.40**
35	27 to 2 Sep	29.4	23.4	97.85	86.4	24.06	2.1	**0.50**
36	03 to 9 Sep	26.5	22.4	97.00	90.6	13.80	1.6	**0.60**
37	10 to 16 Sep	29.6	20.5	94.28	67.6	1.10	2.0	**0.60**
38	17 to 23 Sep	31.9	22.4	86.57	58.7	0.34	3.0	**0.60**
39	24 to 30 Sep	34.0	21.1	86.71	40.3	0.00	3.4	**0.50**
40	01 to 7 Oct	36.5	19.6	74.71	30.3	0.00	3.9	**0.50**
41	08 to 14 Oct	34.6	18.4	80.00	41.3	0.00	3.9	**0.40**
42	15 to 21 Oct	35.2	17.2	68.14	33.3	0.00	4.2	**0.20**
43	22 to 28 Oct	33.0	15.2	75.57	31.0	0.00	3.5	**0.30**
44	29 to 4 Nov	31.6	15.1	70.42	47.0	0.00	3.5	**0.20**
45	05 to 11 Nov	29.3	10.7	77.14	31.3	0.00	2.9	**0.20**
	Correlation studies	0.03	0.87**	0.85**	0.62**	0.61**	-0.45	

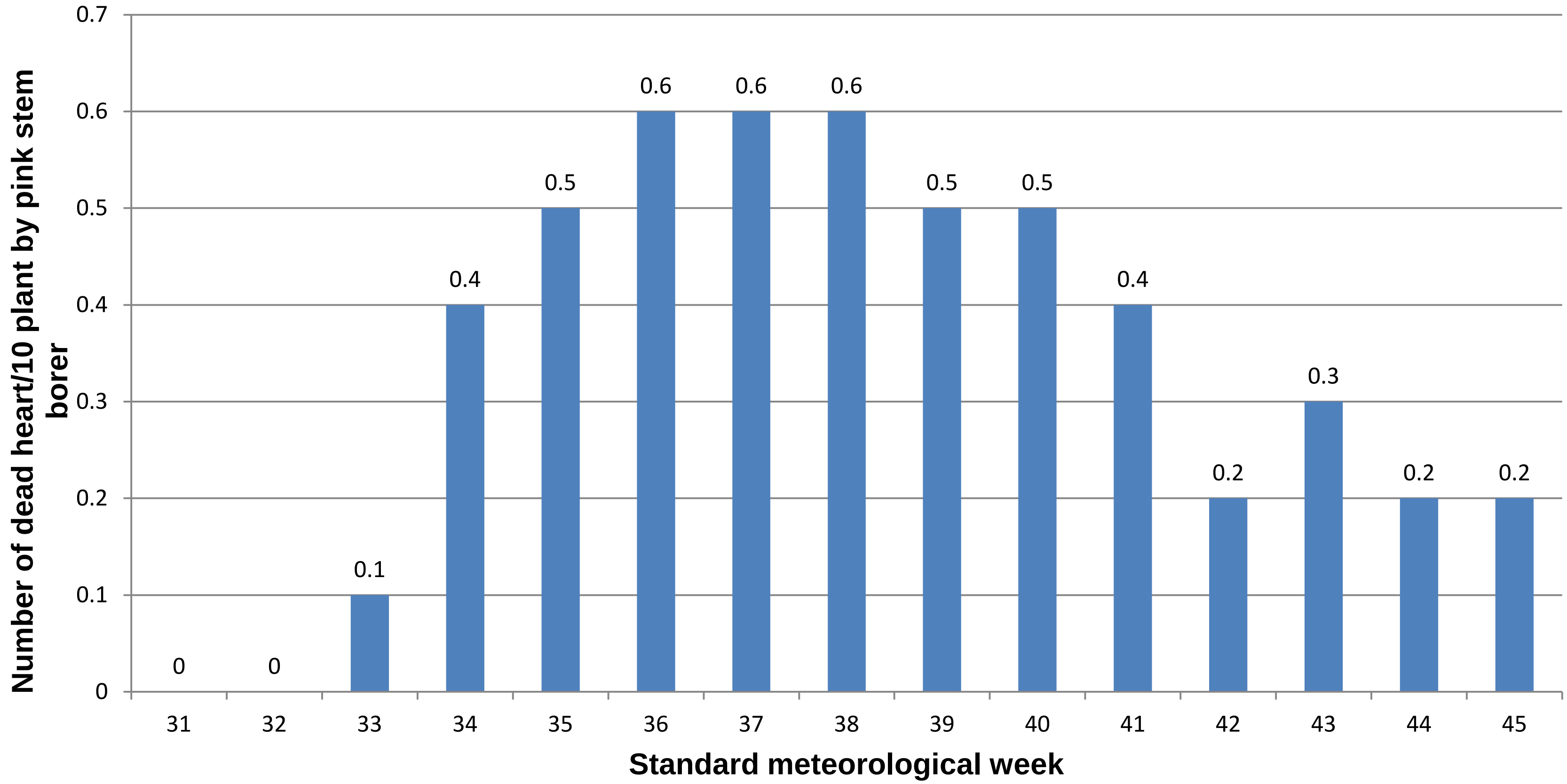

Fig 4.1.3 Seasonal incidence of maize pink stem borer at Tikamgarh during 2018-19

Table: 4.1.4 Correlations coefficient of different dependent and independent variables.

Meteorological parameters	Correlation Coefficient		
	Stem borer	Shoot fly	Pink stem borer
Max. Temperature	0.05	-0.14	0.03
Min. Temperature	0.84**	0.78**	0.87**
RH (morning)	0.88**	0.91**	0.85**
RH (evening)	0.71**	0.75**	0.62*
Evap (mm)	-0.51	-0.60*	-0.45
Rain fall (mm)	0.71**	0.77**	0.61*

- *correlation at 5% level
- **correlation at 1%level

4.2 To study the efficacy of new insecticides against maize stem Borer, *Chilo partellus*

To evaluate the efficacy of treatments on maize stem borer foliar sprays were given only twice - first at 43 days after sowing and second at 59 days after sowing. Observations of maize stem borer were recorded 1 day before spray and 5, 10 and 15 days after each spray. Seed yield (Kg/ha) and economics of the treatments were also computed.

4.2.1 Effect of different insecticides on the population of maize stem borer, (*Chilo partellus)*.

4.2.1.1 First spray

Pre-treatment observations:

Pre-treatment observation was recorded 1 day before first spray. Population of stem borer ranged from 0.47 to 0.70 Number of dead heart/10 plant The stem borer population in various treatment plots did not differ significantly (Table 4.2.1 and fig. 4.2.1).

Post treatment observations

5 days after first spray

All the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.77 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T_2) (0.10 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T_3) (0.13 Number of dead heart/10 plant), Phorate 10G (T_7) (0.20 Number of dead heart/10 plant) Fipronil 5 SC (T_4) (0.30 Number of dead heart/10 plant), Thiamethoxam 25 WG (T_5) (0.37 Number of dead heart/10 plant), and Rynaxpyr 18.5 Ec (T_6) (0.40 Number of dead heart/10 plant) Imidacloprid 17.8 SL was found least effective treatment with 0.50 Number of dead heart/10 plant.

10 days after first spray

All the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.80 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.17 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.20 Number of dead heart/10 plant), Phorate 10G (T7) (0.30 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.33 Number of dead heart/10 plant).

15 days after first spray

After 15 days of spray, all the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.83 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.30 Number of dead heart/10 plant), was found to be most effective followed by Emamectin Benzoate 5 SG (T3) (0.40 Number of dead heart/10 plant), Phorate 10G (T7) (0.50 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.60 Number of dead heart/10 plant).

Over all mean

Pooled statistical analysis of all the observations (5, 10 and 15 DAS) of 1^{st} spray indicated that all the insecticidal treatments were significantly effective in reducing the population of stem borer as compared to control (T_8) (0.78 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.19 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.24 Number of dead heart/10 plant), Phorate 10G (T7) (0.33 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.41 Number of dead heart/10 plant). Whereas Imidacloprid 17.8 SL (T_1) (0.54 Number of dead heart/10 plant), was found least effective treatment.

Table 4.2.1.1 Efficacy of different insecticides against maize stem borer (1^{st} spray)

Treatments	Dose gm or ml/ha	Number of dead heart/10 plant Mean of first spray				
		1 DBS#	5 DAS**	10 DAS	15 DAS	Mean
T1 - Imidacloprid 17.8 SL	110 ml	0.57 (1.03)*	0.50 (1.00)	0.60 (1.05)	0.67 (1.08)	0.59 (1.04)
T2 - Flubendiamide 39.5 SC	150 ml	0.60 (1.05)	0.10 (0.77)	0.17 (0.82)	0.30 (0.89)	0.19 (0.83)
T3 - Emamectin benzoate 5 SG	200gm	0.67 (1.08)	0.13 (0.80)	0.20 (0.84)	0.40 (0.95)	0.24 (0.86)
T4 - Fipronil 5 SC	350 ml	0.70 (1.10)	0.30 (0.89)	0.33 (0.91)	0.60 (1.05)	0.41 (0.95)
T5 - Thiamethoxam 25 WG	100gm	0.53 (1.02)	0.37 (0.93)	0.40 (0.95)	0.60 (1.05)	0.46 (0.98)
T6 - Rynaxpyr 18.5 Ec	160 ml	0.63 (1.06)	0.40 (0.95)	0.50 (1.00)	0.63 (1.06)	0.51 (1.01)
T7 - Phorate 10G	10 kg	0.47 (0.98)	0.20 (0.84)	0.30 (0.98)	0.50 (1.00)	0.33 (0.91)
T8 – Untreated	-	0.60 (1.05)	0.77 (1.13)	0.80 (1.14)	0.83 (1.15)	0.78 (1.13)
SEm±		0.06	0.05	0.04	0.03	0.01
CD at 5%		N/S	0.15	0.12	0.09	0.04

Figures in parenthesis are √x+ 0.5 transformed values

- *√x+ 0.5 transformed values are used for analysis
- #DBS – Day before spray
- **DAS – Day after spray

