INFLUENCE OF WEATHER PARAMETERS ON POPULATION DYNAMICS OF YELLOW STEM BORER (YSB) IN RICE CROP AT RAIPUR

M.Sc. (Ag.) Thesis

by

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DEPARTMENT OF AGROMETEOROLOGY
COLLEGE OF AGRICULTURE
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INFLUENCE OF WEATHER PARAMETERS ON POPULATION DYNAMICS OF YELLOW STEM BORER (YSB) IN RICE CROP AT RAIPUR

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

Sahdev Nag

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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in

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CERTIFICATE - I

This is to certify that the thesis entitled **"Influence of weather parameters on population dynamics of Yellow Stem Borer (YSB) in rice crop at Raipur"** submitted in partial fulfillment of the requirements for the degree of "**Master of Science in Agriculture**" of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Sahdev Nag** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

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

Chairman

Date: 21/7/17

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	(Dr. H. V. Puranik)	---------------------------------- 21/07/17
Member	(Dr. Sanjay Sharma)	----------------------------------
Member	(Dr. (Smt.) G. Chandrakar)	----------------------------------

CERTIFICATE – II

This is to certify that the thesis entitled **"Influence of weather parameters on population dynamics of Yellow Stem Borer (YSB) in rice crop at Raipur"** submitted by **Sahdev Nag** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of M.Sc. (Ag.)** in the **Department of Agrometeorology** has been approved by the external examiner and Student's Advisory Committee after oral examination.

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Faculty Dean -----------------------------------

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Director of Instructions -----------------------------------

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"Words can hardly express my emotions as it is much more than express here."

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Department of Agrometeorology

College of Agriculture, IGKV (Raipur) ***Sahdev Nag***

Date - ……………………………

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LIST OF ABBREVIATIONS AND NOTATIONS

Abbreviation	Description
YSB	Yellow Stem Borer
SMW	Standard meteorological week
AGDD	Accumulated growing degree days
AHTU	Accumulated helio thermal unit
DH	Dead hearts
WEH	White earheads
DT	Day temperature
NT	Night temperature
DV	Diurnal variation
HS	Heat Sum
C.C.S	Correlation coefficients
R^2	Coefficient of determination
Max-T	Maximum temperature
Min-T	Minimum temperature
RF	Rainfall
SSH	Sunshine
mm	Millimeter
RH-I	Morning relative humidity
RH-II	Evening relative humidity
^{0}C	Degree Celsius
%	Per cent
r	Correlation Value
Tb	Base temperature
PET	Potential evapo-transpiration

THESIS ABSTRACT

a.	Title of the Thesis	:	"Influence of Weather Parameters on Population Dynamics of Yellow Stem Borer (YSB) in rice crop at Raipur"
b.	Full Name of the Student	:	Sahdev Nag
c.	Major Subject	:	Agrometeorology
d.	Name and Address of the Major Advisor	:	Shri J.L. Chaudhary (Senior Scientist), Department of Agrometeorology, College of agriculture, IGKV, Raipur (C.G.)
e.	Degree to be awarded	:	M.Sc. (Ag.)

Signature of student

Signature of Major Advisor

Date: 21/7/17

Signature of Head of Department

ABSTRACT

A field experiment was carried out during *kharif* season 2016-17 at Indira Gandhi Krishi Vishwavidyalaya, Raipur to validate the results of influence of weather parameters on population dynamics of yellow stem borer (YSB) in rice crop at Raipur. Yellow stem borer are major insect pest always cause damage to the rice crop resulting in considerable yield losses. The present study aimed to find out the effect of these environmental factors on the severity of insect pest. These finding may give reliable methods to identify environmental condition that are conducive for the development of a particular insect pest. Correlation study of present field population observe data of yellow stem borer and weather parameters the adult population of YSB showed non-significant positive correlation with maximum temperature (r = 0.07) and wind velocity (r = 0.57) whereas, minimum temperature (r = 0.83**), morning relative humidity (r = 0.80**), evening relative humidity (r = 0.82**), rainfall (r = 0.64*), and sunshine hours (r = - 0.88**) had a significant positive correlation. Diurnal variation (DV) (r = 0.83**), heat sum (HS) (0.75**) and night temperature regime (0.72*) showed positive correlation with the moth population. Among all the weather parameters diurnal variation and minimum temperature showed highest degree of correlation with YSB.

The light trap data of yellow stem borer population and weather parameters for a period of nineteen year data are correlated with corresponding week and four week lag meteorological parameters. Significant weeks weather parameters are selected and there after stepwise regression analysis. The findings of present study revealed that maximum temperature, minimum temperature, rainfall, sunshine hours, relative humidity (morning and evening) have profound effect on the development of yellow stem borer, whereas maximum temperature and sunshine hours contributed significant effect on incidence of YSB. Weather based multiple regression models for different standard weeks for yellow stem borer were developed by using data for period (1998-2014) and validated with two year data (2015 and 2016). The finding of this study pest weather model for yellow stem borer of kharif rice was prepared. This model would be useful for early warning and operational rice crop protection from YSB attack. Forewarning of *S. incertulas* is specific for Raipur location for *Kharif* season, and is expected to be in use with pest management advisory to the rice growers of the region.

Keyword: Yellow stem borer, population dynamic, weather parameter, regression analysis, forewarning.

शोधग्रंथ सारांश

अ.	शोधग्रंथ का शीर्षक	–	''रायपुर में धान के फसल पर पीले रंग के तना छेदक की जनसंख्या पर मौसम पैरामीटर के प्रभाव''
ब.	छात्र का नाम	–	सहदेव नाग
स.	मुख्य विषय		कृषि मौसम विज्ञान
द.	मुख्य सलाहकार का नाम एवं पता	–	श्री जे.एल.चौधरी (वरिष्ठ वैज्ञानिक) कृषि मौसम विज्ञान विभाग, कृषि महाविद्यालय, रायपुर, (छ.ग.)
इ.	उपाधि से सम्मानित किया जाना है	–	एम. एस. सी. (कृषि) कृषि मौसम विज्ञान विभाग,

छात्र का हस्ताक्षर

मुख्य सलाहकार का हस्ताक्षर

दिनांक :– 21/7/17

विभागाध्यक्ष के हस्ताक्षर

सरांश

एक क्षेत्रीय प्रयोग खरीफ मौसम में इंदिरा गांधी कृषि विश्वविद्यालय रायपुर क्षेत्र पर वर्ष 2016–17 के दौरान किया गया जिसमें धान की फसल में पीले रंग की तना छेदक की (आबादी) की गतिशीलता पर मौसम के मापदण्डो के प्रभाव के परिणाम को अवलोकन किया गया। पीले रंग की तना छेदक धान फसल का प्रमुख कीट है जो हमेशा फसल को नुकसान पहुंचता है, एवं इसके प्रभाव से फसल के उत्पादन में कमी आती है। वर्तमान अध्ययन का मुख्य उद्देश्य कीट की गंभीरता पर पर्यावरणीय कारकों के प्रभाव का पता लगाना है ।

इस खोज के द्वारा कीट के विकास के लिए उपयुक्त पर्यावरण की स्थिति की पहचान करने के लिए विश्वसनीय तरीकों को दे सकते हैं। वर्तमान क्षेत्र में पीले रंग की तना छेदक की संख्या एवं मौसम के कारको का सहसंबंध का आंकलन करते है तथा पीले रंग की तना छेदक की जनसंख्या के साथ अधिकतम तापमान (आर = 0.07) और पवन वेग (आर = 0.57) गैर महत्वपूर्ण सकारात्मक सहसंबंध देखा गया जबकि न्यनूतम तापमान (आर = 0.80**) सुबह की सापेक्षिक आर्द्रता (आर = 0.83**) शाम का सापेक्ष आर्द्रता (आर = 0.82) वर्षा (आर = 0.64*) और सूर्य प्रकाश की समय (आर = -0.88**) के साथ महत्वपूर्ण संकारात्मक सहसंबंध है। साथ ही दैनिक विधिधता (आर = 0.83**) ताप का योग (आर = 0.75**) और रात का नियत तापमान (आर = 0.72*) के साथ कीट की आबादी का संकारात्मक संबंध देखा गया सभी मौसम पैमाने में दैनिक विधिधता और न्यूनतम तापमान के साथ वाय.एस.बी. का उच्चतम स्तर के संबध दिखाई दिये। पीले रंग के तना छेदक के प्रकाष प्रंपच आकड़ा और मौसम संबधी पैरामीटर के उन्नीस वर्षीय आकड़ा को उसी समाप्त एवं चार सप्ताह पूर्व से संहसंबध और महत्वपूर्ण मौसम पैरामीटर सप्ताह चयनित कर उसे चरण–बध्य तरीके से प्रतिगमन विषलेषण किया।

वर्तमान अध्ययन के निष्कषो से पता चला है कि अधिकतम एवं न्यूनतम तापमान, वर्षा, सूर्यप्रकाश, साप्रेक्षित आर्द्रता (सुबह एवं शाम) का पीले रंग के तना छेदक के विकास पर गहरा असर डालता है। जबकि अधिकतम तापमान और सूर्य प्रकाश का समय पीले रंग के तनाछेदक के घटनाओं पर महत्वपूर्ण प्रभाव डालता है । 1998–2014 के आकड़ा का उपयोग करके पीले रंग के तना छेदक के लिए विभिन्न मानक सप्ताह में मौसम आधारित कई प्रतिगम मॉडल तैयार किये एवं उसे 2 वर्ष 2015 एवं 2016 के साथ मान्य किया। खरीफ धान फसल में पीले रंग के तना छेदक के लिए इस अध्ययन में मौसम मॉडल की खोज की गई। यह मॉडल तना छेदक के हमले के शुरूआती चेतावनी और परिपालन धान फसल संरक्षण के लिए उपयोगी होगा। खरीफ फसल के धान का पीले रंग के तना छेदक का रायपुर स्थान के लिए विषिष्ट है। और इस क्षेत्र के धान उत्पादको को कीट प्रबंधन सलाह के साथ प्रयोग में लाने की उम्मीद है।

CHAPTER – I
INTRODUCTION

Rice (*Oryza sativa L.*) is the world's most important food crop and is the staple food for 50% of the global population (Barrion *et al.*, 2007). Globally, rice is the second most widely consumed cereal next to wheat and it has occupied an area of 163.2 million hectares, with a total production of 719.7 million tonnes (Anonymous, 2014). The history of rice cultivation in China dates from 8000 B.C. to 6000 B.C. (Lawler, 2009). In 2009, the rice output of China was about 195 million tons (National Bureau of Statistics of China, http:// www.stats.gov.cn/).

India ranks 1st in area (43.95 million ha) and 2nd in production (103.61 million tonnes) after China (2nd advance estimate, 2015-16, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture, GOI). Rice being the main source of livelihood for millions of rural household is the backbone for Indian agriculture. The rice plays a very vital role in the national food security; even the rice self-sufficiency in India is precarious. Chhattisgarh, the central eastern state called as the "Rice bowl of India". The total estimated area of Rice in C.G. is 3.76 million ha, production is 7.71 million tonnes and productivity is 2050 kg/ ha, in the year 2014-15 (Krishi Darshika, 2016). The prime causes of low productivity of rice in Chhattisgarh are limited irrigation, lack of improved varieties suitable to different ecosystems, low or imbalanced use of fertilizers and insufficient pest management. It flourishes comfortably in hot and humid climate. In our country and Chhattisgarh state too rice is mainly grown in rainfed condition.

Production of rice is affected by various abiotic and biotic constraints out of which the loss caused by insects is major one. They infest all parts and growth stages, are vectors of insect pests and a major factor responsible for low rice yield particularly in tropical Asia, the world's rice bowl. Rice is attacked by more or less 100 species of insect- pests of which 20 are of economic importance (Pathak and Dhaliwal, 1981). Insect-pests such as stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrosis medinalis*), plant/grass hoppers (*Sogatella furcifera,* *Nephotettix spp., and Nilaparvata lugens*) were reported as major pests while hispa (*Dicladispa armigera*), ear-cutting caterpillar/armyworm (*Mythimna separata*) and root weevil (*Echinocnemus oryzae*) as the minor pests of rice (Dhaliwal and Singh, 1983; Singh *et al.*, 1993, Singh, *et al.,* 2002 and Butter and Singh, 2005). Among them the extent of damage caused by stem borer varied from 80 to 97 per cent (Sharma et al. 1996). The yellow stem borer (YSB) *Scirpophaga incertulas* Walker (Pyralidae: Lepidoptera) of rice is one of the major pests in all rice growing regions of Asia (Listinger J. A. 1979), South East Asian region (Banerjee and Pramanik, 1967) and India in particular (Chelliah *et al*., 1989). Yellow stem borer (YSB), *Scipophaga incertulas* (Walker.) is most destructive and widely occurring insect pest of rice that attacks all stages of crop (Banding and Listsinger, 2005). Feeding by YSB larvae causes death of affected tillers (dead heart symptom) in the vegetative; chaffy and unfilled panicle (white ear symptom) in reproductive phases of crop growth. Rice ecosystems due to 1% dead heart or white ear head, or both phases of stem borer damage results in 2.5%, 4.0%, and 6.4% yield loss, respectively grain production loss over ecosystems, 1% dead heart, or white ear head, or both phases of stem borer damage would be 108, 174 and 278 kg/ha, respectively (Muralidharan and Pasalu, 2006). Yield loss estimate across India varied from 11.2 to 40.1% due to dead heart and 27.6 to 71.7% due to white ears, respectively (Krishnaiah and Varma, 2012). The occurrence of insect pests in paddy fields is influenced by various factors including weather components, cultivation methods and rice varieties. Among these weather component temperature and humidity are the most important factors.

Climatic factors such as temperature, rainfall and relative humidity greatly influence the outbreak of the insect population (Chen *et al.,* 1968; Heong *et al.,* 2007; Siswanto *et al.,*2008). Meteorological factors play an important role in seasonal abundance, distribution and population build up of insect pests. It is difficult to find a direct cause and effect relationship between any single factor and pest activity because the impact of meteorological factors on pests is usually compounded (Garg and Sethi, 1980; Krishnaih *et al.,* 1996; Harinkhree *et al.,* 1998). The meteorological parameters have along term and permanent effect in insect population. According to Ramasubramaniun *et al*., (2006) rainfall and relative humidity played a significant role in the population build up of yellow stem borer and rice gundhi bug apart from these no other meteorological variables were found to be significant. The habitats and survival strategies of insects are strongly dependent on temperature because they are cold–blooded.

For developing any pest management programme for a specific agro-ecosystem, information on abundance and distribution of pest in relation to weather parameters is a basic requirement (Patel and Shekh, 2006). The study of agricultural meteorology in relation to insects will be very useful to farmers in all areas where major insect pests are appearing year after year and causing serious damage to the crop (Adiroubane and Raja, 2010). For survival, breeding and fast multiplication of any insects humidity plays a crucial role. Increasing or decreasing of relative humidity will create congenial environment and can create epidemic situation in the area. This is also applicable in rice stem borer. Moreover, the potential rate of development in insect population is strongly dependent on temperature and relative humidity.

Statistical models are developed for forewarning about infestation of paddy crops using step-wise regression technique and weather indices modelling technique without using transformation of data. The present study has been undertaken to develop some suitable models to know the dynamics of insect pests in relation to weeks as well as with meteorological variables namely temperature (maximum and minimum), rainfall, relative humidity and sunshine on light trap catches of the aforesaid insect pests so that active period may be as certained for forewarning to avoid the loss to the rice crop caused by the infestation of the insect pests.

Population dynamics of YSB like any other species are thus liable to fluctuate according to the dynamic condition of its environment (Chen et al., 1968; Khaliq *et al.,* 2014). Quantification of important mortality factors, both biotic and abiotic is needed to reliably forecast insect populations. Besides, knowledge of the seasonal abundance and population build up trend is essential to ensure timely preparedness to tackle impending pest problems and prevent crop losses (Das et al., 2008).Pest population density may be the resultant of weather parameters of several preceding weeks or months. It thus becomes worthwhile to explore relationship of pest population with weather parameters of several preceding weeks. Several workers have analyzed influence of weather factors on YSB population and observed temperature, humidity, and rainfall to be important ones (Bhatnagar & Saxena, 1999; Das *et al*., 2008; Joshi *et al.,* 2009; Mandal *et al.,* 2011; Sharma *et al.,*2011). As pest–weather relations are empirical and location-specific in nature and thus need to be established individually for different regions.

Efficient, economical and environmental-friendly control of the stem borer may be obtained through knowledge of its timing of attack in relation to weather factors, which may enable prediction of its occurrence so as to allow growers to make timely insecticidal sprays for efficient crop management. Earlier reports indicate empirical relationships between different weather factors and pest occurrence through population dynamic and forewarning models on point scale.

Therefore in the present study, an attempt has been made to find out the effect of some of these environmental factors on the severity of insect pest and further to assess their impact on yield. These finding may give reliable methods to identify environmental condition that are conducive for a particular insect pest development.