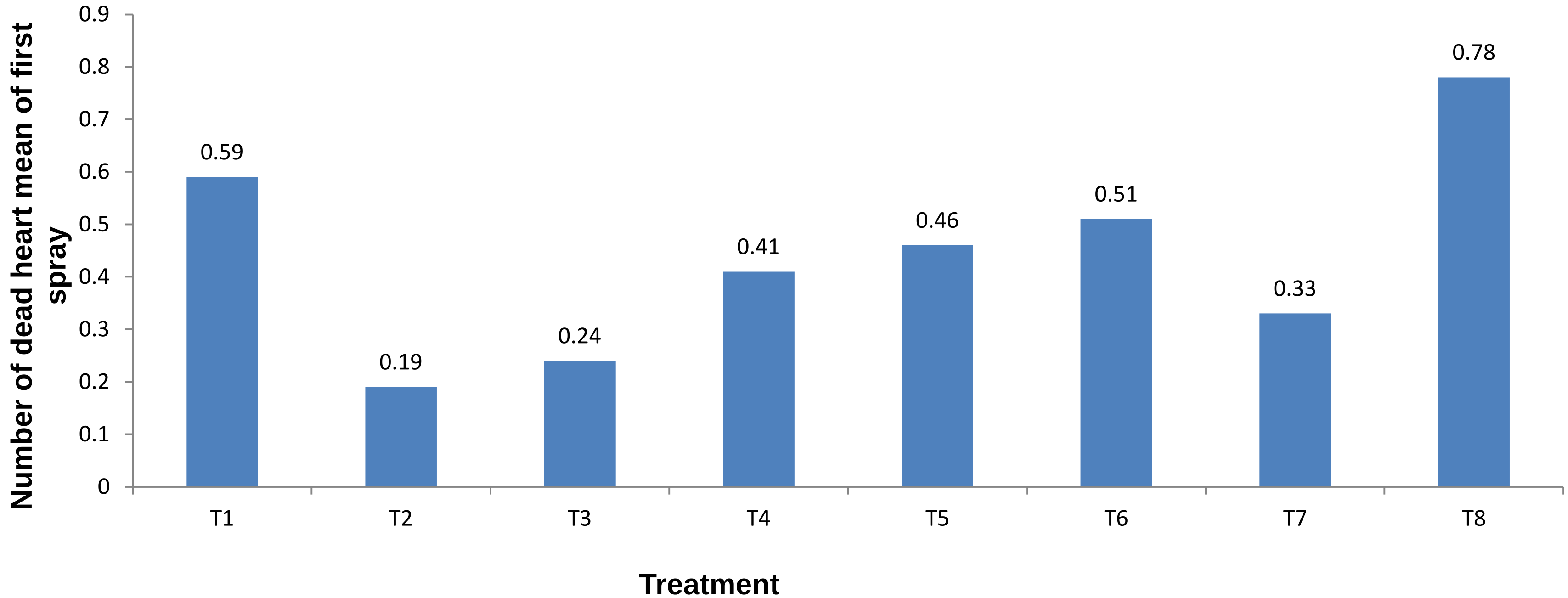

Fig 4.2.1.1 - Efficacy of different insecticides against maize *stem borer* (1st spray)

4.1.1.2 Effect of different insecticides against maize stem borer, *Chilo partellus* (2nd spray).

Pre-treatment observations:

Pre-treatment observation was recorded 1 day before second spray. Population of stem borer ranged from 0.47 to 0.87 number of dead heart/10 plant The stem borer population in various treatment plots did not differ significantly (Table 4.2.2 and fig. 4.2.2).

Post treatment observations:

5 days after second spray:

All the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.73 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T_2) (0.10 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T_3) (0.20 Number of dead heart/10 plant), Phorate 10G (T_7) (0.30 Number of dead heart/10 plant) Fipronil 5 SC (T_4) (0.33 Number of dead heart/10 plant), Thiamethoxam 25 WG (T_5) (0.40 Number of dead heart/10 plant), Rynaxpyr 18.5 Ec (T_6) (0.50 Number of dead heart/10 plant) and Imidacloprid 17.8 SL (T_1) (0.53 Number of dead heart/10 plant).

10 days after second spray:

All the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.77 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.20 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.30 Number of dead heart/10 plant), Phorate 10G (T7) (0.40 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.47 Number of dead heart/10 plant

15 days after second spray:

After 15 days of spray, all the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.80 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.20 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.30 Number of dead heart/10 plant), Phorate 10G (T7) (0.40 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.50 Number of dead heart/10 plant).

Over all mean

Pooled statistical analysis of all the observations (5, 10 and 15 DAS) of 2nd spray indicated that all the insecticidal treatments were significantly effective in reducing the population of stem borer as compared to control (T_8) (0.77 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.17 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.27 Number of dead heart/10 plant), Phorate 10G (T7) (0.37 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.43 Number of dead heart/10 plant). Rynaxpyr 18.5 Ec (0.57 Number of dead heart/10 plant) whereas Imidacloprid 17.8 SL (T_1), (0.59 Number of dead heart/10 plant) was found least effective treatment.

Table 4.1.1.2 Efficacy of different insecticides against maize stem borer (2nd spray)

Treatments	Dose gm or ml/ha	Number of dead heart/10 plant Mean of second spray				
		1 DBS#	5 DAS**	10 DAS	15 DAS	Mean
T1 - Imidacloprid 17.8 SL	110 ml	0.60 (1.05)*	0.60 (1.02)	0.57 (1.03)	0.60 (1.05)	0.59 (1.04)
T2 - Flubendiamide 39.5 SC	150 ml	0.70 (1.10)	0.10 (0.77)	0.20 (0.84)	0.20 (0.84)	0.17 (0.82)
T3 - Emamectin benzoate 5 SG	200gm	0.73 (1.11)	0.20 (0.84)	0.30 (0.89)	0.30 (0.89)	0.27 (0.88)
T4 - Fipronil 5 SC	350 ml	0.87 (1.17)	0.33 (0.91)	0.47 (0.98)	0.50 (1.00)	0.43 (0.97)
T5 - Thiamethoxam 25 WG	100gm	0.67 (1.08)	0.40 (0.95)	0.50 (1.00)	0.57 (1.03)	0.49 (0.99)
T6 - Rynaxpyr 18.5 Ec	160 ml	0.63 (1.06)	0.50 (1.00)	0.60 (1.05)	0.60 (1.05)	0.57 (1.03)
T7 - Phorate 10G	10 kg	0.47 (0.98)	0.30 (0.89)	0.40 (0.95)	0.40 (0.95)	0.37 (0.93)
T8 – Untreated	-	0.70 (1.10)	0.73 (1.11)	0.77 (1.13)	0.80 (1.14)	0.77 (1.13)
SEm± **CD at 5%**		0.05 N/S	0.03 0.11	0.04 0.12	0.04 0.12	0.01 0.02

Figures in parenthesis are √x+ 0.5 transformed values

- *√x+ 0.5 transformed values are used for analysis
- #DBS – Day before spray
- **DAS – Day after spray

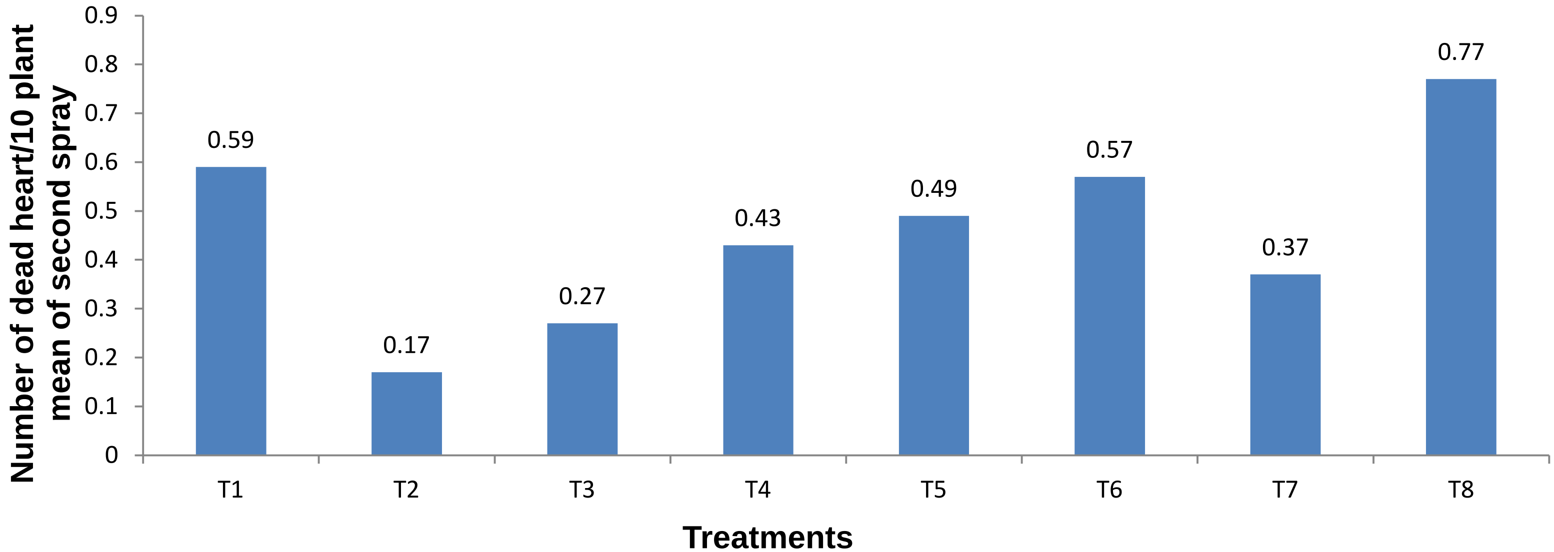

Fig4.1.1.2- Efficacy of different insecticides against maize *stem borer* after 2nd spray

4.1.1.3 Effect of different insecticides against maize stem borer, (*Chilo partellus*)

Pooled mean of 1st and 2nd spray:

Pre-treatment observations:

Pre-treatment observation was recorded 1 day before pooled mean of first and second spray. Population of stem borer ranged from 0.47 to 0.78 Number of dead heart/10 plant The stem borer population in various treatment plots did not differ significantly (Table 4.2.3 and fig. 4.2.3).

Post treatment observations:

Pooled mean population of stem borer at 5 days

All the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.73 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T_2) (0.10 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T_3) (0.17 Number of dead heart/10 plant), Phorate 10G (T_7) (0.25 Number of dead heart/10 plant) Fipronil 5 SC (T_4) (0.32 Number of dead heart/10 plant), Thiamethoxam 25 WG (T_5) (0.38 Number of dead heart/10 plant), Rynaxpyr 18.5 Ec (T_6) (0.45 Number of dead heart/10 plant) and Imidacloprid 17.8 SL (T_1) (0.52 Number of dead heart/10 plant).

Pooled mean population of stem borer at 10 days

All the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.75 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.18 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.25 Number of dead heart/10 plant), Phorate 10G (T7) (0.35 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.40 Number of dead heart/10 plant).

Pooled mean population of stem borer at 15 days:

After 15 days of spray, all the insecticidal treatments were found significantly effective in reducing the population of stem borer as compared to untreated plots (T_8) (0.77 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.25 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.35 Number of dead heart/10 plant), Phorate 10G (T7) (0.42 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.55 Number of dead heart/10 plant).

Over all mean

Pooled statistical analysis of all the observations (5, 10 and 15 DAS) of before pooled mean of first and second spray indicated that all the insecticidal treatments were significantly effective in reducing the population of stem borer as compared to control (T_8) (0.75 Number of dead heart/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.18 Number of dead heart/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.26 Number of dead heart/10 plant), Phorate 10G (T7) (0.35 Number of dead heart/10 plant) Fipronil 5 SC (T4) (0.42 Number of dead heart/10 plant). Whereas Imidacloprid 17.8 SL (T_1) (0.59 Number of dead heart/10 plant), was found least effective treatment.

Table 4.1.1.3 Efficacy of different insecticides against maize stem borer (1st and 2nd spray)

Treatments	Dose gm or ml/ha	Number of dead heart/10 plant (Mean of 1st and 2nd spray)				
		1 DBS#	5 DAS**	10 DAS	15 DAS	Mean
T1 - Imidacloprid 17.8 SL	110 ml	0.58 (1.04)*	0.55 (1.02)	0.58 (1.04)	0.63 (1.06)	0.59 (1.04)
T2 - Flubendiamide 39.5 SC	150 ml	0.65 (1.07)	0.10 (0.76)	0.18 (0.80)	0.25 (0.87)	0.18 (0.82)
T3 - Emamectin benzoate 5 SG	200gm	0.70 (1.10)	0.17 (0.81)	0.25 (0.87)	0.35 (0.92)	0.26 (0.87)
T4 - Fipronil 5 SC	350 ml	0.78 (1.13)	0.32 (0.90)	0.40 (0.95)	0.55 (1.02)	0.42 (0.96)
T5 - Thiamethoxam 25 WG	100gm	0.60 (1.05)	0.38 (0.94)	0.45 (0.97)	0.58 (1.04)	0.47 (0.99)
T6 - Rynaxpyr 18.5 Ec	160 ml	0.63 (1.06)	0.45 (0.97)	0.55 (1.02)	0.62 (1.06)	0.54 (1.02)
T7 - Phorate 10G	10 kg	0.47 (0.98)	0.25 (0.87)	0.35 (0.92)	0.45 (0.97)	0.35 (0.92)
T8 – Untreated	-	0.68 (1.09)	0.73 (1.11)	0.75 (1.12)	0.77 (1.13)	0.75 (1.12)
SEm±		0.04	0.03	0.03	0.02	0.01
CD at 5%		N/S	0.11	0.10	0.08	0.03

Figures in parenthesis are √x+ 0.5 transformed values

- *√x+ 0.5 transformed values are used for analysis
- #DBS – Day before spray
- **DAS – Day after spray

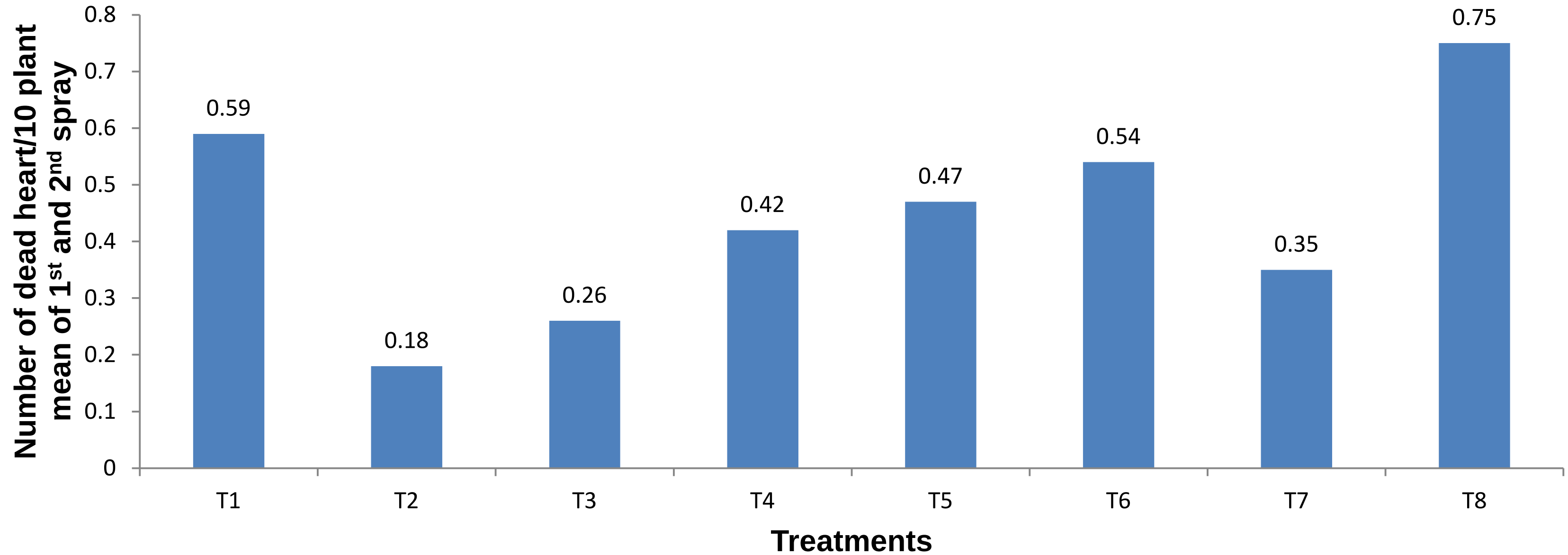

Fig 4.1.1.3 Efficacy of different insecticides against maize *stem borer* (1st and 2nd spray)

Plate 1 A Dead heart caused by stem borer in maize

Plate 1 B Symptoms of dead heart caused by stem borer

4.2.2 Effect of different insecticides on leaf injury of maize stem borer, (*Chilo partellus)*

4.2.2.1 First spray

Pre-treatment observations:

Pre-treatment observation was recorded 1 day before first spray. number of leaf 1 to 3 pinhole/10 plant ranged from 1.83 to 2.50. The number of leaf 1 to 3 pinhole/10 plant in various treatment plots did not differ significantly (Table 4.2.1 and fig. 4.2.1).

Post treatment observations:

Number of Leaf injury/10 plant at 5 days after first spray:

All the insecticidal treatments were found significantly effective in reducing the number of leaf injury/10 plant as compared to untreated plots (T8) (2.43 Number of leaf injury/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.47 Number of leaf injury/10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.70 Number of leaf injury/10 plant), Phorate 10G (T7) (0.80 Number of leaf injury /10 plant) Fipronil 5 SC (T4) (0.93 Number of leaf injury/10 plant), Thiamethoxam 25 WG (T5) (1.00 Number of leaf injury /10 plant), Rynaxpyr 18.5 Ec (T6) (1.07 Number of leaf injury /10 plant) and Imidacloprid 17.8 SL (T1) (1.17 Number of leaf injury /10 plant).

Number of leaf injury/10 plant at 10 days after first spray:

All the insecticidal treatments were found significantly effective in reducing the number of leaf injury as compared to untreated plots (T8) (2.60 Number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.77 Number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.90 Number of leaf injury /10 plant), Phorate 10G (T7) (1.03 Number of leaf injury /10 plant) Fipronil 5 SC (T4) (1.10 Number of leaf injury /10 plant).

Number of leaf injury/10 plant at 15 days after first spray

After 15 days of spray, all the insecticidal treatments were found significantly effective in reducing the number of leaf injury as compared to untreated plots (T8) (02.90 Number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.93 Number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (1.13 Number of Leaf injury /10 plant), Phorate 10G (T7) (1.20 Number of leaf injury /10 plant) Fipronil 5 SC (T4) (1.27 Number of leaf injury /10 plant).

Over all mean

Pooled statistical analysis of all the observations (5, 10 and 15 DAS) of 1st spray indicated that all the insecticidal treatments were significantly effective in reducing the number of Leaf injury as compared to control (T8) (2.64 Number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.72 Number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.91 Number of leaf injury /10 plant), Phorate 10G (T7) (1.01 Number of leaf injury/10 plant) Fipronil 5 SC (T4) (1.10 Number of leaf injury /10 plant). Whereas Imidacloprid 17.8 SL (T1) (1.30 Number of leaf injury /10 plant), was found least effective treatment.

Table 4.2.2.1 Efficacy of different insecticides on the leaf injury level/10 plant caused by *stem borer* (1st spray)

Treatments	Dose gm or ml/ha	Mean number of Leaf 1 to 3 Pin hole /10 plant				
		1 DBS#	5 DAS**	10 DAS	15 DAS	Mean
T1 - Imidacloprid 17.8 SL	110 ml	2.33 (1.68)*	1.17 (1.29)	1.27 (1.33)	1.47 (1.40)	1.30 (1.34)
T2 - Flubendiamide 39.5 SC	150 ml	2.50 (1.73)	0.47 (0.98)	0.77 (1.13)	0.93 (1.20)	0.72 (1.11)
T3 - Emamectin benzoate 5 SG	200gm	2.43 (1.71)	0.70 (1.10)	0.90 (1.18)	1.13 (1.28)	0.91 (1.19)
T4 - Fipronil 5 SC	350 ml	1.87 (1.54)	0.93 (1.20)	1.10 (1.26)	1.27 (1.33)	1.10 (1.26)
T5 - Thiamethoxam 25 WG	100gm	1.83 (1.53)	1.00 (1.22)	1.13 (1.28)	1.40 (1.38)	1.18 (1.30)
T6 - Rynaxpyr 18.5 Ec	160 ml	2.30 (1.67)	1.07 (1.25)	1.17 (1.29)	1.43 (1.39)	1.22 (1.31)
T7 - Phorate 10G	10 kg	2.10 (1.61)	0.80 (1.14)	1.03 (1.24)	1.20 (1.30)	1.01 (1.23)
T8 – Untreated	-	2.33 (1.68)	2.43 (1.71)	2.60 (1.76)	2.90 (1.84)	2.64 (1.72)
SEm± **CD at 5%**		0.06 N/S	0.02 0.08	0.02 0.06	0.02 0.07	0.01 0.04

Figures in parenthesis are $\sqrt{x+0.5}$ transformed values

- *$\sqrt{x+0.5}$ transformed values are used for analysis
- #DBS – Day before spray
- **DAS – Day after spray

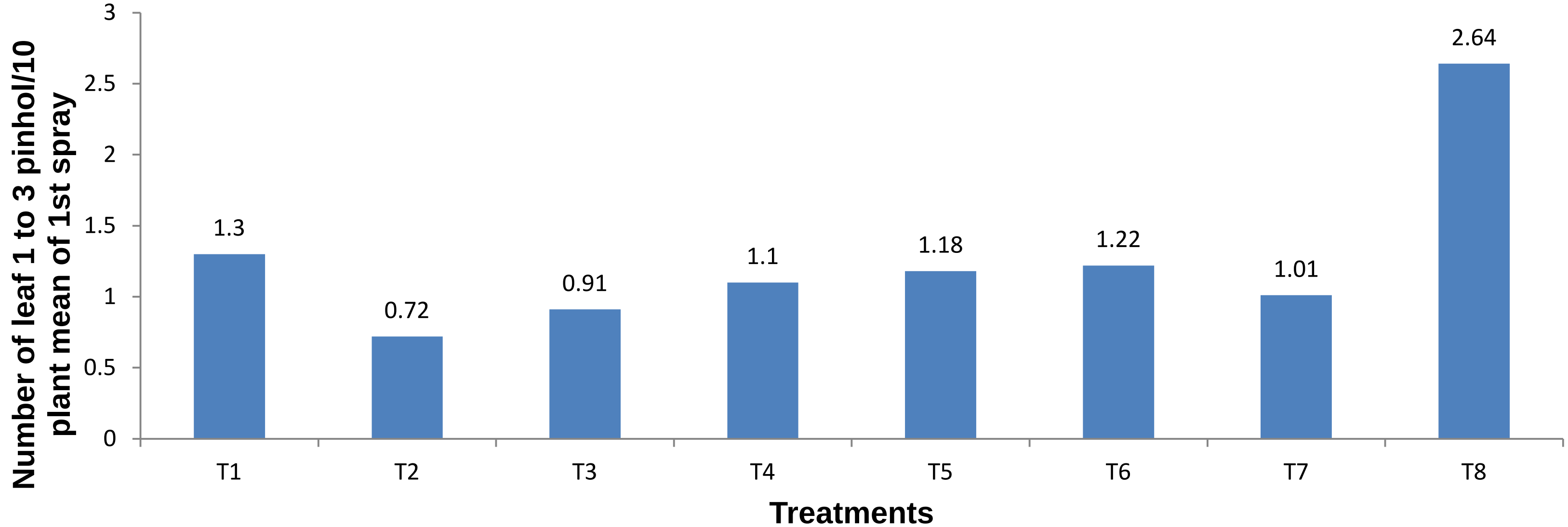

Fig 4.2.2.1. - Efficacy of different insecticides on the Leaf injury level/10 plant caused by *stem borer* (1st spray)

Plate 2. A Pinhole of leaf in maize

Plate 2. B Damaging symptoms of stem borer in maize

4.2.2.2 Effect of different insecticides on number of leaf injury/10 plant caused by maize stem borer, (*Chilo partellus*).