The main objectives of the investigation are given here under:-

- To study the effect of weather parameters on population dynamics of yellow stem borer in rice crop
- To derive indices like day and night time temperature, diurnal variation and heat sum in rice crop
- To develop weather based forewarning model for yellow stem borer in rice crop

CHAPTER – II

REVIEW OF LITERATURE

For the sake of convenience and clarity the review of literature related to "**Influence of weather parameters on population dynamics of Yellow Stem Borer (YSB) in rice crop at Raipur"** has been divided into the following sub headings under the following aspects

2.1 Effect of weather parameters on population dynamics of yellow stem borer in rice crop.

2.2 To derive indices like day and night time temperature, diurnal variation and heat sum in rice crop.

2.3 To develop weather based forewarning model for yellow stem borer in rice crop.

2.1 Effect of weather parameters on population dynamics of yellow stem borer in rice crop.

Sharma *et al.,* (2004) studied the population build up of green leafhopper *Nephotettix virescens* Dist (Cicadellidae, Hemiptera), plant hoppers *Cofana spectra* Dist (Delphacidae, Hemiptera) and *C. yasumatsui* Young (*Kollamimica*, Hemiptera) and rice gundhi bug *Leptocoriza acuta* Thunberg (Alydidae, Hemiptera) in rice growing season (July to November) light trap data of ten years (1988–1997). They result found that the meteorological factors have significant effect on the population build up of *Nephotettix virescens* Dist, *Cofana spectra* Dist and *C. yasumatsui* Young in the month of October. In the case of *Leptocoriza acuta* Thunberg, no other factor but rainfall had positive correlation and population build up in the fourth week of September.

Arif *et al.,* (2006) conducted field experiments to monitor the population dynamics of rice stem borer (*Scirpophaga incertulas*) and spider. The critical infestation of the stem borer occurred during vegetative and panicle stages of boro rice. The maximum infestation of stem borer (6.2 dead hearts/5 hills) and maximum spider population (10.6 spider/m^2) were recorded during the cropping period.

Weather parameters accounted for 93 and 57% of total variations in the stem borer incidence (dead hearts) and spider population respectively.

Yang *et al*., (2009**)** analysed the meteorological conditions affecting the population dynamics. They reported the significant relationships between the population dynamics of paddy stem borer and meteorological factors the average minimum temperature per month and relative humidity (RH) were most influencing parameters.

Shamim *et al*., (2009) studied the population dynamics of Green leaf hopper and white backed plant hopper for ten consecutive years (1994 to 2004) except for 1997. They correlated population data with the weather parameters like maximum and minimum temperature, rainfall, relative humidity and bright sunshine hours. Weather parameters like sunshine hours and found a positive significant correlation (r=0.166) with the population dynamics of GLH. The correlation between WBPH peak population and bright sunshine hours showed positive significant correlation (r=0.269). While maximum temperature, minimum temperature, rainfall and relative humidity showed non-significant effect on population build up of both GLH and WBPH. Green leaf hopper attained peak population during 43rd standard meteorological week; whereas white backed plant hopper reached peak population during 39th standard meteorological week and decreased considerably thereafter.

Adiroubane and Raja (2010) monitored the rice stem borer infestation by weather parameters. They reported that high pest incidence during months of March *(Navarai – Rabi, 2005*), August- September (*Kuruvai –Kharif, 2006*) and October-November (*Samba – Rabi*, 2006). The favourable weather conditions for high stem borer incidence were 27.6ºC, 30.1ºC, 26.1ºC as mean temperatures and relative humidity per cent ranged between 95.9 and 65.7, 82.2 and 54.5, 95.3 and 82.8 pertaining to the *Navarai*, *Kuruvai* and *Samba* seasons, respectively.

Prasad and Tiwari (2010) reported that monitoring and forewarning of *Hellcoverpa armigera, Leucinodes orbonalis, Scirpophaga incertulas* and *Spodoptera litura* at CRC and HRC, S.V.P. Uni. of Agric. & Tech., Meerut. Result found that the moth catches of *H. armigera* population showed significant positive correlation with maximum temperature, while significantly negative correlation with RH. The moth catches of *L. orbonalis* revealed significant positive association with maximum and minimum temperature. In case of S. *Incertulas,* moth catches showed non-significant correlation with weather factors. The population of S. *litura* revealed a significantly positive correlation with maximum temperature but RH showed significant negative correlation.

Sabale *et al.*, (2010) studied the influence of weather factors on light trap catches of green leaf hopper for two species, namely, *Nephotettix nigropictus (Nn)* and *Nephotettix virescens (Nv)* at Pattambi, Kerala. The first peak was observed for both the species during 38^{th} to 41^{st} standard meteorological week, the second peak was observed during 45^{th} std. week and the third peak was observed during 52^{nd} to 2^{nd} std. week. The correlation studies between light trap and net sweep collection with weather parameters that lower minimum temperature, low rainfall and abundant sunshine had major impact on population build up of green leaf hopper.

Chakraborty and Deb (2011) studied the incidence of leaf folder (LF), *Cnaphalocrocis medinalis* population in paddy crop (*Oryza sativa* L.) during the *kharif* seasons (2005-2008) at Hemtabad, Uttar Dinajpur, West Bengal. Result found that the abiotic conditions such as minimum temperature, temperature gradient, maximum relative humidity and average relative humidity had significant positive influence on *C. medinalis* population. In case of minimum relative humidity and sunshine hours a negative influence was observed. Other factors such as maximum temperature, relative humidity gradient, average relative humidity, number of rainy days and rainfall imparted insignificant positive effect on population development.

Singh *et al.*, (2012) analyses the effect of various meteorological parameters on population dynamic under Punjab. The maximum number (percent) of insect pest damage samples received at Plant Clinic were for plant hopper (44%) followed by leaf folder (30%) and stem borer (29%). The weather conditions conducive for the build up of rice pest population were cloudy weather. They observed during the high pest infestation years (pest samples >200) a well distributed (more number of rainy days) near or above normal rainfall was received during June to October.

Karuppaiah and Sujayanad (2012) studied the impact of Climate Change on population Dynamics of brown plant hopper *Nilaparvatha lugens* (Stal) and rice leaf folder, *Cnaphalocrocis medinalis* (Guen) at Indian Agriculture Research Institute, Pusa Campus, New Delhi. Temperature variations indicate the impacts of rising temperature which could make the changes in the pest population dynamics of rice ecosystem. Therefore climate change would result in changes in the population dynamics of insect pests. Thus temperature rise plays a pivotal role in insect population dynamics.

Ramya *et al.,* (2012) conducted an experiment at Agro Climate Research Centre, Tamil Nadu Agricultural University, India to understand the Pest dynamics at elevated temperature. Climate change resulting in increased temperature could impact crop insect-pest populations in several complex ways. Although some climate change temperature effects might tend to depress insect populations, most researchers seem to agree that warmer temperatures in temperate climates will result in more types and higher populations of insects. The population growth of the important insect-pests such as yellow stem borer (*Scirpophaga incertulas*) and brown plant hopper (*Nilaparvata lugens*) of rice. The results revealed that there was an inverse correlation between temperature and total life span, developmental time and also fecundity. However there was a positive correlation between temperature and development rate.

Manikandan *et al.,* (2013) conducted an experiment in Coimbatore, Tamil Nadu. They maintained five different constant temperatures for the development time of yellow stem borer (YSB). The results revealed that the number of eggs laid by YSB increased at higher temperatures while egg hatching was reduced. Egg hatching was higher (90.6%) at 30.6°C in different stages. YSB inverse relationship has been found with development time and incubation temperature level

Justin and Preetha (2013) studied the seasonal incidence of rice yellow stem borer, *Scirpophaga incertulas* (Walker). The results revealed that the infestation was found during August - September and December - February, reaching the peak in January - February, and without any infestation in other months. They correlated incidences of rice yellow stem borer with weather parameters and found a significant positive correlation with relative humidity and negative correlation with minimum temperature and rainfall.

Ram *et al.*, (2014) reported that the larval population of rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) in basmati rice was low during July to fourth week of August and the pest population increased from end of August to start of September and reached its peak (5.10 larvae/hill) during 38th standard week i.e. second fortnight of September negative correlation with larval population such as maximum (r= -0.0909), minimum (r=-0.3796) temperature. They found relative humidity (r=-0.1146) and rainfall (r=-0.5108) during crop season.

Kakde and Patel (2014) carried out a experiment with studied the influence of different planting methods on succession of rice yellow stem borer under conventional (Transplanting) and SRI method of paddy cultivation. They reported that under conventional method, yellow stem borer infestation appeared in peak during first week of September (5.58% DH) and 1st week of October (5.79% WEH). In SRI method, the peak incidence was observed during first week of September (4.19% DH) and last week of September (4.93% WEH). The results of both methods indicated that the weather parameters had less influence on the activity of yellow stem borer damage.

Hussain *et al.*, (2014) studied the population dynamics and impact of abiotic factors like temperature, humidity and rainfall on the population dynamics of leaf hopper *Amrasca biguttula biguttula.* Eight transgenic cotton genotypes at Cotton Research Station, Multan during 2011 and 2012 were cultivated for this experimentation. The results revealed that leaf hopper population to be negatively and significantly correlated with maximum temperature while positively and non-significantly correlated with minimum temperature. In case of rainfall and relative humidity both these factors had a positive and significant correlation with leafhopper population in all transgenic genotypes of cotton.

Chaudhary *et al.,* (2014) conducted experiments during the *kharif* season of 2011-12, at the Agricultural Research Farm, BHU Varanasi. The incidence of BPH in the beginning was very low. As soon as the rain stopped in last week of September then the population increased with the vegetative stage of crop and reached highest in third week of October. The incidence of the pest was severe in the last September to last October. The result showed that population of BPH was positively correlated to temperature and relative humidity whereas negative correlation was found with rainfall.

Kumar *et al.,* (2015) conducted an experiment at Research Farm of Rajendra Agricultural University, Pusa. Pest activity started in 30th standard week and continued upto 41st standard week, meanwhile it reached peak twice in 34th and 37th standard week. Thereafter, its population declined and finally no population was recorded. Weather parameters positively correlated to the population of male moth of yellow stem borer, whereas sunshine (hr) was negatively correlated.

Bhutto *et al.,* (2015) observed the activity of adult moth of yellow rice stem borer. The moth activity of over-wintering generation started during the 4th week of March, reached to its first peak during the 2nd week of April and drastically declined up to the end of May. No moth was captured during June and July. Moth population again started during 2nd week of August to infest rice crop, reached to its second peak during the 1st week of October. Moth population gradually declined from 2nd week of October to last week of November. No moth was captured in the last week of November, December, January and February. Female moths were more attracted to light trap.

Kalita *et al.,* (2015) studies at ICAR Research Complex for NEH region, Sikkim Centre, Tadong. The effect of weather parameters on population buildup of some major rice pest's viz., stem borer, whorl maggot, leaf folder and gundhi bug observations have been taken at fortnightly interval starting from second fortnight of July to first fortnight of November through fixed plot survey during kharif, 2007 and 2008. Result found that stem borer infestation was maximum during August-September (6.82–7.62% dead heart). The maximum white ear head% was recorded in the second fortnight of October (7.56 % in 2007 and 8.14% in 2008). The leaf folder population was found maximum in the last part of August and first part of September (14.50 -16.75 damaged leaves/10 hills). Gundhi bug population was found maximum when the crop attained the milky stage in the first fortnight of October (14.80-16.40 gundhi bug/10 hills). Among the natural enemies the population was found maximum during the last fortnight of September. The correlation study revealed that the population build-up of different pests and their natural enemies was influenced by the weather parameters in both the years.

Kakde and Patel (2015) conducted an experiment at N. M. College of Agriculture, N.A.U., Navsari (Gujarat). Observed the seasonal occurrence of rice leaf folder, *Cnaphalocrocis medinalis* (*Guenee*) the peak level reached during 4th week of September (39th SMW) when leaf damage due to leaf folder was 2.30% under conventional method and 2.66% under SRI method. The correlation results under conventional and SRI method indicated that the weather parameters had less impact on leaf folder damage.

Shah *et al.*, (2015) studies at Agriculture Research Institute Tandojam. Analyzed the correlation and regression of abiotic factors and mustard aphid revealed that a positive but non-significant (P>0.05) relation of *L. erysimi* with relative humidity (r=0.1922), rainfall (r=0.0619) and wind velocity (r=0.1213). *L. erysimi* population was negatively correlated with minimum temperature (r=-0.4735), maximum temperature (r=-0.3537) and evaporation (r=-0.2769). *L. erysimi* population exhibited a positive and significant (P<0.05) correlation with coccinellids: *C. transversalis* (r=0.5432), *C. septempunctata* (r=0.5134) and *M. sexmaculatus* (r=0.8976); while negative and significant correlation of *L. erysimi*was determined with population of *I. scutellaris*.

Nirala *et al.*, (2015) conducted an experiment at research farm of Indira Gandhi Krishi Vishwa Vidyalaya, Raipur. Observed maximum adult of rice case worm (CW) and grasshopper were on 41th SMW of October with 416.0 adult/weeks and 73.0 adult/week respectively and adult population gradually decreased as the crop departing towards maturity stage. The results revealed that Case worm showed non-significant negative correlation with average rainfall (mm) (r = – 0.342), RH-I (r = – 0.135), RH-II (r = – 0.024), Average RH (r = – 0.042) while non significant positive correlation with maximum temperature (r = + 0.166), minimum temperature (r = + 0.095), average temperature (r = + 0.118) and sun shine (hours) (r = + 0.109). Grasshopper showed significant negative correlation with RH-I (r = – 0.455*) and non-significant negative correlation with average rainfall (mm) (r = – 0.135), sun shine (hours) (r = – 0.174) whereas non-significant positive correlation with maximum temperature (r = + 0.078), minimum temperature (r = + 0.157), average temperature (r = + 0.151), RH-II (r = + 0.152) and average RH (r = + 0.074) at 1 and 5 per cent level of significance.

2.2 To derive indices like day and night time, temperature, diurnal variation and heat sum in rice crop

Sahoo *et al.*, (2016) studied the population dynamics of prevailing five insect-pests of mango in relation to weather parameters. The correlation worked out between various pests and weather parameters of previous week and previous fortnight revealed highly significant correlation in most of the cases. Except shoot borer, which was significantly influenced by rainfall, all the other pests were significantly influenced by temperature related indices. Among all the weather parameters heat sum showed highest degree of correlation with fruit fly population.

2.3 To develop weather based forewarning model for yellow stem borer in rice crop

Sondgerath and Muller (1996) developed the model to predict the population dynamics of the cabbage root fly. This model coupled several Lesile processes, one of each stage of the life cycle. The coupling was done via time dependent transition probabilities reflecting the development status of the individuals which was described by the biological age. Comparing the simulation result with laboratory experiments (controlled condition) and field experiments (variable conditions) a good correspondence was observed.

Prajaneshu (1998) presented a deterministic model in terms of an intero differential equation. He developed a non-linear statistical model for describing the dynamics of aphid population growth. The corresponding non-linear statistical model was applied to ten data sets using the Leven berg-Marquardt iterative procedure. Examination of residuals was carried out to study the validity of the underlying assumptions and subsequently the goodness of fit were computed and concluded that the proposed model was quite successful in describing the dynamics of the aphid population growth.

Ramasubramanium *et al.* (2006) developed statistical models for forewarning about infestation of paddy crops using step-wise regression technique and weather indices modelling technique without using transformation of data.

Samui *et al.,* (2007) conducted an experiment on weather based forewarning of leaf folder attack on kharif rice and operational at Pattambi, Kerala. Weather based multiple regression models for the peak infestation period for each of the generations of the pest were developed using data for the period 1987-99. Based on the findings of this study weather pest calendar for leaf folder of kharif rice was prepared. This calendar would be useful for early warnings and operational rice crop protection from leaf folder attack and same result were also found for green jassid attack on kharif rice.

Sastri *et al.,* (2008) conducted an experiment on development of weather based forewarning systems for pest and diseases under Chhattisgarh at Raipur which indicated that for gall midge more diurnal variations in maximum temperature are favourable for development from pupal stage to adult stage. In case of yellow stem borer (YSB), there was positive effect of weather parameters like maximum temperature, minimum temperature and relative humidity I and II within certain range of the insect growth stages. The weather parameters affect the insect growth adversely. In the field experimental studies it was found that early flowering and peak vegetative stages were found to be more favourable for gall midge occurrence. Same was the case for yellow stem borer too. Regarding the effect of weather parameters on gall midge incidence, it was found that: effect of maximum temperature increases as the dates of sowing advance. & effect of minimum temperature decreases as the dates of sowing advance.

Yadav *et al.,* (2010) developed multiple linear regression model (pest-weather models) between monthly mean brown planthopper (BPH) *Nilaparvata lugens* light trap catches and monthly mean values of minimum temperature (Tmin), maximum temperature (Tmax), morning relative humidity (RHI) and evening relative humidity (RHII) observed at Maruteu, Andhra Pradesh during 2000-2007 kharif seasons.