Second spray

Pre-treatment observations:

Pre-treatment observation was recorded 1 day before second spray. Number of leaf injury ranged from 2.00 to 2.83 number of leaf injury /10 plant The leaf injury in various treatment plots did not differ significantly (Table 4.2.2 and fig. 4.2.2).

Post treatment observations:

Number of leaf injury/10 plant at 5 days after second spray:

All the insecticidal treatments were found significantly effective in reducing the number of leaf injury as compared to untreated plots (T8) (2.90 number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.33 number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.50 Number of Leaf injury /10 plant), Phorate 10G (T7) (0.67 number of leaf injury/10 plant) Fipronil 5 SC (T4) (0.77 number of leaf injury/10 plant), Thiamethoxam 25 WG (T5) (0.90 number of leaf injury /10 plant), Rynaxpyr 18.5 Ec (T6) (0.97 number of leaf injury /10 plant) and Imidacloprid 17.8 SL (T1) (1.07 number of leaf injury /10 plant).

Number of Leaf injury at 10 days after second spray:

All the insecticidal treatments were found significantly effective in reducing the number of leaf injury as compared to untreated plots (T8) (3.00 number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.57 number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.60 number of leaf injury /10 plant), Phorate 10G (T7) (0.73 number of leaf injury /10 plant) Fipronil 5 SC (T4) (0.83 number of leaf injury /10 plant).

Number of leaf injury at 15 days after second spray:

After 15 days of spray, all the insecticidal treatments were found significantly effective in reducing the number of leaf injury as compared to untreated plots (T8) (3.07 number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.63 number of Leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.70 number of leaf injury /10 plant), Phorate 10G (T7) (0.80 number of leaf injury /10 plant) Fipronil 5 SC (T4) (0.87 number of leaf injury /10 plant).

Over all mean

Pooled statistical analysis of all the observations (5, 10 and 15 DAS) of 2nd spray indicated that all the insecticidal treatments were significantly effective in reducing the number of leaf injury as compared to control (T8) (2.99 number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.51 number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.60 number of leaf injury /10 plant), Phorate 10G (T7) (0.73 number of leaf injury /10 plant) Fipronil 5 SC (T4) (0.82 number of leaf injury /10 plant). Whereas Imidacloprid 17.8 SL (T1) (1.14 number of leaf injury /10 plant), was found least effective treatment.

Table 4.2.2.2 - Efficacy of different insecticides on the leaf injury level/10 plant caused by *stem borer* (2nd spray)

Treatment	Dose gm or ml/ha	Number of leaf 1 to 3 Pinhol /10 plant Mean of second spray				
		1 DBS#	5 DAS**	10 DAS	15 DAS	Mean
T1 - Imidacloprid 17.8 SL	110 ml	2.40 (1.70)*	1.07 (1.25)	1.13 (1.28)	1.23 (1.32)	1.14 (1.28)
T2 - Flubendiamide 39.5 SC	150 ml	2.50 (1.73)	0.33 (0.91)	0.57 (1.03)	0.63 (1.06)	0.51 (1.01)
T3 - Emamectin benzoate 5 SG	200gm	2.30 (1.67)	0.50 (1.00)	0.60 (1.05)	0.70 (1.10)	0.60 (1.05)
T4 - Fipronil 5 SC	350 ml	2.17 (1.63)	0.77 (1.13)	0.83 (1.15)	0.87 (1.17)	0.82 (1.15)
T5 - Thiamethoxam 25 WG	100gm	2.10 (1.61)	0.90 (1.18)	0.97 (1.21)	1.00 (1.22)	0.96 (1.21)
T6 - Rynaxpyr 18.5 Ec	160 ml	2.30 (1.67)	0.97 (1.21)	1.00 (1.22)	1.07 (1.25)	1.01 (1.23)
T7 - Phorate 10G	10 kg	2.00 (1.58)	0.67 (1.08)	0.73 (1.11)	0.80 (1.14)	0.73 (1.11)
T8 – Untreated	-	2.83 (1.83)	2.90 (1.84)	3.00 (1.87)	3.07 (1.89)	2.99 (1.87)
SEm±		0.05	0.03	0.02	0.02	0.01
CD at 5%		N/S	0.09	0.08	0.06	0.03

Figures in parenthesis are √x+ 0.5 transformed values

- *√x+ 0.5 transformed values are used for analysis
- #DBS – Day before spray
- **DAS – Day after spray

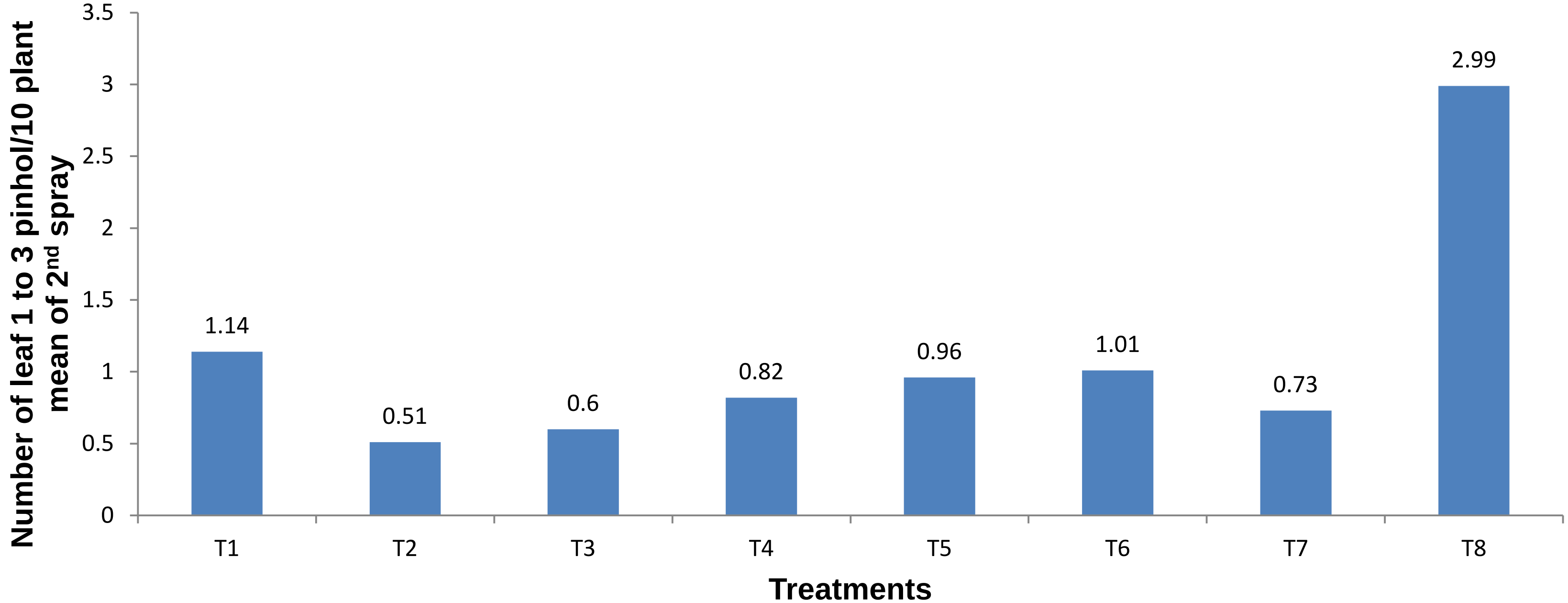

Fig 4.2.2.2 - Efficacy of different insecticides on the leaf injury level/10 plant caused by *stem borer* (2nd spray)

4.2.2.3 Effect of different insecticides on number of leaf injury/10 plant caused by maize stem borer, (*Chilo partellus*)

Pooled mean of 1st and 2nd spray:

Pre-treatment observations:

Pre-treatment observation was recorded 1 day before pooled mean of first and second spray. Number of leaf injury ranged from 2.02 to 2.58 per 10 plant The leaf injury in various treatment plots did not differ significantly (Table 4.2.3 and fig. 4.2.3).

Post treatment observations:

Number of injury at 5 days after Pooled mean of 1st and 2nd spray:

All the insecticidal treatments were found significantly effective in reducing the number of leaf injury as compared to untreated plots (T8) (2.67 number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.40 number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.60 number of leaf injury /10 plant), Phorate 10G (T7) (0.73 number of leaf injury /10 plant) Fipronil 5 SC (T4) (0.85 number of leaf injury /10 plant), Thiamethoxam 25 WG (T5) (0.95 number of leaf injury /10 plant), Rynaxpyr 18.5 Ec (T6) (1.02 number of leaf injury /10 plant) and Imidacloprid 17.8 SL (T1) (1.12 number of leaf injury /10 plant).

Number of leaf injury/10 plant at 10 days after Pooled mean of 1st and 2nd spray:

All the insecticidal treatments were found significantly effective in reducing the number of leaf injury/10 plant as compared to untreated plots (T8) (2.80 number of leaf injury/10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.67 number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.75 number of leaf injury /10 plant), Phorate 10G (T7) (0.88

number of leaf injury /10 plant) Fipronil 5 SC (T4) (0.97 number of leaf injury /10 plant).

Number of leaf injury/10 plant at 15 days after Pooled mean of 1st and 2nd spray:

After 15 days of spray, all the insecticidal treatments were found significantly effective in reducing the number of leaf injury/10 plant as compared to untreated plots (T8) (2.98 number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.78 number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.92 number of leaf injury /10 plant), Phorate 10G (T7) (1.00 number of leaf injury /10 plant) Fipronil 5 SC (T4) (1.07 number of leaf injury /10 plant).

Over all mean

Pooled statistical analysis of all the observations (5, 10 and 15 DAS) of before pooled mean of first and second spray indicated that all the insecticidal treatments were significantly effective in reducing the number of leaf injury/10 plant as compared to control (T8) (2.82 number of leaf injury /10 plant). Among the various treatments Flubendiamide 39.5 SC (T2) (0.62 number of leaf injury /10 plant), was found to be most effective followed by Emamectin benzoate 5 SG (T3) (0.76 number of leaf injury /10 plant), Phorate 10G (T7) (0.87 number of leaf injury /10 plant) Fipronil 5 SC (T4) (0.96 number of leaf injury /10 plant). Whereas Imidacloprid 17.8 SL (T1) (1.22 number of leaf injury /10 plant), was found least effective treatment.