Yadav and Chander (2010) reported that multiple linear pest-weather regression model was developed between weather factors *viz.,* maximum temperature (Tmax), minimum temperature (Tmin), morning relative humidity (RHI) and evening relative humidity (RHII) and logarithmically transformed BPH light trap catches observed during *kharif* season from 2000 to 2007 at Maruteru, Andhra Pradesh. The pest-weather model involving three weather parameters *viz.*, Tmax, Tmin and RH was found to be the best fit as all the three weather factors showed significant influence on BPH light trap catches with the coefficient of determination (R^2) being 0.674.

Mandal *et al.,* (2011) conducted an experiment regarding development of the forewarning system for rice yellow stem borer, *Scirpophaga incertulas* infestation and outbreaks using pheromone traps. Field infestation of *S. incertulas* was evaluated based on percentage occurrence of dead hearts and white ears. Each weather variable was assigned weightage based on their relative importance to stem borer initiation and spread. Pheromone trap catches were used to forewarn regarding their outbreaks on which a linear regression equation was developed for predicting insect infestation in advance. The catching of moth in trap commenced as early as 32 standard week (2nd week of August) with its peak during 37 standard week while incidence of dead heart started at 34 standard week (4th week of August) and reached the peak at 38 standard week (3rd week of September).

Sharma *et al*. (2011) studied the models for forewarning about the infestation of green leafhopper *Nephotettix virescens* (Cicadellidae, Hemiptera), plant hopper *Cofana spectra* (Delphacidae, Hemiptera), rice gundhi bug *Leptocoriza acuta* and yellow stem borer *Scirpophaga incertulas* Walker (Pyralidae, Lepidoptera) in rice growing season (July to November) was studied through light trap collection over fifteen years (1985-1999). Maximum population of *S. incertulas* Walker was recorded in the month of September in all the years. After making a transformation on the response variable that is population of insects, the cubic polynomial model was fitted with week as explanatory variable and it described the dynamics of the populations of all considered insects during the weeks. We also include meteorological factors in the model and it provides the dynamics of the populations of all the above mentioned insects for forecasting.

Rao *et al.* (2014) reported that forewarning models of mustard aphid through experiment data from six north Indian locations were used to study the role of weather on incidence and development of mustard aphid. Result found that time to attain peak population in warm humid climate was relatively shortened than in cool climates. Functional relations proposed in the present investigation between aphid incidence and peak population using previous week weather and pest data for majority of the locations could be used for taking any control measures.

Srivastava *et al.,* (2015) reported that pest and diseases which are major factors limiting the production are also influenced by weather conditions. Therefore an ordinal logistic model was developed for forewarning of important pest/diseases in rice, mustard, pigeonpea, sugarcane, groundnut, mango, banana at various locations. The forewarning through these model can prove to very useful in taking timely control measures. This will help finally to facilitate a graphical user interface for the rural community.

Prasannakumar *et al.,* (2015) studied weather based rice yellow stem borer prediction model by including relationship of weather parameters. Relationship has been studied during seven years at Mandya (Karnataka) as individually explored with peaks of rice yellow stem borer (YSB) *Scirpophaga incertulas* (Walker) through light trap catches. From result it has been interpreted that peaks of YSB trap catches exhibited significant correlation with T_{max} of October 3rd week, T_{min} of November 1st week, RF of October 2nd week, RH-I of November 4th and RH-II of November 1st week and SSH of October 4th week. Weather-based prediction model for YSB was developed by regressing peaks of YSB light trap catches on mean values of different weather parameters of aforesaid weeks.

Vennila *et al.,* (2015) conducted an experiment rice research farm IGKVV, Raipur, used in conjunction with the weather data of the location for development of weather based prediction through iterative approach between range of each weather variable, and population levels *S. incertulas* categorized as to low, medium and high severity. Validation of the weather based criteria for forewarning the population severity using the prediction rules for seasons between 2011 and 2014 indicated 96.3% prediction accuracy. The weather based criteria and prediction rules have been integrated online for forewarning *S. incertulas* population levels for the current and future SMWs under the "Pest dynamics *vis a vis* Climate Change".

Akashe *et al.,* (2016) analyse at zonal Agricultural Research Station, Solapur (MS) during *kharif* seasons for ten consecutive years (2004 to 2013). The effect of weather parameters on thrips (*Thrips palmi* Karny) population. Result found that the thrips population was positively correlated with maximum temperature while it was negatively correlated with RH-I, RH-II and rainfall. The eight years (2004 to 2011) data were used for development of model, which was validated with experimental data of two years (2012 and 2013). The model explained the incidence of thrips on sunflower to an extent of 88 %. Hence, this model can be used for predicting the incidence of thrips on sunflower.

Jayakumar *et al.,* (2016) conducted an experiment on coffee plantations in Regional Coffee Research Station, Chundale and data on weather parameters were recorded during 1977 to 2007 (30 years). These long- term data on the pest damage and weather parameters were utilized to develop weather based forewarning models for coffee berry borer and shot hole borer damage. Highest percent damage of coffee berry borer and shot hole borer was observed during first fortnight of

January. Maximum damage due to coffee berry borer was observed during 1982 and maximum damage due to shot hole borer was observed in 1994. Maximum temperature recorded during the first fortnight of January is predominant weather variable determining infestation of shot hole borer during first fortnight of January

Singh *et* al., (2016) reported that forewarning model for rice leaf folder was developed based on peaks of its light trap catches and value of weather parameters observed during 2007-2012. Forewarning modal was thus developed based on maximum temperature, morning relative humidity, evening relative humidity and sunshine hour, where in these four weather factor together could explain 99% variability in leaf folder light trap peak. Likely causes of the leaf folder outbreak that occurred kharif (rainy season 2012) were explored. Weather analysis suggested that besides other factors, hotter and drier conditions during June and July in 2012 as compared to other year might have played a role in leaf folder outbreak.

Murumkar *et al.,* (2013) studying the effect of environmental factors and crop phenology on *Alternaria* leaf spot disease development in safflower under three different sowing conditions *viz*., early, normal and late at zonal Agricultural Research Station, Solapur in Maharashtra, India. The result revealed that subnormal temperature coupled with above normal humidity and rainfall contributed significantly for the disease incidence and its spread under different sowing situations. By employing step down linear regression models, the incidence of *Alternaria* leaf spot on safflower can be predicted to an extent of 97.6%, 95.3% and 92.2% accuracy under early, normal and late sowing conditions, respectively while with non-linear models the prediction rate for the leaf spot under above sowing situations was improved to 99.8%, 99.6% and 99.4%, respectively.

Reji *et al.,* (2014) studies the relationship between weather parameters viz., maximum temperature (Tmin) and minimum temperature (Tmin), morning (RH-I) and afternoon relative humidity (RH-II) and the severity of stem borer damage (SB). Multiple linear regression analysis was used for formulating pest weather models at three sites in southern india namely, Warangal, Coimbatore and pattambi as SB= -66.849+2.102Tmax +0.095RH-I, SB= 156.518-3.509Tmin – 0.785RH-I and SB= 43.483 -0.418 Tmin -0.283 RH-I respectively. The pest damage predicted using the model at three sites did not significantly differ from the observed damage ($t = 0.442$; $p > 0.05$).

CHAPTER - III

MATERIALS AND METHODS

This chapter deals with the description of materials used and technique adopted during the course of investigation entitled **"Influence of weather parameters on population dynamics of Yellow Stem Borer (YSB) in rice crop at Raipur"** The present investigation was conducted at Department of Agrometeorology College of Agriculture, Research, IGKV, Raipur Chhattisgarh during *kharif* season (July to November) 2016.

3.1 Experimental site

The field experiment was carried out during *kharif* 2016 at College of Agriculture Research Farm, Department of Entomology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh).

3.1.1 Geographical Situation

Raipur situated in Eastern Central part of Chhattisgarh at latitude of 21^0 $16'$ N, longitudes 81^0 $36'$E and altitude 289.5 m above mean sea level.

3.1.2. Climate

Raipur comes under dry sub humid to semi-arid agro climatic zone (Rice zone) of the state. The average annual rainfall is about 1188 mm, out of which 85% rainfall received during rainy season (June to September) and the rest during winter and summer season (October to May). The main source of rainfall is south western monsoon. (The monsoon enters around 10^{th} of June from southern part of Baster and reaches the other parts of Chhattisgarh by 20^{th} June. It starts to withdraw after 15^{th} September from Surguja region and by 25^{th} September, the monsoon.)

May and December months are the hottest and coolest months, respectively. The weekly maximum temperature raise up to 46^0C during summer and minimum temperature drops as low as to 6^0C during winter season. The weekly maximum and minimum temperature were recorded as 33.6 and 20.4^0C, respectively.

Table 3.1: Weekly Meteorological data during crop growth stage period (From 26 SMW to 48 SMW) Kharif season 2016 Station: Labhandi, Raipur (C.G.)

SMW	Date		Max. Temp. (°C)	Min. Temp. (°C)	Rain-fall (mm)	Relative Humidity (%)		Wind Velocity (Kmph)	Evapo-ration (mm)	Sun-shine (hours)
						I	II			
26		**25-01**	35.0	26.2	32.4	88	59	6.2	6.2	8.0
27	**Jul**	**02-08**	31.0	24.5	107.6	95	83	11.2	4.0	1.9
28		**09-15**	29.3	25.1	59.0	91	80	8.0	3.1	1.5
29		**16-22**	30.6	24.5	207.0	94	79	6.1	3.2	0.9
30		**23-29**	31.9	25.4	56.2	91	69	3.9	4.9	5.8
31		**30-05**	30.7	25.3	28.0	92	81	7.0	3.3	2.9
32	**Aug**	**06-12**	32.3	28.6	22.0	91	77	8.7	3.0	1.6
33		**13-19**	28.7	21.6	11.6	89	77	9.4	2.5	1.3
34		**20-26**	31.9	25.6	4.2	90	70	5.0	4.1	5.2
35		**27-02**	32.2	26.0	22.2	90	67	3.6	3.7	4.8
36	**Sep**	**03-09**	30.7	25.3	62.8	87	68	5.9	3.5	1.4
37		**10-16**	31.1	24.3	132.8	95	80	2.9	3.6	3.3
38		**17-23**	32.2	24.9	91.6	94	69	2.5	4.7	6.2
39		**24-30**	30.0	24.5	134.6	97	89	2.8	3.3	3.4
40	**Oct**	**01-07**	26.5	24.8	48.2	95	72	2.7	3.2	4.5
41		**08-14**	31.5	22.9	9.2	94	50	1.4	3.4	5.6
42		**15-21**	31.6	19.0	0.0	90	35	1.1	4.1	10.0
43		**22-28**	31.5	18.1	0.0	89	36	1.5	3.8	9.5
44		**29-04**	30.6	19.8	0.0	85	51	2.1	3.3	8.0
45	**Nov**	**05-11**	30.2	15.7	0.0	88	29	1.9	3.6	8.5
46		**12-18**	29.0	14.4	0.0	89	35	1.5	3.0	7.8
47		**19-25**	30.0	11.3	0.0	89	25	0.9	3.0	8.5
48		**26-02**	30.7	13.0	0.0	88	27	1.2	3.2	8.5

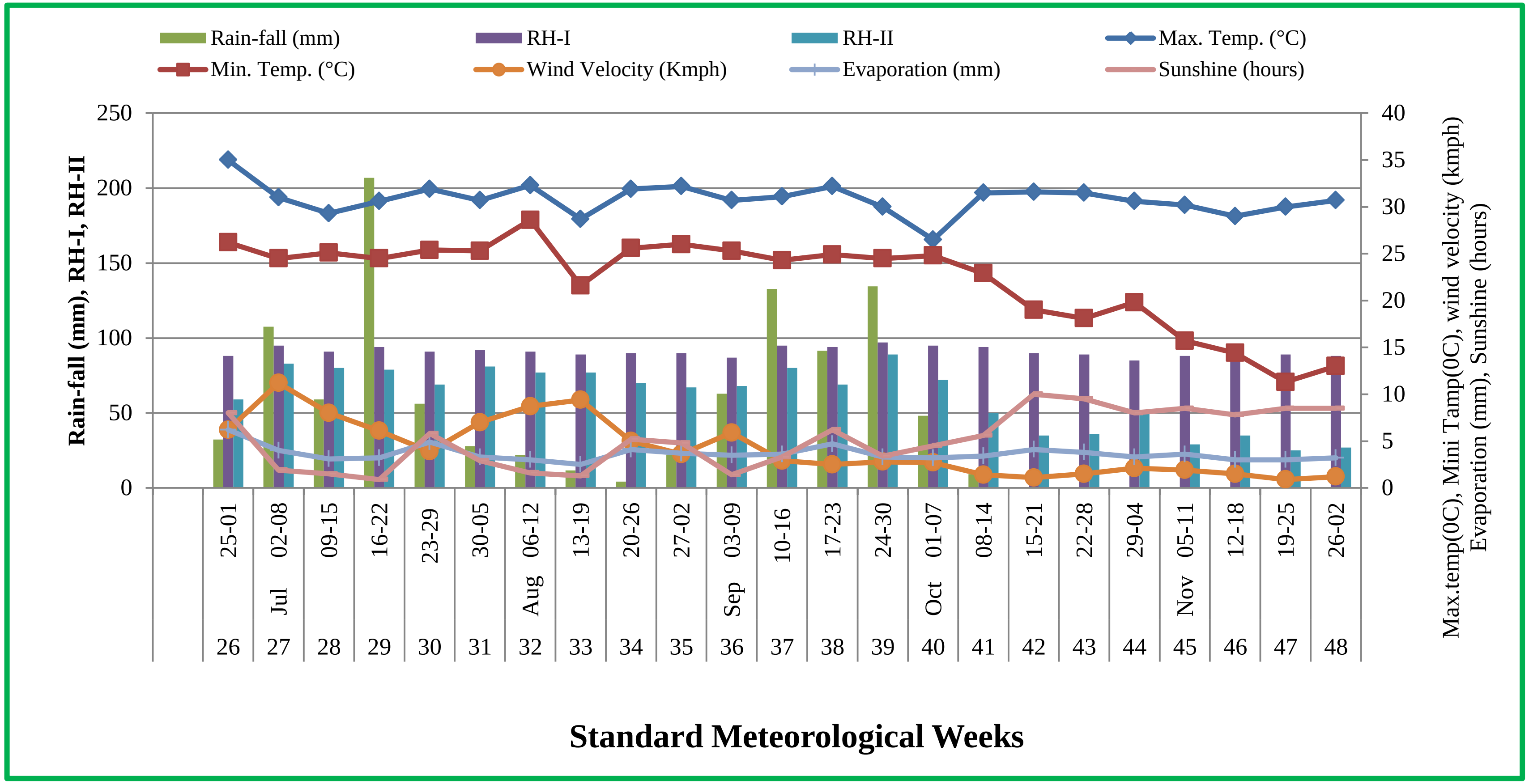


Fig -1: Meterological data during kharif season - 2016

3.1.3. Weather condition during crop period

During the crop gro22wth period the maximum temperature ranged from 29^0C to 42.1^0C where as minimum temperature ranged from 14.4^0C to 29.5^0C. The total rainfall recorded 1124.2 mm during the crop period of month of June to September 2016, the morning relative humidity varied from 57 to 94 per cent while in after noon it varied from 25 to 80 per cent.

3.2 Experiment details:

The experiment was conducted at the research farm of IGKV Raipur (CG) during Kharif 2016. Stem borer (YSB) was found most active in kharif season. The maximum YSB adult population was daily observation at growing stages of rice crop. The experimental field was free from insecticide sprays. The pest succession of major insect pests of rice was co- related with weather parameters to observe the effect of individual parameters on pest incidence. An field experiment of department of entomology Raipur with rice variety swarna was taken under observation under different damage levels at different stages of crop growth. Damage is caused by the caterpillars by producing dead hearts. The larva feeds inside the stem causing drying of the central shoot or 'dead heart' in young plant and drying of the panicle or 'white ear' in older plant.

3.2.1 Infestation of Yellow stem borer

The infestation of yellow stem borer (*Scirpophaga incertulas* Walker) was recorded on 10 hills randomly in a plot by counting total number of tillers and “Dead hearts” on each hill then the % was calculated by using following formula-

$$\text{Dead heart } \% = \frac{\text{Number of Dead hearts}}{\text{Total Number of tillers}} \times 100$$

Similarly White earheads were counted per 10 hills randomly in a plot and then percent white earheads was taken out from the total number of earhead per 10 hills at those four places before harvesting.

$$\text{White earhead percent \%} = \frac{\text{Number of white earheads}}{\text{Total number of panicles}} \times 100$$

3.3 Heat units

3.3.1 Growing Degree Days

Growing degree days (GDD) concept assumes that there is a direct and linear relationship between growth and developments of plants and temperature and the growth is dependent on the total amount of heat units to which it is subjected during its life time. The growing degree days was computed by using following formula:

$$\mathbf{GDD = \Sigma\ [(Tx + Tn)/2 - Base\ temperature]}$$

Where,

Tx = Daily maximum temperature

Tn = Daily minimum temperature

The base temperature is defined as, "The temperature below which no plant physiological activity takes place" which is considered 10^{o}C for *Kharif* crops.