Table 4.2.2.3 – Efficacy of different insecticides on the Leaf injury level/10 plant caused by *stem borer* (pooled 1st & 2nd spray)

Treatments	Dose gm or ml/ha	Number of Leaf 1 to 3 Pinhole /10 plant Mean of first and second spray				
		1 DBS#	5 DAS**	10 DAS	15 DAS	Mean
T1 - Imidacloprid 17.8 SL	110 ml	2.37 (1.69)*	1.12 (1.27)	1.20 (1.30)	1.35 (1.36)	1.22 (1.31)
T2 - Flubendiamide 39.5 SC	150 ml	2.50 (1.73)	0.40 (0.95)	0.67 (1.08)	0.78 (1.13)	0.62 (1.06)
T3 - Emamectin benzoate 5 SG	200gm	2.37 (1.69)	0.60 (1.05)	0.75 (1.12)	0.92 (1.19)	0.76 (1.12)
T4 - Fipronil 5 SC	350 ml	2.02 (1.59)	0.85 (1.16)	0.97 (1.21)	1.07 (1.25)	0.96 (1.21)
T5 - Thiamethoxam 25 WG	100gm	1.97 (1.57)	0.95 (1.20)	1.05 (1.24)	1.20 (1.30)	1.07 (1.25)
T6 - Rynaxpyr 18.5 Ec	160 ml	2.30 (1.67)	1.02 (1.23)	1.08 (1.26)	1.25 (1.32)	1.12 (1.27)
T7 - Phorate 10G	10 kg	2.05 (1.60)	0.73 (1.11)	0.88 (1.18)	1.00 (1.22)	0.87 (1.17)
T8 – Untreated	-	2.58 (1.76)	2.67 (1.78)	2.80 (1.82)	2.98 (1.87)	2.82 (1.82)
SEm±		0.05	0.02	0.01	0.01	0.01
CD at 5%		N/S	0.06	0.04	0.04	0.03

Figures in parenthesis are √x+ 0.5 transformed values

- *√x+ 0.5 transformed values are used for analysis
- #DBS – Day before spray
- **DAS – Day after spray

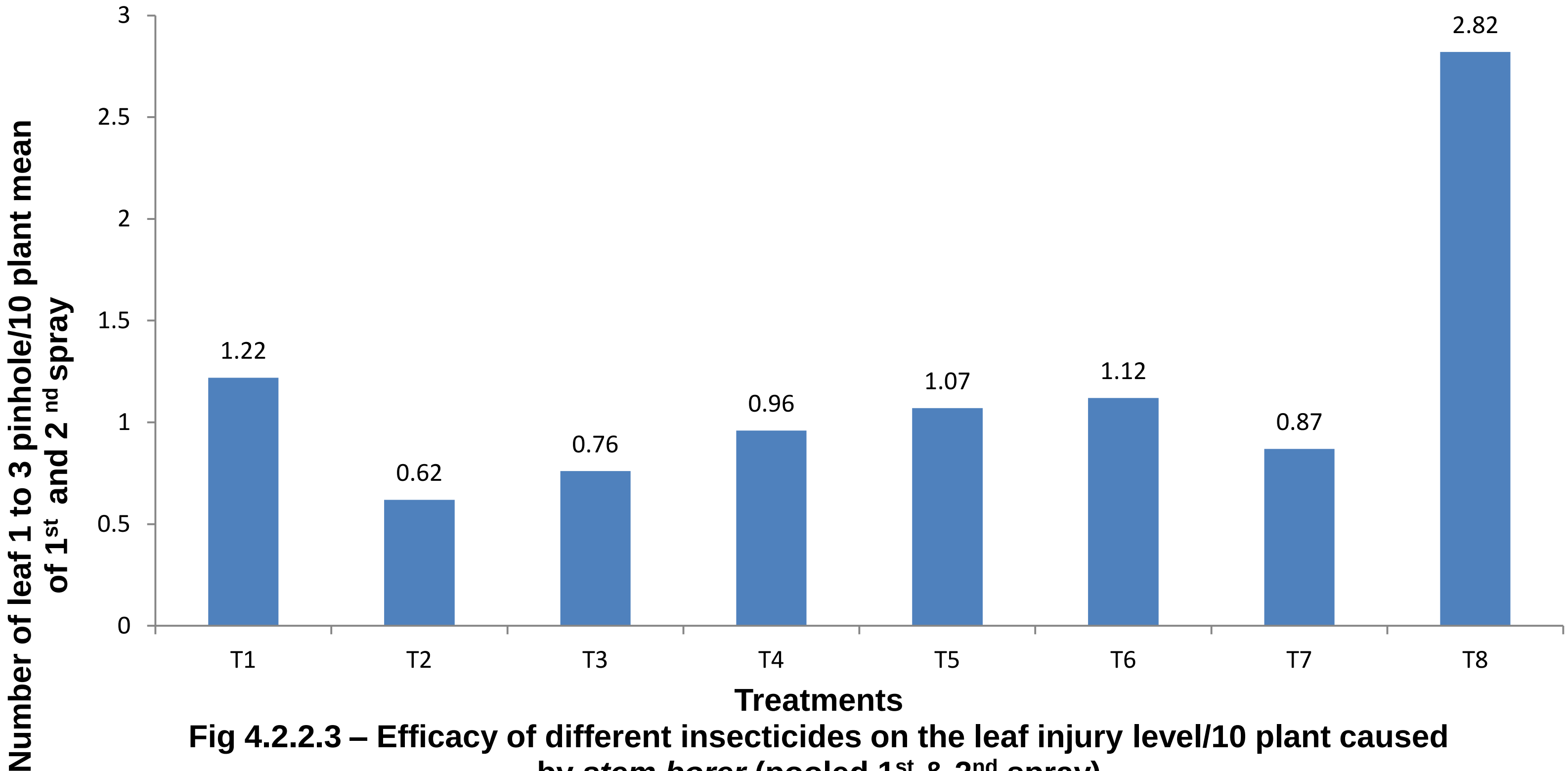

Fig 4.2.2.3 – Efficacy of different insecticides on the leaf injury level/10 plant caused by *stem borer* (pooled 1st & 2nd spray)


Plate .3. A Leaf injury caused by maize stem borer


Plate 3. B. Observation of dead heart in maize field

4.2.3 To work out the economics of different treatments of maize.

4.2.3.1 Effect on seed yield

All the insecticidal treatments recorded significantly higher seed yield (1853.83 to 2316.67 kg/ha) in comparison to control (1632.83 kg/ha).). Maximum seed yield (2316.76 kg/ha) was recorded in the plots treated with Flubendiamide (T_2) followed by Emamectin benzoate (T_3) (2245.33 kg/ha), Phorate (T_7) (2209.50 kg/ha), Fipronil (T_4) (2145.00 kg/ha), Thiamethoxam (T_5) (2118.17 kg/ha), Rynaxpyr (T_6) (2016.67 kg/ha), Imidacloprid (T_1) (1853.83 kg/ha).

Table 4.2.3.1 Seed yield under different treatments.

Treatments	Yield kg/ha
T1 - Imidacloprid 17.8 SL	1853.83
T2 - Flubendiamide 39.5 SC	2316.67
T3 - Emamectin benzoate 5 SG	2245.33
T4 - Fipronil 5 SC	2145.00
T5 - Thiamethoxam 25 WG	2118.17
T6 - Rynaxpyr 18.5 Ec	2016.67
T7 - Phorate 10G	2209.50
T8 – Untreated	1632.83
SEm ±	37.00
C.D. at 5%	108.84

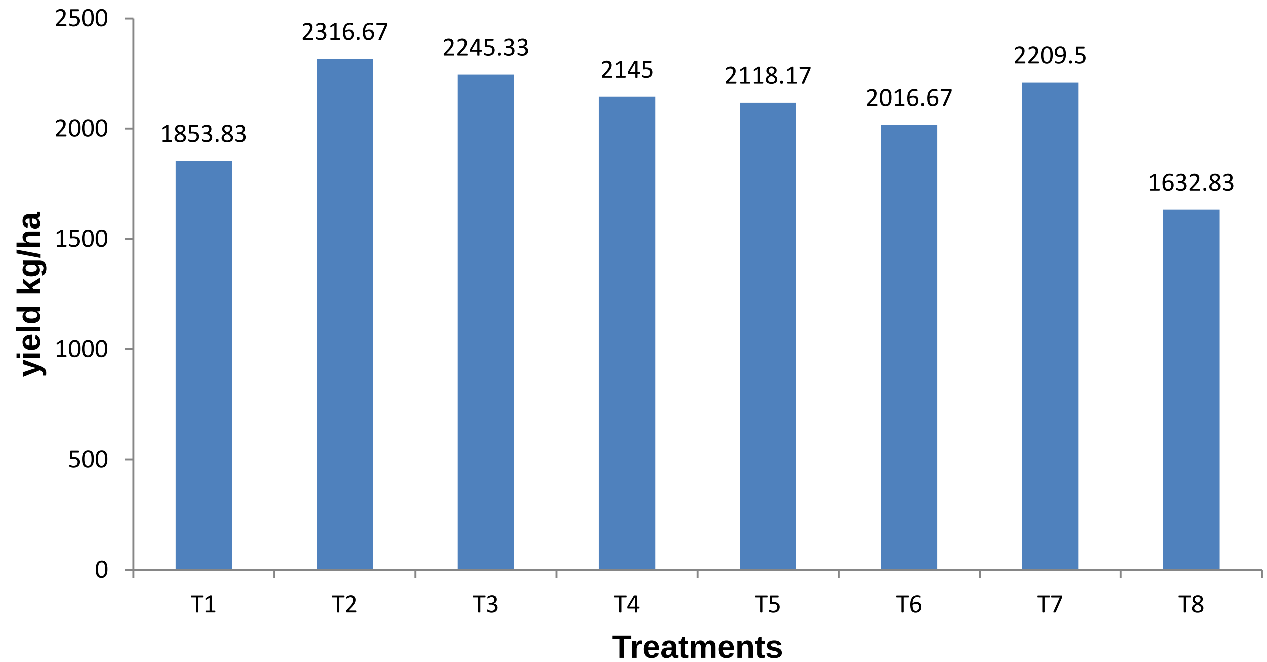

Fig 4.2.3.1 Seed yield under different treatments

4.2.4 Economics of different treatments

All the insecticidal treatments recorded significantly higher seed yield (1853.83 to 2316.67 kg/ha) in comparison to control (1632.83 kg/ha).). Maximum seed yield (2316.76 kg/ha) was recorded in the plots treated with Flubendiamide (T_2) followed by Emamectin benzoate (T_3) (2245.33 kg/ha), Phorate (T_7) (2209.50 kg/ha). Among all the insecticidal treatments, two sprays of Flubendiamide (T_2) (9963/ha) gave maximum net profit followed by Emamectin benzoate (T_3) (9925/ha) Phorate (T_7) (8780/ha), but maximum incremental cost benefit ratio was recorded in Fipronil (T_4) and Rynaxpyr (T_6) (1:7.40) due to low cost of the treatments.