3.3.2 Helio Thermal Unit (HTU)

HTU is calculated by multiplying GDD with actual sunshine hours (n).

$$\mathbf{HTU = GDD \times n}$$

Where, n = actual sunshine hour.

3.4 Different indices

For this study daily rainfall, maximum temperature and minimum temperature data were collected from the Department of Agrometeorology IGKV Raipur (Chhattisgarh). Using meteorological data derived indices like day temperature (DT), night temperature (NT), diurnal variation (DV) and heat sum (HS) were calculated as per Venkataraman and Krishnan (1992) formula which given below-

$$DT = Tmax - 0.4\,(Tmax - Tmin)$$

$$NT = Tmin + 0.4\,(Tmax - Tmin)$$

$$DV = DT - NT$$

$$HS = \sum \frac{Tmax + Tmin}{2} - \text{Base temperature}$$

Summarized information on different meteorological parameters was correlated with the insect population. Correlation studies between weather parameters and insect population were made using crop growing period data.

3.4 Weather based forewarning model

Weekly total of daily recorded population were calculated for determining the seasonal activity of yellow stem borer according to standard meteorological weeks prescribed by the Agro-meteorological Department, Raipur IGKV (C.G.). The meteorological data on maximum and minimum temperature (^{0}C), morning (maximum) and evening (minimum) relative humidity (%), sunshine hours and rainfall (mm) of each day were obtained from the meteorological observatory of the institute. Correlation analysis was carried out between weather parameters and light trap collection populations during kharif season of 2016 and regression analysis was worked out as per method.

3.5.1 Insect Variables

Weekly light trap data on *Scirpophaga incertulas* (Walker) for last eighteen years was collected from department of Entomology IGKV Raipur. YSB is a serious pest of deep water rice. Adults mate only once and up to 150 eggs are laid per female. Each female lays 1-3 egg masses. Egg masses are usually laid on leaf tips but they are also laid on the base of the stems. Favourable temperature for egg laying of YSB is 24 - 29^{0}C and relative humidity 90-100%, Egg period varies from 5-9 days. Suitable temperature for egg hatching are 30.6^{0}C, newly hatched larvae disperse through silken threads and bore into the plant. Usually only one larva is found in a tiller. The number of moults and larval duration (30-40 days) depends on the prevailing temperature which ranges from 17- 35^{0}C. Pupal stage is completed in the stem in 7-10 days and for the pupal development ptimum temperature ranges from 15-28^{0}C. Pupae become adult in approximately 6-12 days and maximum survival temperature is 36^{0}C.

3.5.2 Weather variables

Weighted accumulation of weekly weather data for eighteen years was done, weight being correlation coefficient for insect. Weather index was formed for selected weather factors (Maximum temperature, minimum temperature, relative humidity morning and rainfall). As weather factors at standard week 27-48 were important for insect pest severity, more weights have been given in weather factors which are more important in deciding the severity of insect pests.

3.5.3 Multiple regression analysis:

When the numbers of variable which explain the dependent variable are more than one, multiple linear regression analysis can be used. Here the model is.

$$Y= \propto +\beta_1X_1+ \beta_2X_2+................+ \beta_pX_p+ \varepsilon$$

Where

Y is the dependent variable and $\mathbf{X_{i's}}$ are independent variables with $\beta_{i's}$ as the partial regression coefficients of $\mathbf{X_{i's}}$ on Y.

Whereas, insects pest was taken dependent variable and environmental factors as independent variables. The estimates of coefficients ($\beta_{i's}$ and ά**)** are to be computed using the method of least squares. For selecting the variable to be included in the model stepwise procedure was used by Drapper and Smith (1996).

The significance of the model is tested based on F test .Partial regression coefficient also tested for their significant difference from zero, using **t** test at 5 percent level of significance. Multiple coefficient of determination (R^2) is also calculated as:

$$R^2 = \frac{\textbf{Regression sum of squares}}{\textbf{Total sum of squares}}$$

$$= \frac{\sum_{i=1}^{p} b_i \sum_{j=1} x_{ij} y_i}{\sum_{j=1}^{n} y_i^2}$$

3.5.4 Regression equation After analysis a multiple linear equation has been determined, which may be a useful tool for prediction of YSB population in the region.

Regression equation for Predicted population –

Y = a + (b1) (x1) + (b2) (x2) + (b3) (x3) + (b4) (x4)

Where-

Y	=	Predicted population
A	=	Intercept
b1, b2, b3, b4	=	Regression coefficient
x1, x2, x3, x4	=	Dependent variables

Formula of Deviation % -

Deviation % = Predicted yield -Actual yield /Actual yield*100

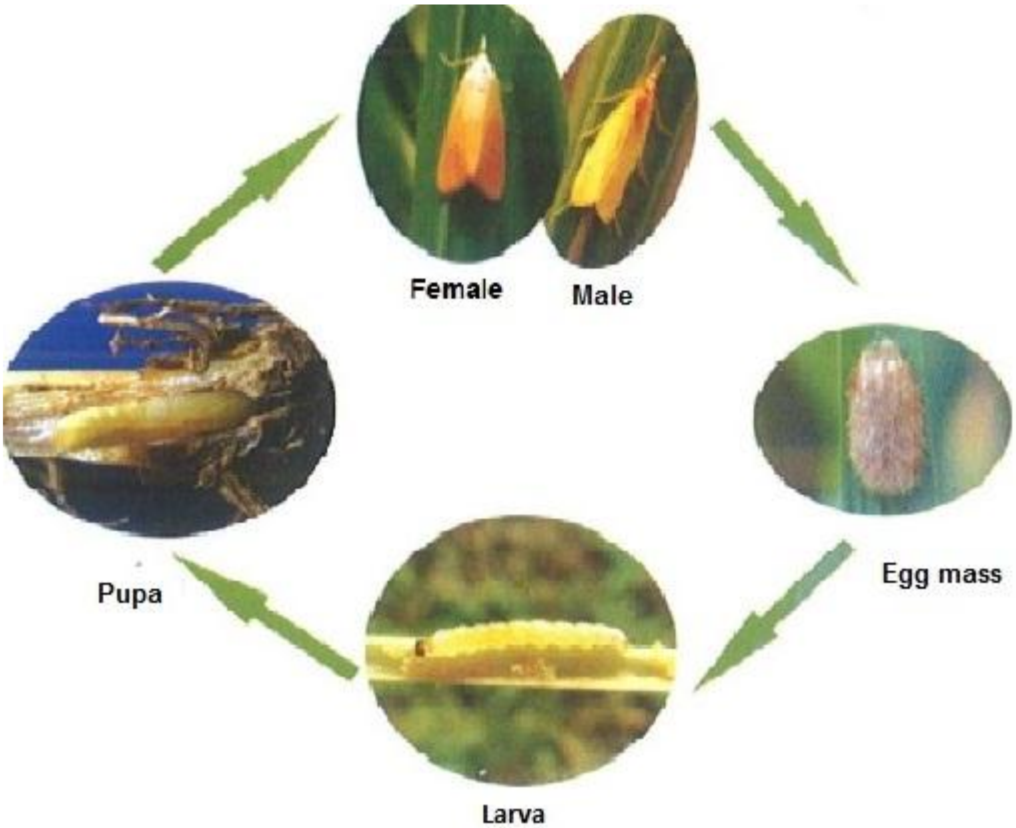
Note: values for the coefficients "a", "b", "c" and constant are as given in SPSS output file.

Plate No. 1 Picture of Field visit on Shri J.L. Chaudhary

Plate No. 2 Picture of field observation during vegetative phase

Plate No. 3 Picture of showing Dead heart infestation in vegetative phase

Plate No. 3 Picture of showing Dead heart infestation in vegetative phase



Life cycle of the yellow stem borer, *Scirpophaga incertulas*

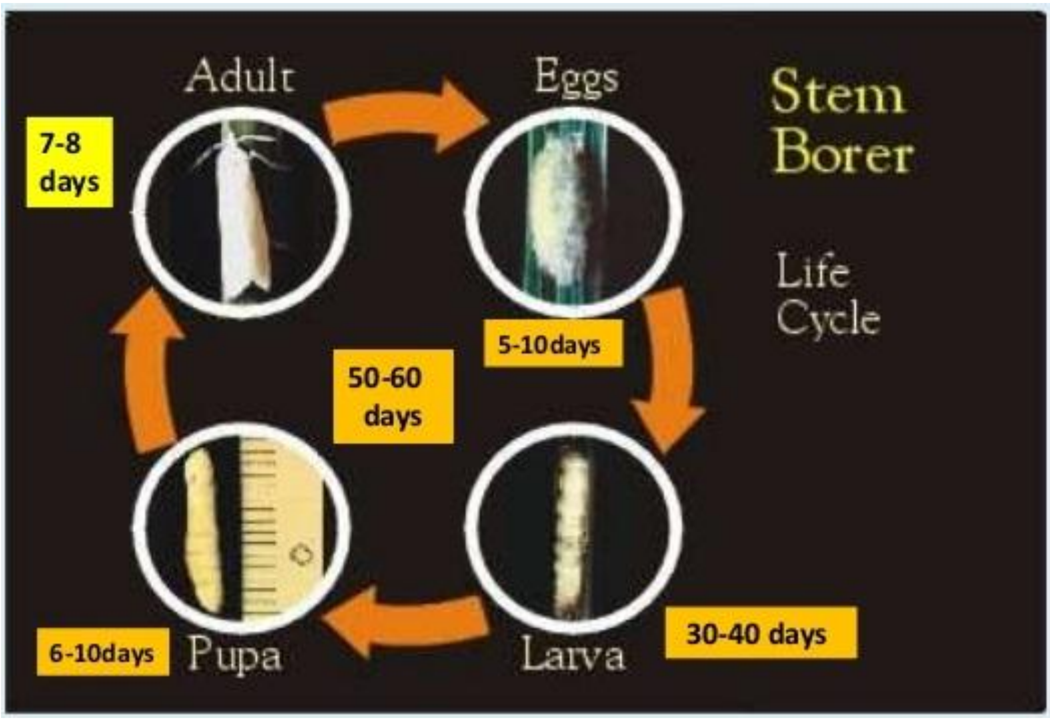


Plate No. 7 Picture of Showing life cycle of the yellow stem borer, *Scirpophaga incertulas.*

Plate No.4 Picture of Yellow stem borer at tillering stage

Plate No. 6 Picture of Showing white earhead infestation in reproductive stage.

CHAPTER – IV

RESULT AND DISCUSSION

This chapter deals with the brief description of results obtained under different objectives of the experiment entitled **“Influence of weather parameters on population dynamics of Yellow Stem Borer (YSB) in rice crop at Raipur”** conducted during the kharif season of 2016 at the Department of Entomology Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The results and discussion are presented here under different sub headings:

4.1 To study the effect of weather parameters on population dynamics of yellow stem borer in rice crop.

4.2 To derive indices like day and night time, temperature, diurnal variation and heat sum in rice crop.

4.3 To develop weather based forewarning model for yellow stem borer in rice crop.

4.1 To study the effect of weather parameters on population dynamics of yellow stem borer in rice crop.

Periodical observations, on the Population dynamics of yellow stem borer, the moth population affecting the crop growing period from September to November (Table 4.1) revealed that the adult of yellow stem borer appeared in the second week of September (37th SMW). Which can be take as the appearance of YSB. Initially the 46 moth population has observed in this week the moth population has reached a peak of 114 during 39th standard meteorological week, the fourth week of September. It is interesting to note that in a 47th standard meteorological week YSB population decreases to a low of zero. During this period, maximum and minimum temperature, morning and evening relative humidity, wind velocity and bright sunshine hours were observed as 30^0C, 24.5^0C, 97 %, 89 %, 2.8 km/h and 3.4 h/day respectively. After reaching the peak the moths population generally declined in the months of October and November. Thereafter, the moth population gradually decreased, reaching 14 moths during the fourth week of October on wards as the crop approached maturity.

The present findings are in confirmation with the findings of Shamim *et al.*, (2009) study on the Effect of weather parameters on population dynamics of green leaf hopper and white backed plant hopper in paddy grown in middle Gujarat region.

Table 4.1: Field Population dynamics of important insect-pest of Yellow stem borer Rice in Raipur during -2016

Standard meteorological week	Month and date (stating day of SMW)	Yellow stem borer /week
35	27 August	21
36	03 September	25
37	10 September	46
38	17 September	65
39	24 September	114
40	01 October	92
41	08 October	40
42	15 October	15
43	22 October	20
44	29 October	14
45	05 November	20

4.1.1 Correlation between weather parameters and Rice yellow stem borer

The maximum activity of rice yellow stem borer was recorded during the fourth week of September. The correlation worked out between monthly weather parameters YSB population through “SPSS” **(**Statistical Package for the Social Sciences) adult population of yellow stem borer showed non-significant positive correlation with maximum temperature (r = 0.07) and wind velocity (r = 0.57) whereas, minimum temperature (r = 0.83**), morning relative humidity (r = 0.80**), evening relative humidity (r = 0.82**), rainfall (r = 0.64*), and sunshine hours (r = - 0.88**) had a significant positive correlation with adult population (Table 4.2). Results revealed that the YSB population build up is favoured under

Wet, humid and cloudy weather conditions. In present investigation the weather parameters and yellow stem borer adult population beneficial effect of morning relative humidity, evening relative humidity and minimum temperature but significant negative effect of sunshine hours. Low temperature and high relative humidity created favourable climatic condition for adult and larval development resulting in maximum population during kharif season. There after decreasing adult population due to increasing sunshine hour during the study period.

similarly Kumar *et al.,* (2015) maximum temperature (°C), minimum temperature (°C), morning relative humidity (%), evening relative humidity (%), rainfall (mm) and evaporation (mm) were positively correlated with the population of male moth of yellow stem borer, whereas, sunshine (hr) was negatively correlated (-0.453). They also found that weather parameters contribute 34.60 per cent fluctuation of population male moths (*Scirpophaga incertulas).*

Present findings are in confirmation with the Chakraborty and Rath (2013) reported that the Tmax and Tmin was negative correlation with the field population. High positive correlation was found with RH-I only two year (2005 and 2006). Effect of RH-II upon the occurrence of YSB population was insignificant in the year 2005 and 2006 but had a significantly positive relation in other two year. High rainfall within a short spell of the time shows a significantly negative relation with the occurrence in the year 2006 and 2008. Somashekara and Javaregowda (2015) also reported that relationship of environmental parameters with population build up of YSB indicated that evening relative humidity (RH) and rainfall showed significant negative correlation but Min. Temp, Max. Temp and morning RH had a positive correlation ship with the population YSB based on light trapped data.

Table No. 4.2: Correlation studied on the incidence of rice Yellow stem borer with weather parameters.