4.2.3.2 Economics of different treatments.

Treatments Details	Grain yield kg/ ha	Additional yield kg/ha over control	Additional profit Rs/ha	Cost of treatment s (Rs/ha)	Net profit (Rs/ha)	ICBR ratio
T1 - Imidacloprid 17.8 SL	1853.83	221	3978	776	3202	1:4.13
T2 - Flubendiamide 39.5 SC	2316.67	683.84	12363.12	2400	9963	1:4.15
T3 - Emamectin benzoate 5 SG	2245.33	612.5	11025	1800	9225	1:5.12
T4 - Fipronil 5 SC	2145.00	512.17	9219.06	1090	8129	1:7.40
T5 - Thiamethoxam 25 WG	2118.17	485.34	8736.12	1200	7536	1:6.23
T6 - Rynaxpyr 18.5 Ec	2016.67	383.84	6909.12	822	6087	1:7.40
T7 - Phorate 10G	2209.50	576.67	10380.06	1600	8780	1:5.48
T8 – Untreated	1632.83	-	-	-	-	-

- Selling rate of maize (Rs/qt.) : 1800 Labour charge of two sprays (Rs) : 600
- Rate of insecticide Rs/liter- Imidacloprid @ 800/- , Flubendiamide @ 6000/-, Emamectin benzoate @ 3000 Fipronil @ 700/-, Thiamethoxam @ 3000/-, Rynaxpyr @ 695/-, Phorate @ 50/-

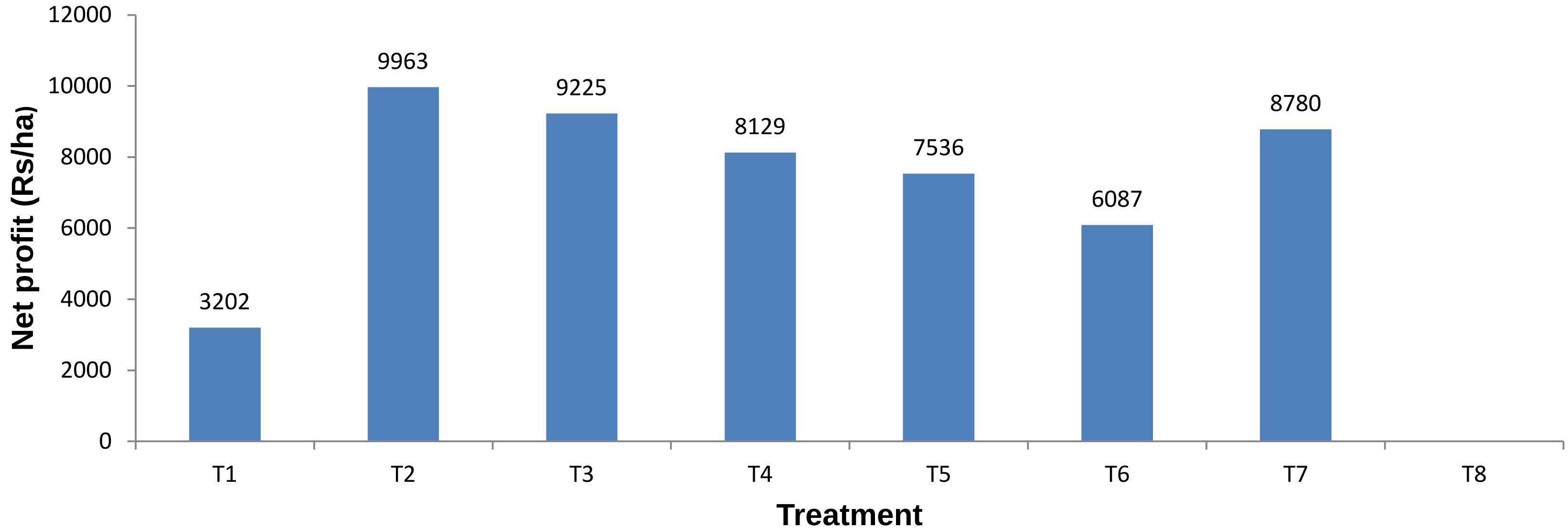

Fig 4.2.3.2 Economics of different treatments

DISCUSSION

The investigation on population dynamics of major insect pests *i.e* maize stem borer (*Chilo partellus* Swinhoe), pink stem borer (*Sesamia inferens* Walker), shoot fly (*Atherigona soccata* Rondani) and management of maize stem borer (*Chilo partellus* Swinhoe), are discussed as under.

5.1 To study the seasonal incidence of major insect pests of maize:

5.1.1 Maize stem borer, (*Chilo partellus*)

The first appearance of maize stem borer, *Chilo partellus* was recorded during 32nd SMW (06 Aug to 12 Aug) with the population 0.10 number of dead heart/10 plant when the crop was 15 to 20 days old and 3 to 5 leaf stage of maize plant. Thereafter, the population was observed in increasing trend up to 35th SMW and reached at its peak (0.70 number of dead heart/10 plant) during 35th SMW (27 Aug. to 02 Sep.), when the crop was 35 to 40 days old and 10 to 12 leaf taselling stage of plant. After that a declined trend was observed and reached its lowest level with the population of (0.10 number of dead heart/10 plant) during 44th SMW when the crop was 95 to 105 days old and in the grain filling stage. During the study period, maximum and minimum temperature were 29.4 ^{0}C and 23.4 ^{0}C, and morning and evening relative humidity were 97.85% and 86.4% respectively. whereas the rainfall and evaporation were 24.06 mm and 2.1 mm respectively

Correlation studies:

The correlation studies between stem borer population and weather parameters revealed that it was highly significantly and positive correlated with minimum temperature, morning and evening relative humidity and rainfall (0.84,0.88,0.71 and 0.71).The relation between the stem borer with maximum temperature and evaporation was negatively correlated but statistically non-significant (0.05 and -0.51).

Singh *et al.* (2018) similar result were observed by starting maximum dead hearts of *Chilo partellus* (Rondani) were recorded during crop season from 20th to 26th August (34thSMW).

Pankaj *et al*. (2016) also showed that the stem borer infestation started from second week of August (33rd SMW) with 4.61 percent dead heart. The infestation gradually increased and peak of 16.53 per cent dead heart in first week of September (36th SMW).

Similerly, Singh and Singh (2013) also reported that the infestation of Stem borer *(Chilo partellus*) was highest at the temperature of 29.5°C and at relative humidity 85% and lowest infestation of *Chilo partellus* was found at the temperature of 31.2°C and at relative humidity 75% respectively.

The present finding also match with Meti *et al.* (2014) who also reported that the incidence of stem borers started appearing from August 2nd fortnight onwards in all the conservation agriculture practice treatment. The per cent dead heart by stem borers showed highly significant and positive correlation with rainfall and relative humidity showed positive correlation. In farmer's practice the minimum temperature had also highly significant positive correlation with per cent dead heart by stem borers.

5.1.2 Maize shoot fly (*Atherigona soccata* Rondani)

The first appearance of maize shoot fly (*Atherigona soccata* Rondani) was recorded during 32nd SMW (06 Aug to 12 Aug.) with the population 0.10 number of dead heart/10 plant when the crop was 15 to 20 days old and in 3 to 5 leaf stage of maize plant Thereafter, the population was observed in an increasing trend up to 35th SMW and reached at its peak level (0.80 number of dead heart/10 plant) during 35th SMW (27 Aug. to 02 Sep) when the crop was 35 to 40 days old and 10 to 12 leaf tasselling stage of plant. After that a declining trend was observed and reached its lowest level with (0.20 number of dead heart/10 plant) during 41th SMW. At that time the crop was 80 to 95 days old and in pollination stage. During the study period, maximum and minimum temperature were 29.4 ^{0}C and 23.4 ^{0}C, respectively and morning and evening relative humidity were 97.85% and 86.4% respectively. while rainfall and evaporation were 24.06 mm and 2.1 mm respectively

Correlation studies:

The correlation studies between maize shoot fly *(Atherigona soccata* Rondani) population and weather parameters revealed highly significantly and positive correlated with minimum temperature, morning and evening relative humidity and rainfall (0.79,0.91,0.75,0.77) The relation between shoot fly and maximum temperature (-0.14) was negative non-significant and evaporation was recorded negative significant correlated (-0.60).

Similarly, Keerthi *et al.* (2017) also observed that the oviposition by shoot fly reached peak (3.10 eggs/ plant) during 35th SMW and also it was almost equal (2.9 eggs/ plant) during 33rd SMW. Similar trend was observed with respect to dead hearts, where it gradually increased and reached peaks (96.12 and 94.32%) during 33rd and 35th SMW.

The present studied are in agreement with Pawar *et al*. (2015) who also reported that the shoot fly, *Atherigona soccata* was at peak incidence (dead hearts) in the month of August. Minimum temperature, morning and evening relative humidity showed significant and positive effect while maximum temperature had significant and negative effect on the incidence of shoot fly.

5.1.3 Maize pink stem borer (*Sesamia inferens* Walker).

The first appearance of maize pink stem borer (*Sesamia inferens* Walker) was recorded during 33rd SMW (13 Aug to 19 Aug) with the population 0.10 number of dead heart/10 plant when the crop was 20 days old and in 5 leaf stage. Thereafter, the population increased gradually up to 36th SMW and reached at its peak level (0.60 number of dead heart/10 plant) during 36nd SMW (03 Sep. to 09 Sep.). After that the population remained at the same level in 37th and 38th SMW when the crop was 40 days old and 12 leaf cob development stage of plant. Thereafter a declining trend was observed and reached its lowest level with the population of (0.20 number of dead heart/10 plant) during 45th SMW. During the study period maximum and minimum temperature were 26.5 ^{0}C and 22.4 ^{0}C, respectively, morning and evening relative humidity were 97% and 90.6% respectively, while rainfall and evaporation were 13.8 mm and 1.6 mm respectively.

Correlation studies:

The correlation studies between maize pink stem borer (*Sesamia inferens* Walker) population and weather parameters revealed a highly significantly positive correlated with minimum temperature and morning relative humidity (0.87,0.62). The relation between pink stem borer and maximum temperature was found to be positively correlated but non significant (0.03) and relation with rainfall and evening relative humidity was positive and significant (0.61, 0.85) while the relation with evaporation was negatively but non-significantly correlated (-0.45).

More or less similar finding were reported by Umesh *et al.* (2018) who mentioned that the peak infestation caused by pink stem borer were 27.85 and 29.50 percent, in the last week of August (34th Standard Week) during *kharif* season 2016 and 2017, respectively. The data also revealed that the correlation between percent infestation of *Sesamia inferens* was found to be positive and significant with minimum (r=0.53) temperature, morning relative humidity (r=0.45) and evening relative humidity (r=0.72) respectively, while rainfall had a positive correlation (r=0.38) with percent infestation during kharif, 2016.

The present studied differs with Deole *et al.* (2017) who recorded that the interactions between the larval population and weather parameters revealed non-significant, negative correlation with maximum temperature (r = - 0.6519 and - 0.4964), while the interactions with morning and evening relative humidity was positively significant (r = 0.610 and 0.649) respectively.

Similar finding were reported by Kumar *et al.* (2017) on the population fluctuation of maize stem borer with relation to abiotic factors, where incidence of maize stem borer, *Chilo partellus* (Swinhoe) appeared from 2nd week of August and continued up to 4th week of October.with matches with the current findings.