Weather parameter	Correlation coefficients (r)
Maximum Temperature (^{0}C)	0.07
Minimum Temperature (^{0}C)	0.83**
Rainfall (mm)	0.64*
Morning Relative humidity (%)	0.80**
Evening Relative humidity (%)	0.82**
Wind velocity (km/h)	0.57
Sunshine hours (hours)	-0.88**

*. Correlation is significant at 5% level (2-tailed)

**. Correlation is significant at 1% level (2-tailed)

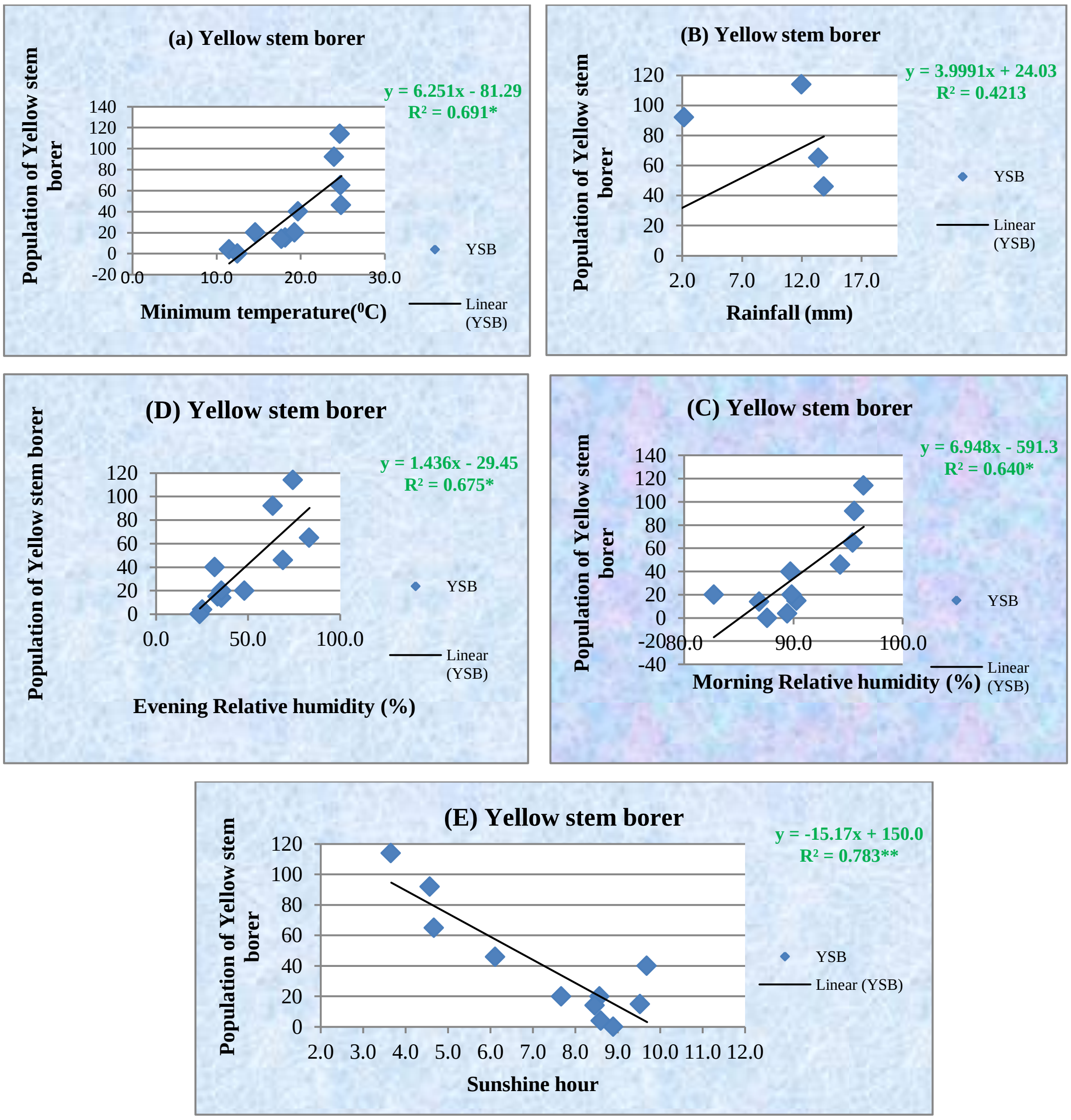


Fig. 1(a-e): Scattered diagram and regression line showing the relation between population of insect pests of rice yellow stem borer and significant weather parameters

4.1.2 Dead heart infestation of Yellow stem borer, *Scirpophaga incertulus* (Walker)

The incidence of moths was abundant during the rice growing season for yellow stem borer infection. Initiation of dead heart at 36th standard week (1st week of September) and reached the peak at 39th standard week (4th week of September). Dead heart infestation ETL under Raipur conditions is considered as 10% and in experimental studies was found to varying between 5% to 13.4%. Week wise distributions are 35 SMW (5%), 36 SMW (6%), 37 SMW (9%), 37 SMW (12%), 38 SMW (12%), 39 SMW (13.4%), 40 SMW (11%), 41 SMW (9%), 42 SMW (6%), 43 SMW (4%) and 44 SMW (4.6%) respectively. Accumulated growing degree days (AGDD) and Accumulated helio thermal unit (AHTU) were ranging from 1237.9-1614.7& 1736.5-1963.7 and 3705.1-5354.0 & 5914.3-7655.7 respectively during initiation and peak period of moth. Infestation by the YSB was severe at a range of 1614.7-1963.7 ^{0}C AGDD and 5354.0 -7655.7 AHTU. During the crop period weathers parameters played a major key role in the population dynamics.

The weekly average field population was found to have significant and possible correlation with weekly mean R.H, and accumulated Helio thermal unit (AHTU) and negative correlation with difference of maximum and minimum temperatures, weekly Sunshine hour (SH). The multiple correlation and regression of moth population with the weather parameters was developed as an equation.

TP/week = -52.8767 + 0.001427 (AHTU) + 0.009327(RAIN) + [-0.71335(MAX.T-MINI.T)] + 0.602506 (RH-I)

The coefficient of determination (R^2) between light trap catches of *S. incertulus* and weather parameters were 0.83 Adjusted R = 0.78, Standard Error = 1.88, TP = total population

The correlation and regression analysis clearly indicated that the population build up was dependent on weathers factors. The correlation coefficient (r) between field population of *S. incertulus* and weather parameters were found significant (Table 4.3) based on observed data.

The present investigation confirms the results of other work reported above. Higher population of YSB the present week were plant showed higher damage symptoms of dead heart or white ear head next week because of adult are egg laying. There after development of larva, is damage main shoot of rice during vegetative and reproductive phase.

Mandal *et al.*, (2011) reported that the catching of moth in the trap was commenced as early as 32 standard week (2nd week of August) with its peak during 37 standard week while incidence of dead heart started at 34 standard week (4th week of August) and reached the peak at 38 standard week (3rd week of September). Similarly Sujithra *et al.*, (2010) also reported that the higher trap catches during standard week 37 seemed to justify the more stem borer damage in the field in standard week of 38 and 39. They also observed the pest severe damage the crop data range was 1203.1-1967.8^{0}C AGDD and 6539.9-9180.8 AHTU. Table 4.3 leads to the conclusion/interpretation then AHTU are directly related to weekly moth population. It means all three weather parameters Max.T, Mini.T and sunshine hours an which AHTU is based is related with population build-up of YSB moths. Similarly mean weekly RH is meeting conducive environment for YSB population build-up.

Table No. 4.3: Relationship between weather variable and field population of yellow stem borer.

Variable	Weekly AHTU	Weekly (Max.T-Min. T)	Weekly total (RF)	Weekly mean(RH)
Moths population weekly	0.50*	0.19	-0.10	0.51*

*. Correlation is significant at 5% level (2-tailed)

**. Correlation is significant at 1% level (2-tailed)

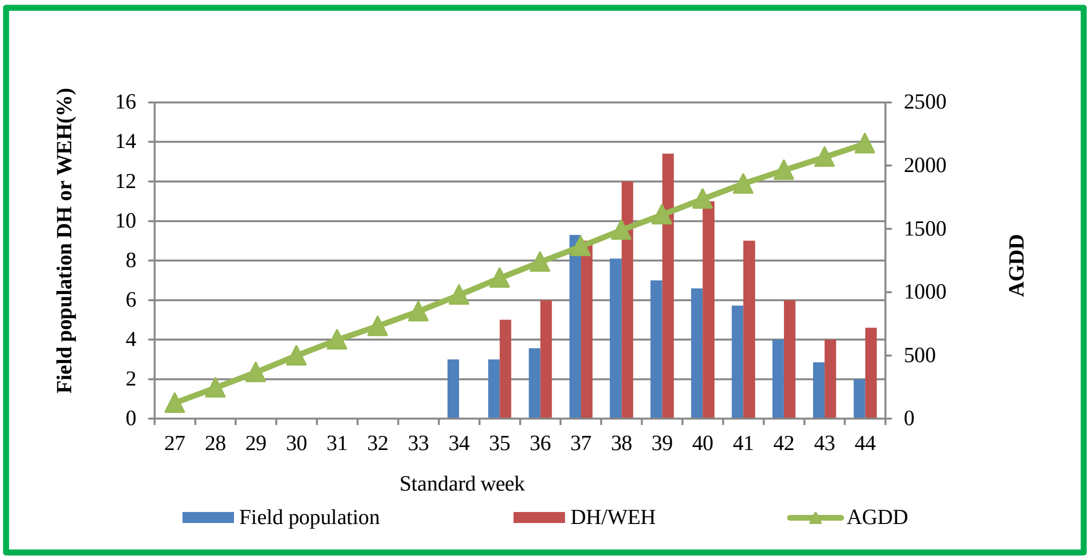


Fig.2 Effect of accumulated GDD on occurrence of *Scirpophaga incertulus* in *kharif* rice 2016.

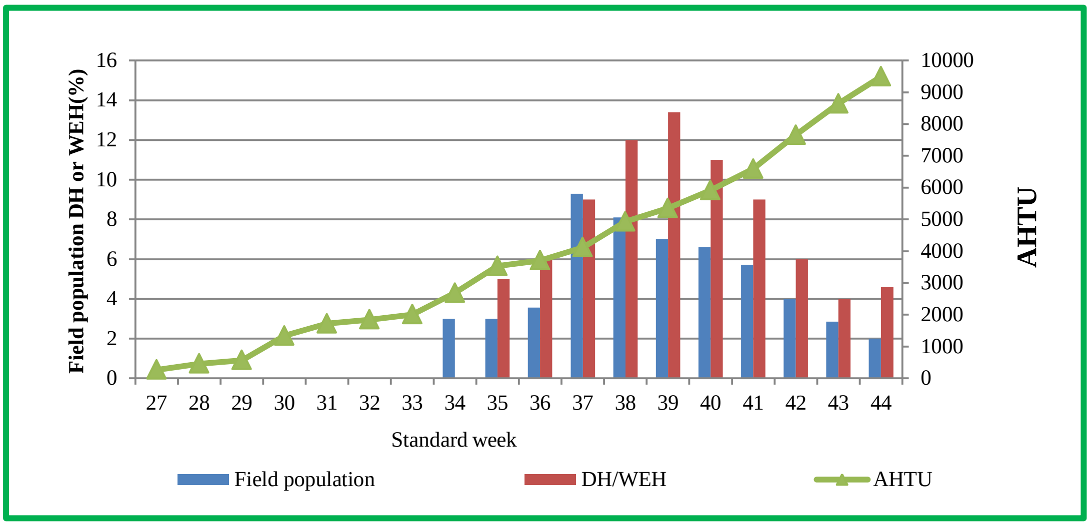


Fig. 3 Effect of accumulated HTU on occurrence of *Scirpophaga incertulus* in *kharif* rice 2016.

To derive indices like day and night time, temperature, diurnal variation and heat sum in rice crop.

Populations of rice yellow stem borer, *Scirpophaga incertulus* (Walker) were studied in Swarna variety of rice. The observations recorded from fourth week of August (35th standard week) to harvest of the crop (Table 4.1). The pest population recorded as number of moth per week during the crop season *Kharif* 2016. The moth population was low during August to second week of September. Experimentation revealed that the peak population of YSB in the month of September the pest population declined thereafter. The correlation between weakly mean population of YSB and meteorological parameters was worked out. Result revealed that average minimum temperature (Tmin) (r = 0.83**) and diurnal variation (DV) (r = 0.83**) showed a higher positive correlation with the moth population (Table 4.4).

It was also observed that heat sum (HS) (0.75**) was positively and significantly correlated with moth population. Though the day temperature regime (0.58) showed weather correlation with yellow stem borer population but night temperature regime (0.72*) shows better positive correlation. Scattered diagram as well as trend line was made to analyze the degree of relationship between moth population and significant weather parameter (Fig.4 a-d), which also indicated the strong positive correlation between the two variables.

In present investigation result revealed that maximum temperature and day temperature non-significant correlation of YSB population while other weather indices like diurnal variation, heat sum, night temperature and minimum temperature showed significantly correlated population of YSB.

Sahoo *et al.,* (2016) average maximum temperature (Tmax) and heat sum (HS) showed higher correlation (r = 0.87*) with the hopper population. It was also observed that diurnal variation (DV) was almost positively and significantly correlated with mango hopper population. Though day temperature regime showed better correlation with hopper population than night temperature regime, however these two derived indices did not show any better degree of association than the recorded Tmax. values.

Table 4.4: Correlation studies between incidence of insect-pests of Yellow stem borer and weather indices.

Weather indices	Yellow stem borer population
Maximum Temperature (°C)	0.07
Minimum Temperature (°C)	0.83**
Day Temperature (°C)	0.58
Night Temperature (°C)	0.72*
Diurnal variation	0.88**
Heat Sum	0.75**

*. Correlation is significant at 5% level (2-tailed)
** .Correlation is significant at 1% level (2-tailed)

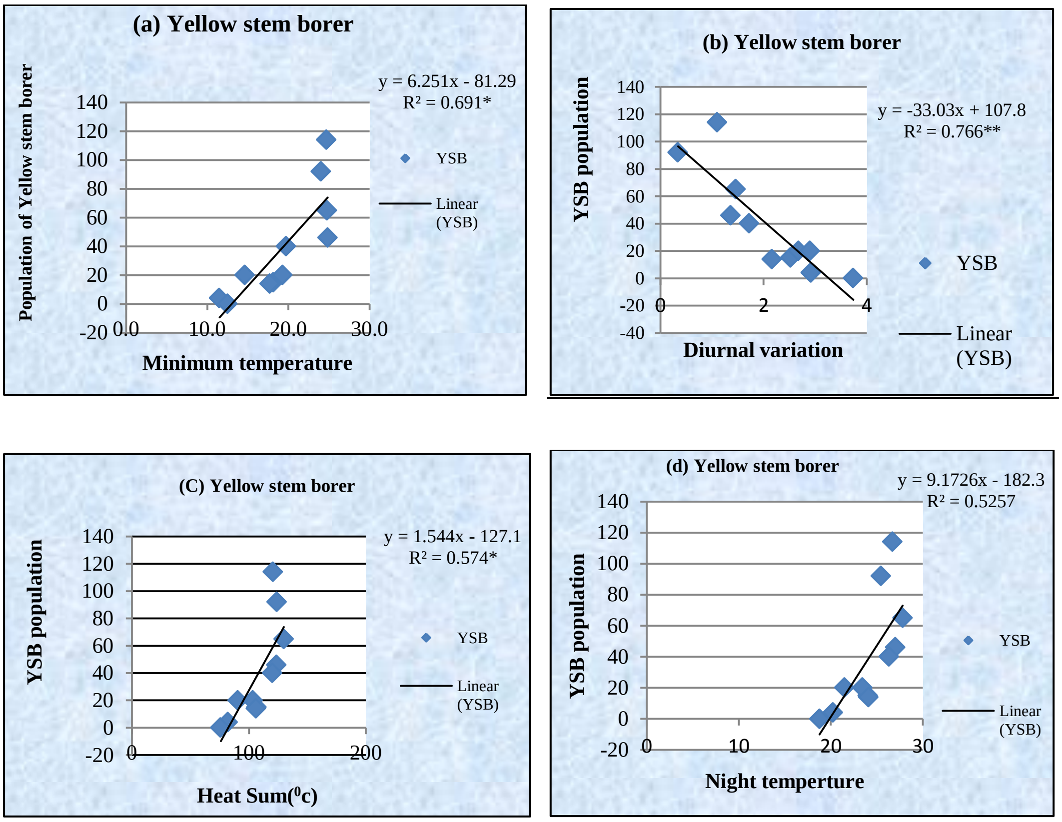


Fig.4 (a-d): Scattered diagram and regression line showing the relation between population of insect pests of rice yellow stem borer and significant weather parameters

4.2 To develop weather based forewarning model for yellow stem borer in rice crop.

4.3.1 Weather parameters and yellow stem borer relationship

In this analysis, correlation coefficients (c.c.s) between yellow stern borer population and individual meteorological parameters for the corresponding and each of the four previous weeks have been worked out the light trap data and significant meteorological parameters were selected for further analysis and developing forewarning models. The parameters which were found most predominantly by stepwise multiple regression technique. For most predominantly parameters were found by step wise multiple regression technique which parameter was chosen for the development of the multiple regression equation.

Correlation coefficients (c.c.s) between the weekly average YSB population (YSB) and Tmax during the first appearances and peak infestation period between 27^{th} to 48^{th} week (both corresponding and each of four previous weeks) show the influence of Tmax on the growth and development of YSB Fig 4.1 (a). Out of 110 c.c.s, 7 c.c.s significant at 5 % level. It was observed that 59 c.c.s were positively correlated and 51 c.c.s were negatively correlated. It interesting to note that development of adult YSB at 37^{th} week was profoundly influenced by higher Tmax of the same week. Development of larva of YSB at 37th and 38th week is influenced by higher Tmax (c.c. significant at 5 % level).

Correlation coefficients (c.c.s) was worked out between YSB and Tmin during the first appearance and peak infestation period. In 38^{th} 40^{th} and 42^{th} week c.c.s were negative and 35^{th} week c.c.s was positively correlated. 5 c.c.s of them were significant at the 5 % level. This negative and positive significant c.c.s clearly indicated that YSB population at all the generations were mostly controlled by lower Tmin beneficial and it was indicated that development of the larva and adult were favoured by lower Tmin.