Similerly Meti *et al*. (2014) also reported that stem borers showed highly significant and positive correlation with rainfall and minimum temperature. Rainfall had highly significant positive correlation per cent dead heart by stem borers while, in farmer's practice minimum temperature had also highly significant positive correlation with per cent dead heart by stem borers whereas, rainfall and relative humidity showed positive correlation, which is agreement with the present finding.

5.2 To study the efficacy of new insecticides against maize stem borer, *Chilo partellus*

5.2.1 Efficacy of different insecticides against maize stem borer

All the insecticidal treatments were found significantly effective in reducing the population of maize stem borer as compared to control (T_8). Two sprays of Flubendiamide 39.5 SC (T2) was found to be most effective followed by Emamectin benzoate 5 SG (T3), Phorate 10G (T7),) Fipronil 5 SC (T4), Thiamethoxam 25 WG (T5), Rynaxpyr 18.5 Ec (T6), Imidacloprid 17.8 SL (T1) was found as the least effective treatment

5.2.2 Effect of different insecticides on leaf injury and number of dead heart caused by maize stem borer.

All the insecticidal treatments were found significantly effective in reducing leaf injury and number of dead heart caused by maize stem borer as compared to control (T_8). Two sprays of Flubendiamide 39.5 SC (T2) was found to be most effective followed by Emamectin benzoate 5 SG (T3), Phorate 10G (T7),) Fipronil 5 SC (T4), Thiamethoxam 25 WG (T5), Rynaxpyr 18.5 Ec (T6), Imidacloprid 17.8 SL (T1) was found least effective treatment.

The present finding match with Mallapur and Manjunath (2014) who evaluated the efficacy of different insecticides against maize stem borer, *C. partellus* and found that flubendiamide 480 SC at 0.2 ml/l spinosad 45 SC at 0.02 ml/l, emamectin benzoate 5 SG at0.2 g/l, carbofuran 3 G at 7.5 kg/ha were found effective in reducing the maize stem borer population, leaf injury rating and dead heart formation compared to control.

Similarly Kumar *et al*. (2017) also found that the minimum leaf injury rating was recorded with Flubendiamide (3.23) followed by thiamethoxam (3.43), Emamectin benzoate (3.57), rynaxypyr (4.03) and cartap hydrochloride (4.17) treated plots. Flubendiamide 20 WG was recorded the best effective treatment with the minimum dead heart percent per plant (13.33%), which was followed by emamectin benzoate 5 SG (20.0%) thiamethoxam 25 WG (20.0%), and rynaxypyr 0.4G (20.0%), respectively,which are agreement with the present findings.

Similar findings were also reported by Devendra *et al* (2018), Reddy *et al* (2018), Kumar *et al* 2017 and Sidar *et al* 2017.

5.3.1 Effect on seed yield and economics under different insecticidal treatments:

All the insecticidal treatments recorded significantly higher seed yield (1853.83 to 2316.67 kg/ha) in comparison to control (1632.83 kg/ha).).

Maximum seed yield (2316.76 kg/ha) was recorded in the plots treated with Flubendiamide (T_2) followed by Emamectin benzoate (T_3) (2245.33 kg/ha), Phorate (T_7) (2209.50 kg/ha), Fipronil (T_4) (2145.00 kg/ha), Thiamethoxam (T_5) (2118.17 kg/ha), Rynaxpyr (T_6) (2016.67 kg/ha), Imidacloprid (T_1) (1853.83 kg/ha). Among all the insecticidal treatments, two sprays of Flubendiamide (T_2) (9963/ha) gave maximum net profit followed by Emamectin benzoate (T_3) (9925/ha) Phorate (T_7) (8780/ha), but maximum incremental cost benefit ratio was recorded with the treatment of Fipronil (T_4) and Rynaxpyr (T_6) (1:7.40) due to low cost of treatment in comparision to others.

This is agreement with Kumar *et al.* (2017) who also recordedthe highest grain yield was recorded Flubendiamide 20 WG (34.00qha^{-1}), treated plots followed by Emamectin benzoate 5SG (31.92 q ha-1) and Rynaxypyr 0.4%G (30.6 qha^{-1}) The grain yields was also significantly highly influenced by flubendiamide 20 WG, followed by emamectin benzoate 5 SG and rynaxypyr 0.4% G and fipronil 0.3% G. Among different insecticides tested, the highest net return was found in flubendiamide 20WG (Rs.21496.2).

Similarly Chouraddi and Mallapur (2017) evaluated newer molecules of insecticides on management of maize stem borers among the different newer molecules of insecticides evaluated, emamectin benzoate 5SG @ 0.2 g/l or spinosad 45SC @ 0.2 ml/l at 25 DAS as well as whorl application of carbofuran 3G @ 7.5 kg/ha being at par with each other proved superior over untreated control.

The present finding slightly, differs with Shahid Iqbal *et al.* (2018) who reported Fipronil to be the best in the maximum CBR *i.e.* 1:24 as compared to 1:15 and 1:13 in Carbofuran and Cartal, respectively.

SUMMARY, CONCLUSION AND SUGGESTIONS

FOR FURTHER WORK

The Present study entitled **"Seasonal incidence of major insect pests of maize *(Zea mays* L.*)* and their management through new insecticides"** was conducted in *kharif season 2018*-19 at Research Farm, JNKVV, College of Agriculture, Tikamgarh (MP) the studies were divided into three sections as detailed below.

The present investigation was undertaken with the following objectives:

1. To study on the population dynamics of major insect pests of maize and their correlation with weather parameters.
2. To study the efficacy of different insecticides against maize stem borer, *Chilo partellus*.
3. To work out the economics of different treatments of major insect pests of maize.

6.1: Summary:

The results of present study have been summarized in following heads.

6.1.1 To study the seasonal incidence of major insect pests of maize:

Studies on the seasonal incidence of major insect pests of maize *(Zea mays* L.) *i.e* maize stem borer (*Chilo partellus* Swinhoe), pink stem borer (*Sesamia inferens* Walker), shoot fly (*Atherigona soccata* Rondani) and management of maize stem borer (*Chilo partellus* Swinhoe), were the major pests which damaged the crop.

6.1.1.1: The first appearance of maize stem borer, *Chilo partellus* was recorded during 32nd SMW (06 Aug. to 12 Aug.) with the population 0.10 number of dead heart/10 plant. At that time crop was 15 to 20 days old and 3 to 5 leaf stage of maize plant. thereafter, the population was observed in increasing trend up to 35th SMW and reached at its peak (0.70 number of dead heart/10 plant) during 35th SMW (27 Aug. to 02 Sep.), when the crop was 35 to 40 days old and 10 to 12 leaf tasseling stage of plant. After that a declining trend was observed and reached its lowest level with the population of (0.10) number of dead heart/10 plant) during 44th SMW at that time the crop was 95 to 105 day old and in grain filling stage. The correlation studies between stem borer population and weather parameters revealed that stem borer population was highly significant and positively correlated with minimum temperature, morning and evening relative humidity and rainfall (0.84,0.88,0.71 and 0.71).The correlation between the stem borer and maximum temperature and evaporation was negative but statistically non-significant (0.05 and -0.51).

6.1.1.2: The first appearance of maize shoot fly (*Atherigona soccata* Rondani) was recorded during 32th SMW (06 Aug to 12 Aug.) with the population 0.10 number of dead heart/10 plant when the crop was 15 to 20 days old and 3 to 5 leaf stage of maize plant Thereafter, the population was observed in an increasing trend up to 35th SMW and reached at its peak level (0.80 number of dead heart/10 plant) during 35th SMW (27 Aug. to 02 Sep) when the crop was 35 to 40 days old and 10 to 12 leaf tasseling stage of plant. After that the population of shoot fly declined and reached its lowest level with the population of (0.20 number of dead heart/10 plant) during 41th SMW at that time the crop was 80 to 95 days old and in pollination stage. The correlation studies between maize shoot fly *(A. soccata* Rondani) population and weather parameters revealed highly significant and positively correlated with minimum temperature, morning and evening relative humidity and rainfall (0.79,0.91,0.75,0.77). The relation between shoot fly and maximum temperature (-0.14) was negative non-significant and evaporation recorded negative significant correlation (-0.60).

6.1.1.3: The first appearance of maize pink stem borer (*Sesamia inferens* Walker) was recorded during 33th SMW (13 Aug. to 19 Aug.) with the population 0.10 number of dead heart/10 plant after 20 days old crop when the crop was 5 leaf stage. Thereafter, the population increased gradually up to 36th SMW and reached at its peak level (0.60 number of dead heart/10 plant) during 36th SMW (03 Sep. to 09 Sep.). Thereafter, the population remained at the same level thus 37th and 38th SMW when the crop was 40 days old and 12 leaf cob development stage of plant. Thereafter, reached its lowest level with (0.20 number of dead heart/10 plant) during 45th SMW at that time the crop was 105 to 110 days old and in grain mature stage. The correlation studies between maize pink stem borer (*S. inferens* Walker) population and weather parameters revealed highly significant positive correlation with minimum temperature and morning relative humidity (0.87,0.62). The relation between pink stem borer and maximum temperature was found positive correlated but non significantly (0.03) and relation with rainfall and evening relative humidity was positive and significant (0.61, 0.85) while the correlation with evaporation was negatively non significant. (-0.45).

6.1.2 To study the efficacy of new insecticides against Maize stem borer, (*Chilo partellus*)

Effect of different insecticides on leaf injury and number of dead heart caused by maize stem borer

6.1.2.1: All the insecticidal treatments were found significantly effective in reducing leaf injury and number of dead heart caused by maize stem borer as compared to control (T_8). Two sprays of Flubendiamide 39.5 SC (T2) was found to be most effective followed by Emamectin benzoate 5 SG (T3), Phorate 10G (T7),) Fipronil 5 SC (T4), Thiamethoxam 25 WG (T5), Rynaxpyr 18.5 Ec (T6). Imidacloprid 17.8 SL (T1) was found least effective treatment.

6.1.3: To work out the economics of the management of maize stem borer, *Chilo partellus*

All the insecticidal treatments recorded significantly higher seed yield (1853.83 to 2316.67 kg/ha) in comparison to control (1632.83 kg/ha).). Maximum seed yield (2316.76 kg/ha) was recorded in the plots treated with Flubendiamide (T_2) followed by Emamectin benzoate (T_3) (2245.33 kg/ha), Phorate (T_7) (2209.50 kg/ha), Fipronil (T_4) (2145.00 kg/ha). Among all the insecticidal treatments, two sprays of Flubendiamide (T_2) (9963/ha) gave maximum net profit followed by Emamectin benzoate (T_3) (9925/ha) Phorate (T_7) (8780/ha), but maximum incremental cost benefit ratio was recorded in the treatment of Fipronil (T_4) and Rynaxpyr (T_6) (1:7.40) due to low cost of treatments.