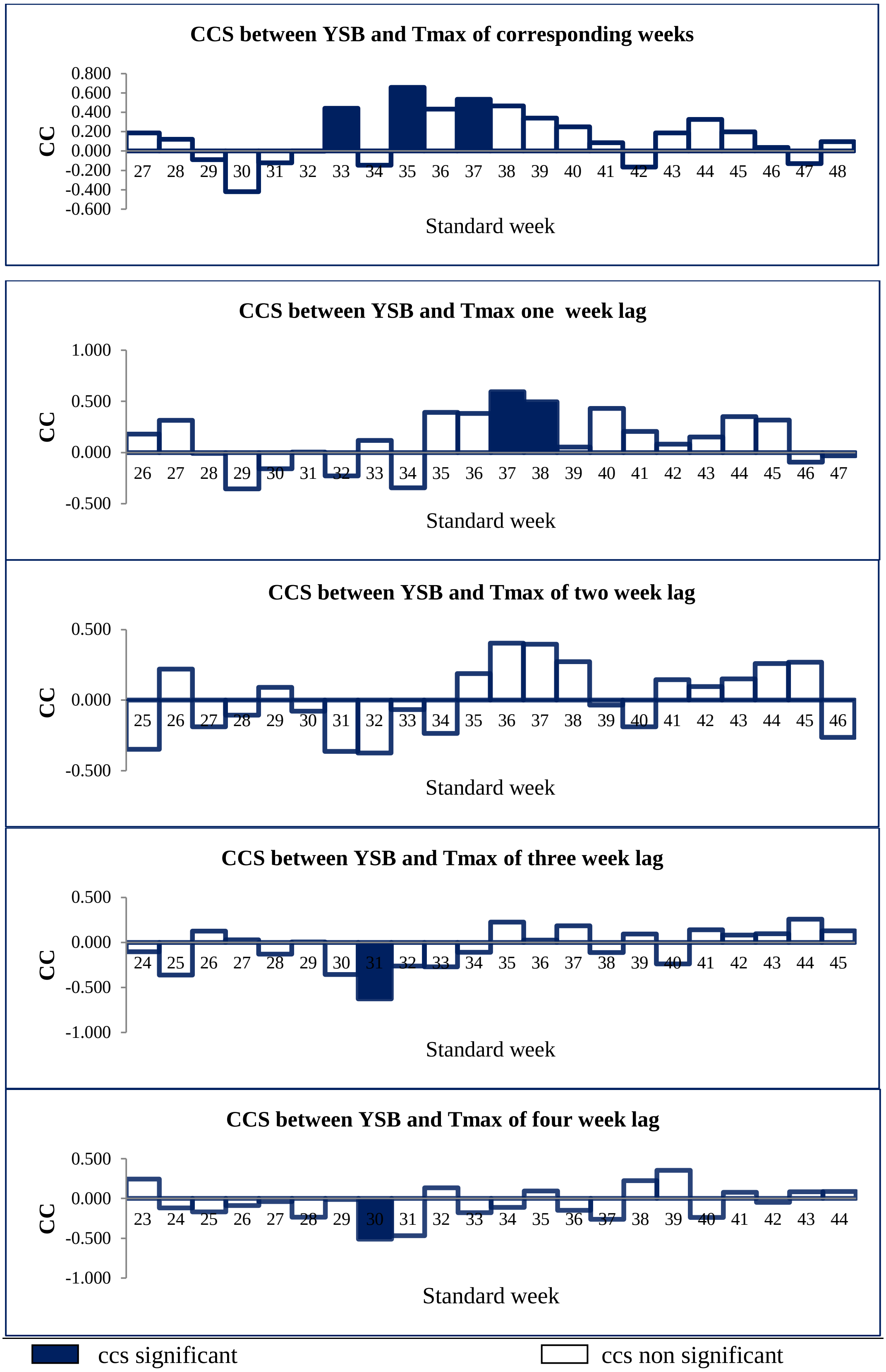


Fig 4.1 (a) correlation coefficients between yellow stem borer and Tmax respectively, for corresponding week, 1^{st} week lag, 2^{nd} week lag, 3^{rd} week lag and 4^{th} week lag.

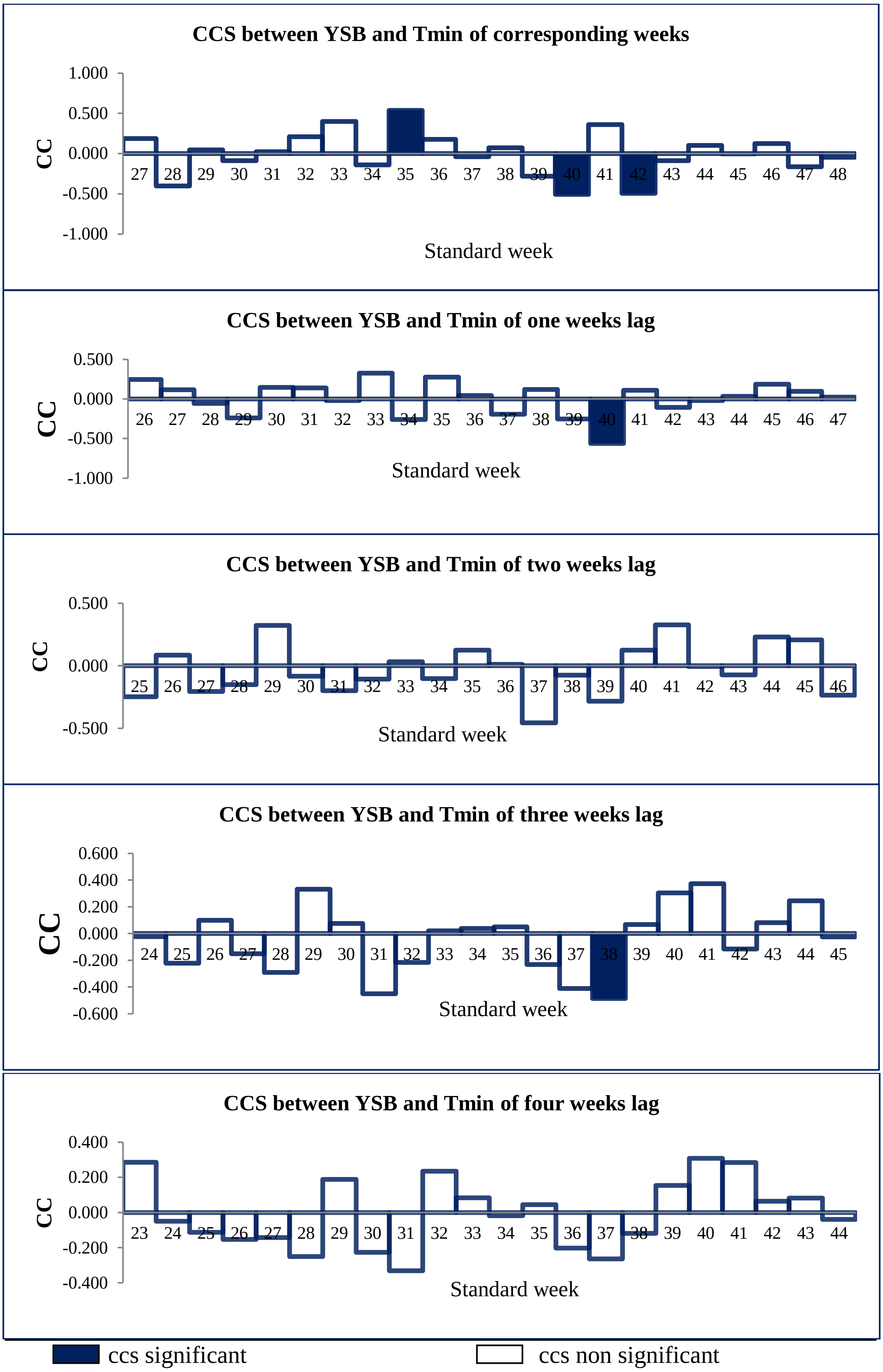


Fig 4.1 (b) correlation coefficients between yellow stem borer and Tmin respectively, for corresponding week, 1st week lag, 2nd week lag, 3rd week lag and 4th week lag.

In case of rainfall 51c.c.s were positively and 59 c.c.s were negatively correlated. 6 c.c.s of them were significantly correlated at 5% level Fig. 4.1(c). Rainfall at 29th, 31st, and 40th week had influenced significantly adult development of YSB during corresponding, first, second, third and fourth week during lst and 2nd generation. It is interesting to note that development of adult YSB at 31st week was profoundly influenced by lower RF of the same week egg, larva and pupa development at 1st and 2nd generation.

The correlation coefficient between relative humidity morning and yellow stem borer was calculated in Fig. 4.1(d) out of 110 c.c.s value, 64 c.c.s were positively and 46 c.c.s negatively correlated. This clearly indicates that higher morning relative humidity was beneficial to YSB population.

Afternoon relative humidity showed a profound effect in building up YSB during 29th, 31st and 34th week. Out of 110 c.c.s, 56 c.c.s were positively and 54 c.c.s were negatively correlated. 8 c.c.s of them were significant at the 5 % level. The RH-II at 35th, 36th, and 40th week influenced significantly for egg laying, larva and pupa development as seen in fig.4.1 (e).

The correlation coefficient worked out between SSH and YSB during vegetative and reproductive stage of rice of first and peak appearance in light trap. SSH of 33rdand 35th weeks were found beneficial for the adult development of corresponding, first, second and third week of lag. Similarly 40thand 48th week lower sunshine had influenced significantly egg laying, larva and pupa development at 2nd generation in Fig. 4.1(f). Out of 110 c.c.s values, 64 c.c.s were positively and 46 c.c.s were negatively correlated. 8 c.c.s of them were significant at the 5 % level.

From the above results we can conclude that 110c. c. s were worked out separately for meteorological Parameters, 7 c.c.s were significant for Tmax, 5 c.c.s for Tmin, and 6, 11, 8, 8 c.c.s, for RF, RH-I, RH-II, and SH respectively. This significant c.c.s may be helpful in development of egg, larva and pupa.

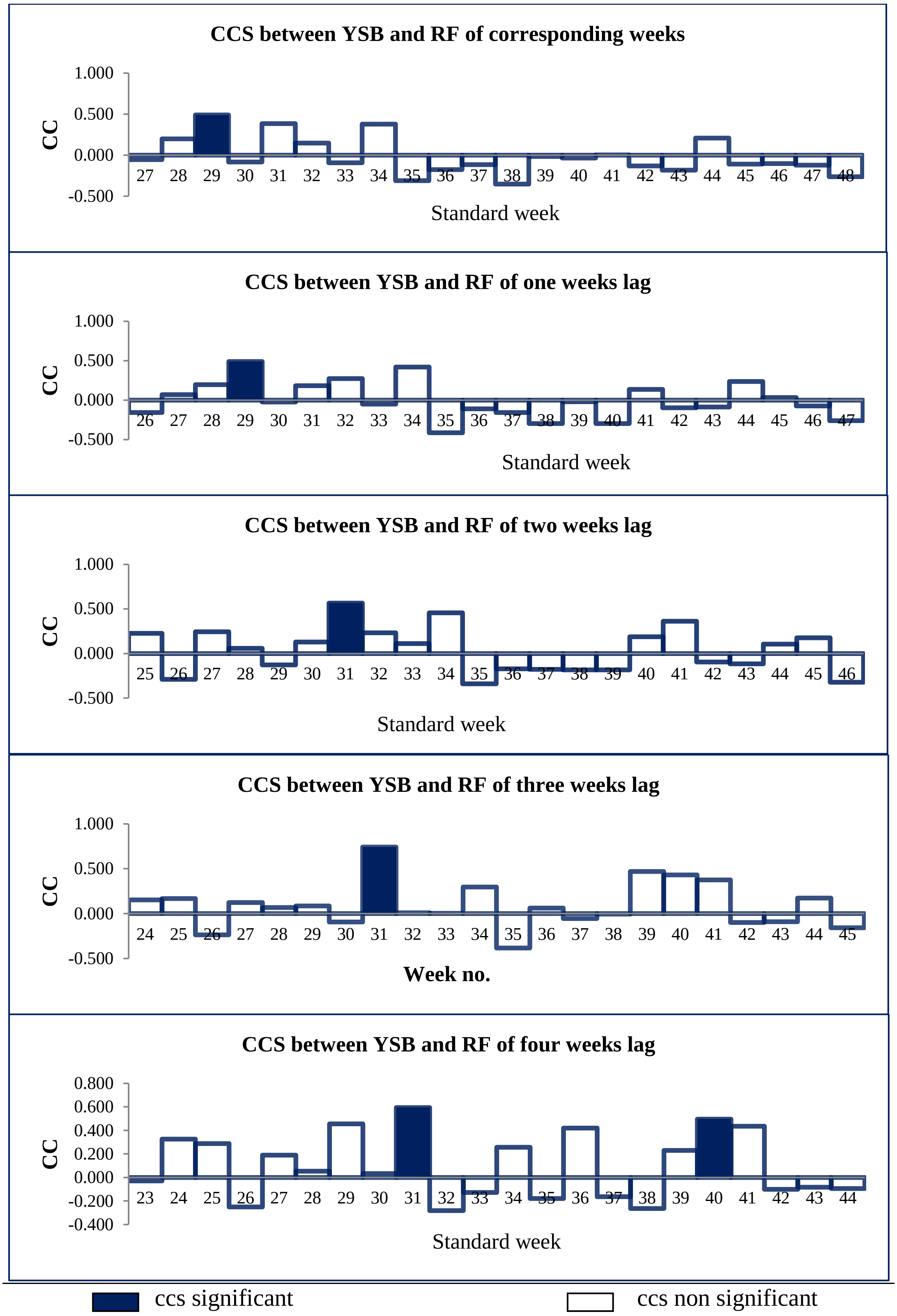


Fig 4.1 (c) correlation coefficients between yellow stem borer and RF, respectively for corresponding week, 1st week lag, 2nd week lag, 3rd week lag and 4th week lag.

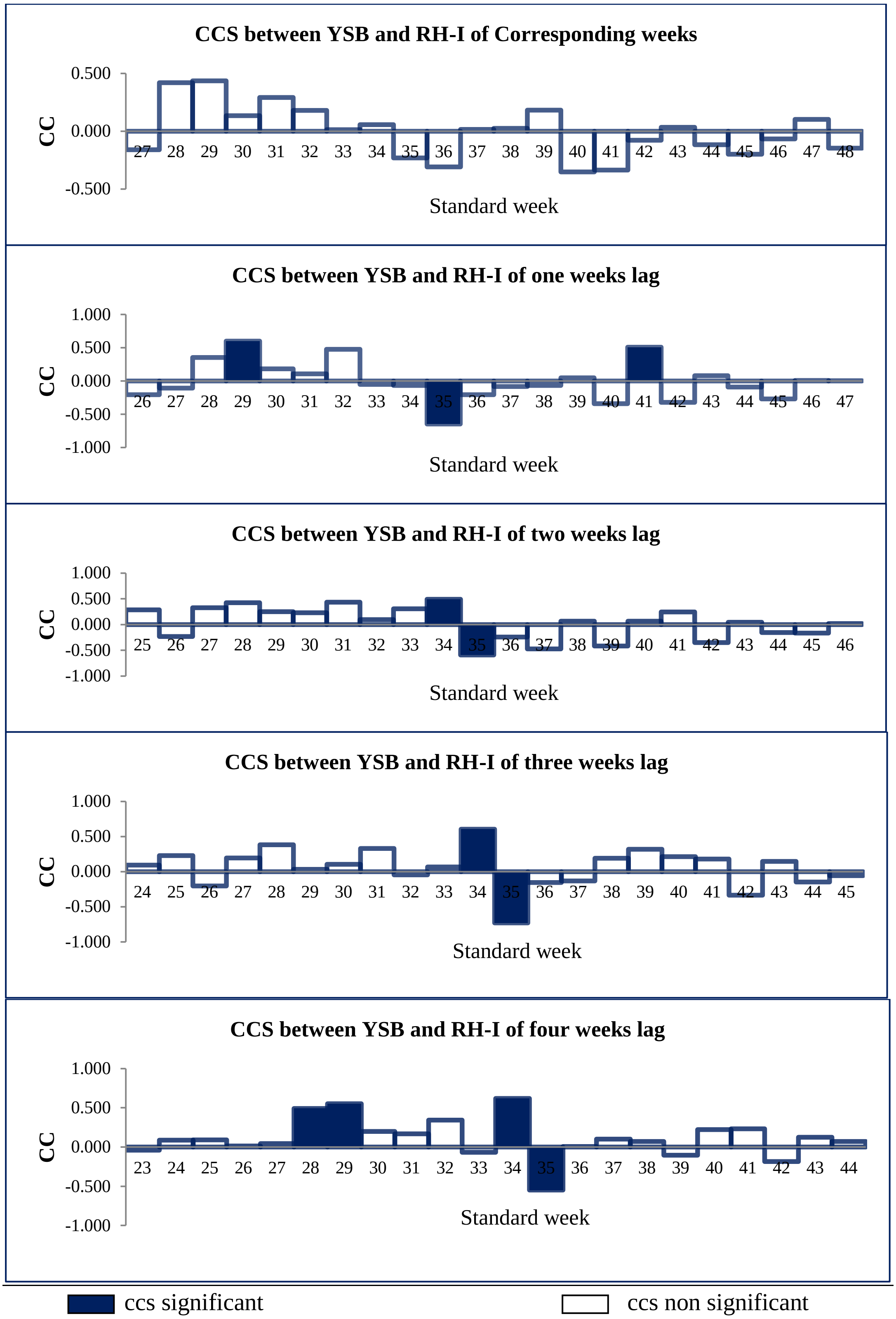


Fig 4.1 (d) correlation coefficients between yellow stem borer and RH-I respectively, for corresponding week, 1st week lag, 2nd week lag, 3rd week lag and 4th week lag.

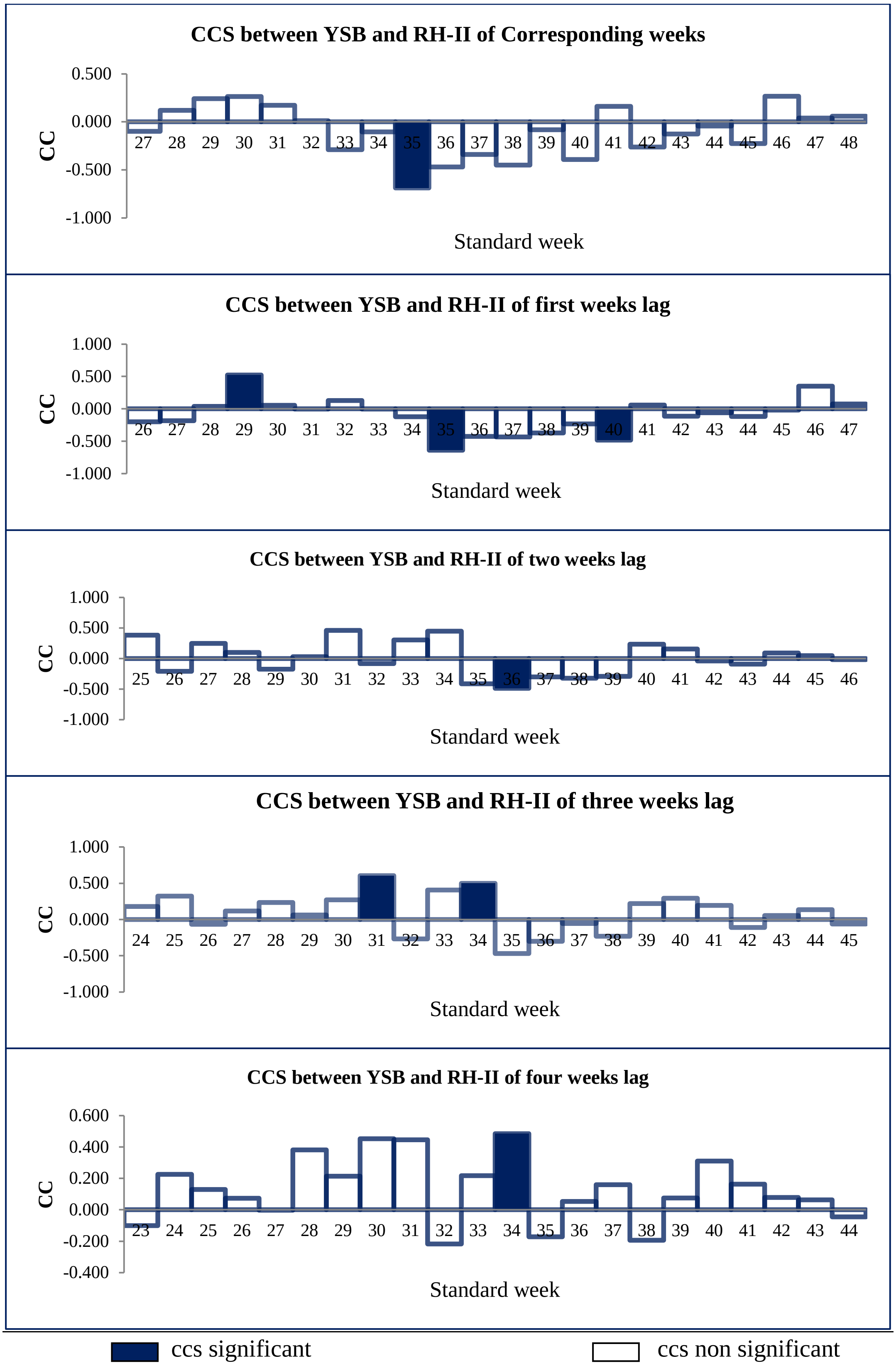


Fig 4.1 (e) correlation coefficients between yellow stem borer and RH-II, respectively for corresponding week, 1st week lag, 2nd week lag, 3rd week lag and 4th week lag.

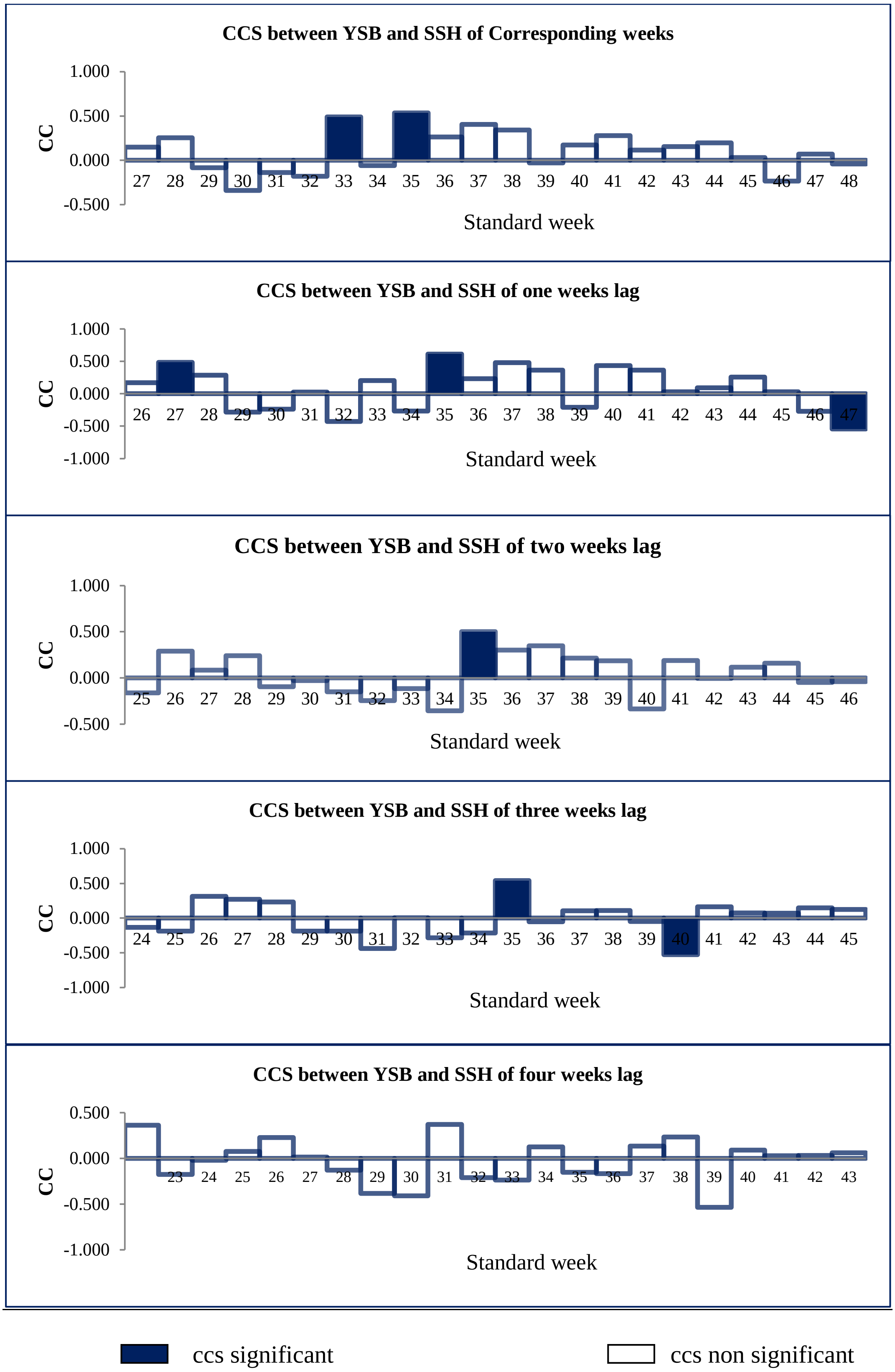


Fig 4.1 (f) correlation coefficients between yellow stem borer and SSH, respectively for corresponding week, 1st week lag, 2nd week lag, 3rd week lag and 4th week lag.

In effect has been made to tabulate the weathers factors (corresponding week and lag weeks) and this will largely help in developing forecasting equation for YSB under Raipur conditions.

Table No. 4.5: Population of YSB in a particular week for rice crop is significantly correlated with weather parameters on the basis of long term light trap data as follows: (1998-2014)

S. No.	YSB population	Weather factors
01.	Build up of population in 28 standard meteorological week	• Sunshine houres-1 week lag(positive)
02.	29 week population	• Rainfall Corresponding week(positive)
03.	30 week population	• Rainfall-1week lag (positive), • Morning relative humidity-1week lag (positive), • Evening relative humidity1week lag (positive).
04.	32 week population	• Morning relative humidity4week lag (negative)
05.	33 week population	• Maxi. Temp- Corresponding week(positive), • Rainfall -2week lag (positive), • Morning relative humidity-4week lag (positive), • Sunshine hours corresponding week(positive),
06.	34 week population	• Maxi. Temp- 3 week lag (negative), • Maxi. Temp- 4 week lag (negative), • Rainfall -3week lag (positive), • Evening relative humidity 3week lag (Positive).
07.	35 week population	• Maxi. Temp- Corresponding week(positive), • Mini. Temp- Corresponding week(positive), • Rainfall -4week lag (positive), • Evening relative humidity Corresponding week (negative), Sunshine hours corresponding week (positive)

8.	36 week population	• Morning relative humidity 1week lag (negative) • Morning relative humidity 2week lag (positive). • Evening relative humidity1week lag (negative) • Sunshine hours 1 week lag (positive),
09.	37 week population	• Morning relative humidity 2week lag (negative) • Morning relative humidity 3week lag (positive). • Evening relative humidity 3week lag (positive). • Sunshine hours 2 week lag (positive),
10.	38 week population	• Maxi. Temp-1 week lag (positive), • Morning relative humidity 3week lag (negative) • Morning relative humidity 4week lag (positive). • Evening relative humidity 2week lag (negative) • Evening relative humidity 4week lag (positive). • Sunshine hours 3 week lag (positive)
11.	39 week population	• Maxi. Temp-1 week lag (positive), • Morning relative humidity 4week lag (negative)
12.	40 week population	• Mini. Temp- Corresponding week(negative)
13.	41 week population	• Mini. Temp-1 week lag (negative) • Mini. Temp-1 week lag (negative) • Evening relative humidity 1week lag (negative)
14.	42 week population	• Mini. Temp-Corresponding week (negative) • Morning relative humidity 1week lag (positive).
15.	43 week population	• Sunshine hours 3 week lag (negative)
16.	44 week population	• Rainfall -4week lag (positive), • Sunshine hours 4 week lag (positive),

4.3.2 Weather based forewarning modal for Yellow stem borer of rice

Weather plays an important role in determining the incidence of crop pests, and hence the models based on weather parameters are useful for forewarning of pest incidence (Agrawal and Mehta, 2007). Long term historical data (Nineteen years *i.e.* from 1998 to 2016) the data was subjected to step down regression by eliminating the non-significant factors and including only significant factors under normal sowing conditions for predicting the incidence of rice YSB for using regression models (Table 4.6). The multiple regression models were used for prediction of occurring of stem borer incidence during a particular standard week in rice growing seasons.

These weather parameters contributed significantly to the moth incidence and its further spread under normal sowing situation. These weather parameters were used to develop the forewarning model for Rice yellow stem borer. These model help to predict the infestation and severity of Yellow stem borer of rice.

The multiple regression equation which describes the average relationship between the YSB and significant weather parameters obtained by step wise regression is expressed below:

Y_{28} = -0.179+3.312xSSH (1 week lag) (R^2 = 0.233*)

Y= yellow stem borer population during the second week of July (28 SMW)

In this model, one weather parameters *viz.*, SSH, could account for 23% variability in YSB light trap catches.

The pest-weather model during data SMW was YSB light trap catches and one weather parameters *viz.*, RAIN. The resulting model was as follows:

$Y_{29\ (a)}$ = 2.332+0.039x RAIN (corresponding week) (R^2= 0.24*)

$Y_{29\ (b)}$ = -54.5895 + 1.885999 x SH (1Week lag) + 0.369703 x RH-I (2 week lag) + 0.935439 x T-MAXI (2week lag) (R^2=0.182*)

Y= yellow stem borer population during the third week of July (29 SMW)

So there two models, only second equation can be used is forecasting equation as relationship with corresponding week gives no information in advance.

Further, in stepwise regression, the pest weather model was established between YSB light trap catches and one weather parameters *viz.*, RH-I as follows:

Y_{30} = -175.248+1.98 x RH-I (1week lag) (R^2 = 0.359**)

Y= yellow stem borer population during the fourth week of July (30 SMW)

In this model also, the value of coefficient of determination (R^2) was significantly higher with one weather parameters *viz.*, RH-I, there by showing that RH-I has its impact in population build up.

RH-I is an important weather parameter determining YSB population. The pest-weather model was established between YSB light trap catches and weather parameters *viz.*, RH-I. The resulting pest-weather model was as follows:

Y_{32} = -94.984+1.199 x RH-I (4 week lag) (R^2 = 0.239*)

Y= yellow stem borer population during the first week of August (32 SMW)

In this model also, the value of coefficient of determination (R^2) was somewhat lower but importance of RH-I, is again coming in picture.

This suggested that RAINFALL was also an important parameter affecting light trap catches. Therefore, the pest-weather model, consisting of weather parameters *viz.,* RAIN, was found to be the best fit as weather factors showed significant influence on YSB light trap catches. The eventual pest-weather model between YSB light trap catches and weather parameters *viz.*, RAIN was thus established as:

Y_{33} = 10.309168+0.130849 x Rain (2 week lag) (R^2 = 0.507**)

Y= yellow stem borer population during the second week of August (33 SMW)

In this model, the value of coefficient of determination (R^2) was significantly higher with one weather parameters *viz.*, Rain, there by showing that rain in middle phase of rice crop is contributing for YSB population buildup.

The pest-weather model was thus YSB light trap catches and one weather parameters *viz.*, RAIN. The resulting model was as follows:

Y_{34} = 8.2849734+0.0601031 x RAIN (3week lag) (R^2 = 0.55**)

Y= yellow stem borer population during the third week of August (34 SMW)

The pest-weather model was thus YSB light trap catches and two weather parameters *viz.*, RAIN and RH-II the resulting model was as follows:

$Y_{35(a)}$ = 76.57548+0.111855 x Rain (4 Week lag) - 0.84205 x RH-II (Corresponding week) (R^2 = 0.629**)

$Y_{35(b)}$ = 140.8654+0.46547x RAIN (4week lag)-1.85963x RH-II (1week lag) (R^2 = 0.372**)

Y= yellow stem borer population during the fourth week of August (35 SMW)

Out of two equations only second equation can be used as predication model.

The pest-weather model during 36th SMW YSB light trap catches and one weather parameter *viz.*, RH-II the resulting model was as follows:

Y_{36} = 208.19664-2.3427053 x RH-II (1 week lag) (R^2 = 0.421**)

Y= yellow stem borer population during the first week of September (36 SMW)

For the first time, the role of RH-II has come into picture and this can be convently used as forecasting parameter.

The pest-weather model during 37th SMW YSB light trap catches and two weather parameters *viz.*, RH-I and SSH the resulting model was as follows:

Y_{37} = -63.7767+0.514886 x RH-I (2 week lag) +19.74407x SSH (2 week lag) (R^2 = 0.552**)

Y= yellow stem borer population during the second week of September (37 SMW)

In this model, two weather parameters *viz.*, RH-I and SSH, could account for 55% variability in YSB light trap catches.