6.2: Conclusion:

Study was carried out on the seasonal incidence of major insect pests and efficacy of new generation insecticide for the management of maize stem borer during *kharif* 2018. From the study, it was concluded that three insect pests viz stem borer, pink stem borer and shoot fly were found to be serious pests of maize crop at Tikamgarh (M.P.). The correlation studies between stem borer population and weather parameters revealed that stem borer population was highly significant and positively correlated with minimum temperature, morning and evening relative humidity and rainfall (0.84,0.88,0.71 and 0.71) The relation between the stem borer and maximum temperature and evaporation was negative but statistically non-significant (0.05 and -0.51). The correlation studies between maize shoot fly *(A. soccata* Rondani) population and weather parameters revealed highly significant and positively correlated with minimum temperature, morning and evening relative humidity and rainfall (0.79,0.91,0.75,0.77) The relation between shoot fly and maximum temperature (-0.14) was negative and non-significant while evaporation was recorded to be negative and significantly correlated (-0.60) The correlation studies between maize pink stem borer (*S. inferens* Walker) population and weather parameters revealed highly significant and positively correlated with minimum temperature and morning relative humidity (0.87,0.62). The correlation between pink stem borer and maximum temperature was found positive but non significant (0.03) and with rainfall and evening relative humidity it was positive and significant (0.61, 0.85) where as with evaporation it was negative non significantly correlated (-0.45).

Among seven insecticides tested, two sprays of Flubendiamide 39.5 SC (T2) was found to be most effective against reducing leaf injury and number of dead heart caused by maize stem borer followed by Emamectin benzoate 5 SG (T3), Phorate 10G (T7), Fipronil 5 SC (T4), Thiamethoxam 25 WG (T5), Rynaxpyr 18.5 Ec (T6). Imidacloprid 17.8 SL (T1) was found least effective treatment.

The maximum seed yield was recorded in plots treated with Flubendiamide (T_2) followed by Emamectin benzoate (T_3) (2245.33 kg/ha), Phorate (T_7) (2209.50 kg/ha), Among all the insecticidal treatments, two sprays of Flubendiamide (T_2) (9963/ha) gave maximum net profit followed by Emamectin benzoate (T_3) (9925/ha) Phorate (T_7) (8780/ha), but maximum incremental cost benefit ratio Fipronil (T_4) and Rynaxpyr (T_6) (1:7.40).

6.3 Suggestions for further work:

6.3.1 It is evident from the present studies that the insect pests of Maize can be managed by the new insecticides, and showing toxicity against the eggs, larvae and adults of the insect pests.

6.3.2 Indiscriminate use of chemical pesticides and their adverse effect of new insecticide on the environment need to be worked out of pests resistance and resurgence

6.3.3: Bio efficacy of new generation insecticide should be studied continuously against the management of maize stem borer.

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APPENDICES

All treatments analysis

Stem borer, *Chilo partellus*

FIRST SPRAY

Pre-treatments (1 DBS)

Appendix- 8.1

ANOVA for number of dead heart caused by stem borer 1 day before of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.05	0.024261	1.944017
Treatment	7.00	0.03	0.004141	0.33
Error	14.00	0.17	0.01248	
Total	23.00			

Post treatments (5 DAS)

Appendix- 8.2

ANOVA for number of dead heart caused by stem borer 5 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.02	0.008762	1.068796
Treatment	7.00	0.30	0.043131	5.26
Error	14.00	0.11	0.008198	
Total	23.00			

Post treatments (10 DAS)

Appendix- 8.3

ANOVA for number of dead heart caused by stem borer 10 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.005312	0.985528
Treatment	7.00	0.26	0.037504	6.96
Error	14.00	0.08	0.00539	
Total	23.00			

Post treatments (15 DAS)

Appendix- 8.4

ANOVA borer number of dead heart caused by stem borer 15 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.000582	0.209713
Treatment	7.00	0.14	0.019858	7.15
Error	14.00	0.04	0.002776	
Total	23.00			

Pooled mean of First Spray

Post treatments (5, 10 and 15 DAS)

Appendix- 8.5

ANOVA for number of dead heart caused by stem borer 5, 10 and 15 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.06	0.03084	45.38863
Treatment	7.00	0.22	0.031661	46.60
Error	14.00	0.01	0.000679	
Total	23.00			

Stem borer, *Chilo partellus*

SECOND SPRAY

Pre-treatments (1 DBS)

Appendix- 8.6

ANOVA for number of dead heart caused by stem borer 1 day before of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.000464	0.054488
Treatment	7.00	0.07	0.010048	1.18
Error	14.00	0.12	0.008522	
Total	23.00			

Post treatments (5 DAS)

Appendix- 8.7

ANOVA for number of dead heart caused by stem borer 5 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.007024	1.57527
Treatment	7.00	0.24	0.034522	7.74
Error	14.00	0.06	0.004459	
Total	23.00			

Post treatments (10 DAS)

Appendix- 8.8

ANOVA for number of dead heart caused by stem borer 10 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.003959	0.783774
Treatment	7.00	0.18	0.025249	5.00
Error	14.00	0.07	0.005051	
Total	23.00			

Post treatments (15 DAS)

Appendix- 8.9

ANOVA for number of dead heart caused by stem borer 15 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.000787	0.141791
Treatment	7.00	0.17	0.023734	4.28
Error	14.00	0.08	0.005551	
Total	23.00			

Pooled mean of second Spray

Post treatments (5, 10, and 15 DAS)

Appendix- 8.10

ANOVA for number of dead heart caused by stem borer 5, 10, and 15 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.006399	22.1912
Treatment	7.00	0.20	0.029219	101.34
Error	14.00	0.00	0.000288	
Total	23.00			

Stem borer, *Chilo partellus*

FIRST SPRAY

Pre-treatments (1 DBS)

Appendix- 8.11

ANOVA for leaf injury caused by stem borer 1 day before of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.006217	0.56657
Treatment	7.00	0.12	0.017565	1.60
Error	14.00	0.15	0.010973	
Total	23.00			

Post treatments (5 DAS)

Appendix- 8.12

ANOVA for leaf injury caused by stem bore 5 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.002133	0.987537
Treatment	7.00	0.98	0.139443	64.56
Error	14.00	0.03	0.00216	
Total	23.00			

Post treatments (10 DAS)

Appendix- 8.13
ANOVA for leaf injury caused by stem bore 10 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.003211	2.611825
Treatment	7.00	0.78	0.112044	91.13
Error	14.00	0.02	0.001229	
Total	23.00			

Post treatments (15 DAS)

Appendix- 8.14
ANOVA for leaf injury caused by stem bore 15 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.001528	0.895575
Treatment	7.00	0.80	0.114694	67.22
Error	14.00	0.02	0.001706	
Total	23.00			

Pooled mean of First Spray
Post treatments (5, 10 and 15 DAS)

Appendix- 8.15
ANOVA for leaf injury caused by stem bore 5, 10 and 15 day after of first spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.09	0.04713	108.9768
Treatment	7.00	0.85	0.121177	280.19
Error	14.00	0.01	0.000432	
Total	23.00			

Stem borer, *Chilo partellus*

SECOND SPRAY

Pre-treatments (1 DBS)

Appendix- 8.16

ANOVA for leaf injury caused by stem bore 1 day before of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.02	0.010108	1.22619
Treatment	7.00	0.12	0.017227	2.09
Error	14.00	0.12	0.008243	
Total	23.00			

Post treatments (5 DAS)

Appendix- 8.17

ANOVA for leaf injury caused by stem bore 5 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.000742	0.274724
Treatment	7.00	1.68	0.240125	88.92
Error	14.00	0.04	0.002701	
Total	23.00			

Post treatments (10 DAS)

Appendix- 8.18

ANOVA for leaf injury caused by stem bore 10 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.001242	0.55822
Treatment	7.00	1.51	0.216249	97.17
Error	14.00	0.03	0.002226	
Total	23.00			

Post treatments (15 DAS)

Appendix- 8.19

ANOVA for leaf injury caused by stem bore 15 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.000938	0.72605
Treatment	7.00	1.46	0.208733	161.49
Error	14.00	0.02	0.001293	
Total	23.00			

Pooled mean of second Spray

Post treatments (5, 10 and 15 DAS)

Appendix- 8.20

ANOVA for leaf injury caused by stem bore 5, 10 and 15 day after of second spray

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.02	0.009309	20.2936
Treatment	7.00	1.54	0.220638	481.01
Error	14.00	0.01	0.000459	
Total	23.00			

Stem borer, *Chilo partellus*

POOLED MEAN OF FIRST AND SECOND SPRAY

Pre-treatment (1 DBS)

Appendix-8.21

ANOVA for number of dead heart caused by stem borer 1st and 2nd spray 1 day before

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.007413	1.300815
Treatment	7.00	0.04	0.006332	1.11
Error	14.00	0.08	0.005699	
Total	23.00			

Post treatment (5 DAS)

Appendix- 8.22

ANOVA for number of dead heart caused by stem borer 1st and 2nd spray 5 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.01	0.004781	1.105243
Treatment	7.00	0.26	0.036747	8.49
Error	14.00	0.06	0.004326	
Total	23.00			

Post treatment (10 DAS)

Appendix- 8.23

ANOVA for number of dead heart caused by stem borer 1st and 2nd spray 10 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.001051	0.274151
Treatment	7.00	0.21	0.030373	7.92
Error	14.00	0.05	0.003835	
Total	23.00			

Post treatment (15 DAS)

Appendix- 8.24

ANOVA for number of dead heart caused by stem borer 1st and 2nd spray 15 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	4.14000	0.016051
Treatment	7.00	0.15	0.021309	8.25
Error	14.00	0.04	0.002581	
Total	23.00			

Pooled mean of first and second second Spray

Post treatments (5, 10 and 15 DAS)

Appendix- 8.25

ANOVA for number of dead heart caused by stem borer 1st and 2nd spray 5, 10 and 15 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.03	0.013815	37.83585
Treatment	7.00	0.19	0.027728	75.94
Error	14.00	0.01	0.000365	
Total	23.00			

Stem borer, *Chilo partellus*

POOLED MEAN OF FIRST AND SECOND SPRAY

Pre-treatment (1 DBS)

Appendix- 8.26

ANOVA for leaf injury caused by stem borer 1st and 2nd spray 1 day before

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.02	0.00797	1.039058
Treatment	7.00	0.10	0.014281	1.86
Error	14.00	0.11	0.00767	
Total	23.00			

Post treatment (5 DAS)

Appendix- 8.27

ANOVA for leaf injury caused by stem borer 1st and 2nd spray 5 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.001462	1.487471
Treatment	7.00	1.30	0.186237	189.51
Error	14.00	0.01	0.000983	
Total	23.00			

Post treatment (10 DAS)

Appendix- 8.28

ANOVA for leaf injury caused by stem borer 1st and 2nd spray 10 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.001689	3.699903
Treatment	7.00	1.12	0.159514	349.35
Error	14.00	0.01	0.000457	
Total	23.00			

Post treatment (15 DAS)

Appendix- 8.29

ANOVA for leaf injury caused by stem borer 1st and 2nd spray 15 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.00	0.001055	1.819619
Treatment	7.00	1.10	0.156475	269.85
Error	14.00	0.01	0.00058	
Total	23.00			

Pooled mean of first and second second Spray

Post treatments (5, 10 and 15 DAS)

Appendix- 8.30

ANOVA for leaf injury caused by stem borer 1st and 2nd spray 5, 10 and 15 day after

Source of variation	D.F.	S.S.	M.S.S	F cal
Replication	2.00	0.05	0.025094	61.94666
Treatment	7.00	1.17	0.166489	410.99
Error	14.00	0.01	0.000405	
Total	23.00			

Curriculum Vitae

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5. List special scientific interest and studies
   1. I would like to build my career on modern technical farming especially in Precision Agriculture. .
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