T-MAXI and RH-II was an important weather parameter determining YSB population. The pest-weather model was thus YSB light trap catches and two weather parameters *viz.*, T-MAXI and RH-II the resulting model was as follows:

Y_{38} = -602.0827+27.942022 x T-MAXI. (1 week lag) -2.226066 x RH-II (2 week lag) (R^2 = 0.711**)

Y= yellow stem borer population during the third week of September (38 SMW)

The pest-weather model was thus YSB light trap catches and one weather parameters *viz.*, RH-I the resulting model was as follows:

Y_{39} =6218.472-64.6553 x RH-I (4 week lag) (R^2 = 0.32**)

Y= yellow stem borer population during the fourth week of September (39SMW)

Further analysis lead to interpretation that minimum temperature was also an important parameter affecting light trap catches. Therefore, the pest-weather model, consisting of weather parameters *viz.*, T-MINI the resulting model was as follows:

Y_{40} = 799.3676+65.68396xT-MAX (2 week lag) + 9.938021x RAIN (1 week lag)-42.8026x RH-II (1 week lag) (R^2 = 0.213*)

Y= yellow stem borer population during the first week of October (40SMW)

The pest-weather model was also developed in 41SMW through YSB light trap catches and one weather parameters *viz.*, T-MINI the resulting model was as follows: Y_{41} = 2378.8006 - 93.077282 x T-MINI. (3 week lag) (R^2 = 0.315**)

Y= yellow stem borer population during the second week of October (41SMW)

The pest-weather model through YSB light trap catches and one weather parameters *viz.*, RH-I has been developed and the resulting model was as follows:

Y_{42} = -1878.2991+21.978723 x RH-I (1 week lag) (R^2 = 0.257*)

Y= yellow stem borer population during the third week of October (42SMW)

The pest-weather model was thus YSB light trap catches and one weather parameters *viz.*, SSH the resulting model was as follows:

Y_{43} =130.1496-5.46519 x SSH (3 week lag) (R^2 = 0.202*)

Y= yellow stem borer population during the fourth week of October (43SMW)

This suggested that rainfall and sunshine hour are also important parameters affecting light trap catches. Therefore, the pest-weather model, consisting of weather parameters *viz.*, RAIN, was found to be the best fit as weather factors showed significant influence on YSB light trap catches. The eventual pest-weather model between YSB light trap catches and weather parameters *viz.*, RAIN and SSH was thus established as:

Y_{44} = 158.621-0.79 x RAIN (4 week lag) -10.837 x SSH (4 week lag)(R^2 = 0.524**)

Y = yellow stem borer population during the fifth week of October (44SMW)

In this model, two weather parameters *viz.*, RAIN and SSH, could account for 52% variability in YSB light trap catches.

Prasannakumar *et al.,* (2015) Pest–weather model clearly suggested the Tmin, RF, and RH-I to be important weather parameters that influenced YSB light trap catches at Mandya, Karnataka. Besides, satisfactory model 8-year data mean influence the YSB light trap catches.

Similarly Yadav and Chander (2010) weather parameters contributed significantly for the thrips incidence and its further spread under normal sowing situation. These weather parameters were used to develop the forewarn model for sunflower thrips. They also develop sunflower thrips and showed 88% variation in thrips population.

Table No. 4.6: Different relationship established between YSB light trap catches and meteorological parameters so as to develop a weather forecasting model for the pest.

SMW	Model Equation	R^2
28	Y_{28} = -0.179+3.312xSSH (1 week lag)	0.233*
29	Y_{29} = 2.332+0.039xRAIN (corresponding week)	0.24*
	Y_{29} = -54.5895 + 1.885999 x SH(1Week lag) + 0.369703 x RH-I (2 week lag) + 0.935439 x T-MAXI (2week lag)	0.182*
30	Y_{30} = -175.248+1.98xRH-I (1week lag)	0.359**
32	Y_{32} = -94.984+1.199xRH-I (4 WEEK LAG)	0.239*
33	Y_{33} = 10.309168+0.130849 x RAIN(2 WEEK LAG)	0.507**
34	Y_{34} = 8.2849734+0.0601031 x RAIN (3WEEK LAG)	0.55**
35	Y_{35} = 76.57548+0.111855 x RAIN (4 WEEK LAG) - 0.84205 x RH-II (Corresponding week**)**	0.629**
	Y_{35} = 140.8654+0.46547xRAIN(4week lag)-1.85963x RH-II(1week lag)	0.372**
36	Y_{36} = 208.19664-2.3427053 x RH-II (1 week lag)	0.421**
37	Y_{37} = -63.7767+0.514886 x RH-I (2 week lag) +19.74407x SSH (2 week lag)	0.552**
38	Y_{38} = -602.0827+27.942022 x T-MAXI. (1 week lag) -2.226066 x RH-II (2 week lag)	0.711**
39	Y_{39} = 6218.472-64.6553 x RH-I (4 week lag)	0.32**
40	Y_{40} = 799.3676+65.68396xT-MAX (2 WEEK LAG) + 9.938021 x RAIN (1 WEEK LAG)-42.8026x RH-II (1 WEEK LAG)	0.213*
41	Y_{41} = 2378.8006-93.077282 x T-MINI. (3 week lag)	0.315**
42	Y_{42} = -1878.2991+21.978723 x RH-I (1 week lag)	0.257*
43	Y_{43} = 130.1496-5.46519 x SSH (3 week lag)	0.202*
44	Y_{44} = 158.621-0.79 x RAIN (4 week lag) -10.837 x SSH(4 week lag)	0.524**

*Significant at 5% level, ** Significant at 1% level

4.3.3 Validation of weather based forewarning of YSB (*S .incertulas walker)*

The severity of *S. incertulas* was predicted for forewarning during each of the 16 SMW (28-44) for *Kharif* season of 2015 and 2016. Where in the predictions higher than the observed severity that would not have wrong management implications were used to assess prediction accuracy. The prediction accuracy in respect of *Kharif* seasons *viz.*, 2015 and 2016 were 98 and 99%, respectively.

Based on model validation during 2015 and 2016 for the population dynamics of the pest were analyzed which revealed that models can successfully work for the prediction of pest. This experiment may be helpful to forewarning the farmers raising rice in region of the state to minimize the losses from the stem borer attack depending upon their population dynamics and damage percentage in kharif rice.

Vennila *et al.,* (2015) worked prediction severity of *S. incertulas* through forewarning model for all 16 SMWs (27-42) for *Kharif* season of 2011 – 2014. They found that accuracy of *Kharif* seasons *viz.,* 2011, 2012 2013and 2014 were 100, 90 100 and 95%, respectively with a mean of 96.3%.

Similarly Akashe *et al.,* (2016) validated forewarning model (statistical equations) with the two year (2012 and 2013) observed data on thrips. Found that equation is best fitted for thrips prediction.

Table No. 4.7: Validation of developed model during -2015

Standard Meteorological week	Observed	Predicated	% Deviation
28	12	19	58.3
29	2	3	50.0
30	5	5	0.0
32	9	12	33.3
33	13	17	30.8
34	8	11	37.5
35	12	14	16.7
36	19	21	10.5
37	6	8	33.3
38	152	192	26.3
39	125	141	12.8
40	158	160	1.3
41	74	89	20.3
42	70	78	11.4
43	68	88	29.4
44	56	75	33.9

Table No. 4.8: Validation of developed model during -2016

Standard Meteorological week	Observed	Predicated	% Deviation
28	4	6	50
29	8	10	25
30	11	11	0
32	12	14	16.7
33	11	14	27.3
34	8	10	25.0
35	22	23	4.5
36	36	51	41.7
37	60	77	28.3
38	89	116	30.3
39	272	399	46.7
40	72	85	18.1
41	19	24	26.3
42	71	78	9.9
43	86	106	23.3
44	59	72	22.0

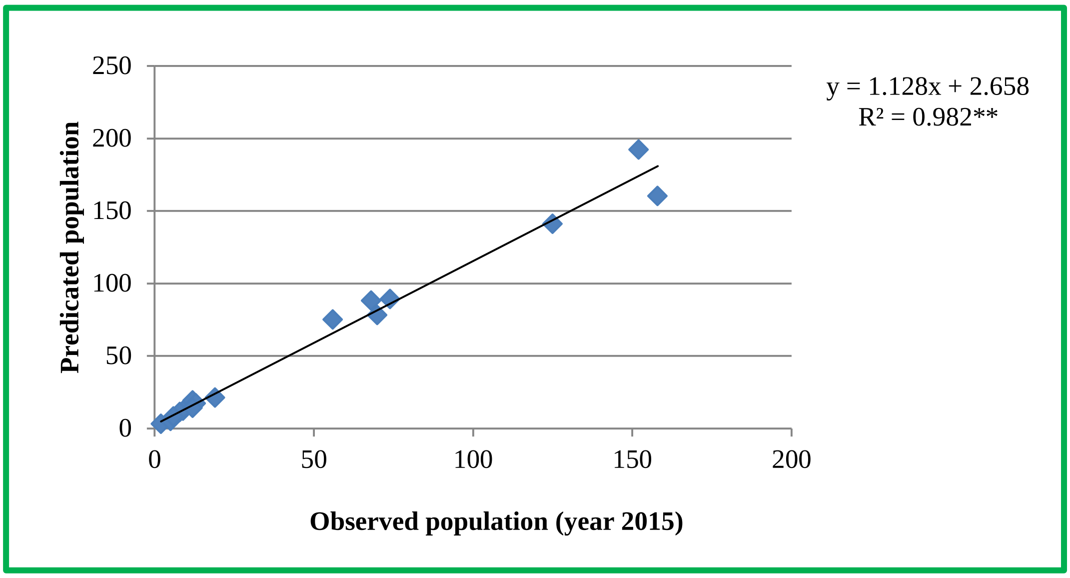


Fig. 5 Scattered diagram and regression line showing the observed and predicted Yellow stem borer population during 2015

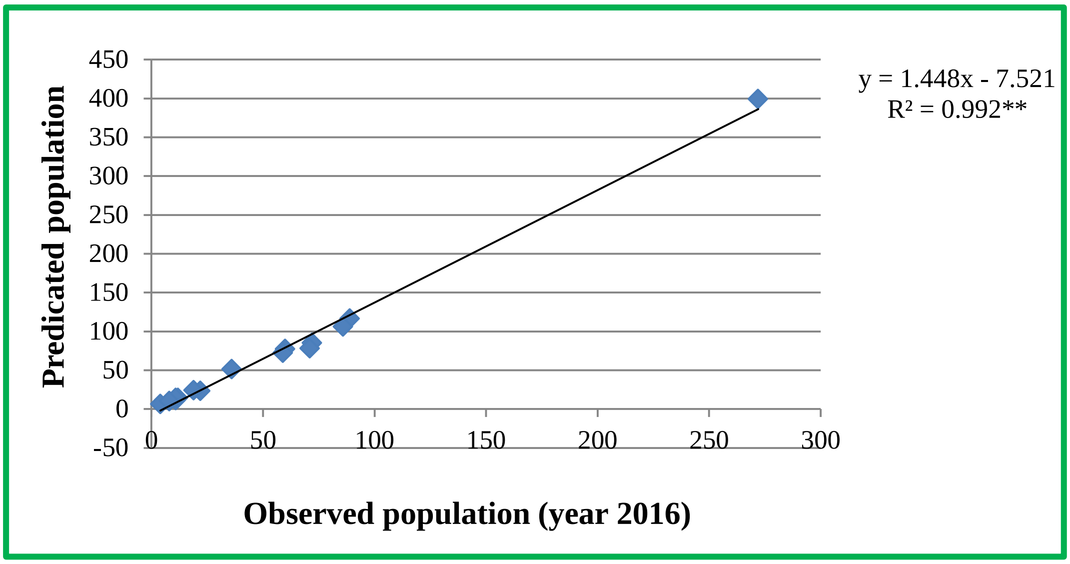


Fig. 6: Scattered diagram and regression line showing the observed and predicted Yellow stem borer population during 2016

CHAPTER-V

SUMMARY AND CONCLUSIONS

Rice is the most important cereal crop grown in India and other parts of the world. One of the major constraints for its lower productivity is the damage inflicted by insect pests. Among these the yellow stem borer, *Scirpophaga incertulus* (Wlk.) is the major one. It causes a considerable loss in the vegetative and the panicle initiation stage during *kharif* seasons. The present investigation **"Influence of weather parameters on population dynamics of Yellow Stem Borer (YSB) in rice crop at Raipur"** was carried out during *Kharif* seasons of 2016 at Research and Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Based on the results obtained from the study some of the important points are summarized in the present chapter.

In the present investigation, attempt was made to record the population dynamics of yellow stem borer (YSB). The maximum activity and damage due to high population density of yellow stem borer was observed during *kharif* rice season from 27th to 48th standard week for YSB, the correlation between weekly mean population of YSB and meteorological parameters was worked out. The population dynamics of YSB were correlated with the weather parameters like maximum and minimum temperature, rainfall, relative humidity (morning), relative humidity (evening) and bright sunshine hours. The result revealed that there was a significant positive correlation between population of YSB and minimum temperature (r = 0.83**), rainfall, relative humidity (morning) and relative humidity (evening) and significant negative correlation between population of YSB and sunshine hour (r = -0.88**). While other weather parameters viz. maximum temperature and wind velocity having non–significant effect of population build-up of yellow stem borer.

Similarly, the correlation between YSB population and diurnal variation (DV) showed significant positive correlation (r = 0.83**). Heat sum, night temperature and minimum temperature showed significant positive correlation. One other weather parameters maximum temperature and day temperature showed non – significant effect of population build-up of yellow stem borer. The population dynamics of yellow stem borer for seventeen consecutive years (1998 to 2014) were correlated with the weather parameters like maximum temperature and minimum temperature, rainfall, relative humidity (morning), relative humidity (evening) and bright sunshine hours. A correlation coefficient can be worked out for corresponding and 4 previous week taken as lag weeks. The significant correlation coefficient can be worked for further examination of relation with weather for yellow stem borer under different model. A critical examination of significant correlation coefficient between yellow stem borer population and meteorological parameters can be worked out for yellow stem borer separately. In YSB 110 c.c.s were worked out separately for meteorological Parameters, 7 c.c.s were significant for Tmax, 5 c.c.s for Tmin, and 6, 11, 8, 8 c.c.s, for RF, RH-I, RH-II, and SH respectively. These significant c.c.s may be helpful in development of egg, larva and pupa.

Now the significant correlation coefficients are taken for generating the model for forecasting the period of first appearance and maximum attack. Thus first see the individual effect of weather indices on YSB models. This model can be fitted to the data set, taking YSB as dependent variable and weather parameters as independent variable. The results showed that there was an improvement in explaining the relationship by this model in case of YSB. Therefore weather indices models can be applied, this model can be worked out for significant week of corresponding and all the four previous (Lag) weeks.

CONCLUSIONS

1. From the results it can be concluded that Yellow Stem Borer population is showing high build-up and peak activity during 3rd week of September to 1st week of October and this is verified through light trap catch data also. In the life cycle of the insects in second generation (larva development) peak population reaches if there is matching favourable temperature ranging from 24-31^{0}C. Another parameter relative humidity (90-95%) is also found to be favourable in second generation insect development. This panicle initiation

stage is the most economic damaging and vulnerable stage for rice crop and therefore insect larva stage development should be closely monitored. Insect egg laying is crucial factor and its in two phases i.e. nursery (Developing in larval stage during rice vegetative phase) and maximum tillering (turning into larval stage in panicle initiation stage). Pupa development stage is generally matching with grain filling stage of rice crop and almost non-destructive. Rice dough stage is generally matching with YSB adult stage.

2. It is concluded from the result that relative humidity and minimum temperature was favourable for YSB population build-up.
3. The initiation of dead heart and white earhead was found in 34 SMW and peak during 38 to 40 SMW. During this period AHTU and AGDD value varied from 533.4-781.7 and 3971.4- 5145.6 respectively. There after a decreasing trend of DH/WEH was found with crop maturity.
4. From the regression equations it has been conclude that the deviation percentage of YSB population was found to be more efficient 2015 as compare to 2016 but some weeks showed a high deviation percentage so there is a need of further improvement.

Suggestions for future research work

Based on the present study the following suggestion can be taken care for future research work.

1. Information regarding cropping system of a area, variety type and post management methods should be collected and used for increasing accuracy of prediction model.
2. Much more information are needed about stem borer in relation to natural enemies and host plant.
3. Location specific web application should be designed for prediction of stem borer in rice crop.

REFERENCE

Adiroubane, D. and Raja, K. 2010. Influence of weather parameters on the occurrence of rice yellow stem borer *Scirpophaga incertulas (Walker)* Journal of Rice Research, 3(1): 5-9.

Agrawal, R. and Mehta, S.C. 2007. Weather-based forecasting of crop yields, pests and diseases – IASRI models. Journal of Indian Society of Agricultural Statistics, 61 (1): 255-263.

Akashe, V. B., Jadhav, J. D., Bavadekar, V. R., Pawar P. B. and Amrutsagar V. M. 2016. Forewarning model for sunflower thrips (*Thrips palmi Karny).* Journal of Agrometeorology, 18(1): 68-70.

Anonymous, 2014. Food and Agriculture Organization. Rome, Italy.

Arif, P., Misra, A. K., Mandal, S. K. and Abdus, S. 2005. Activity of *Scirpophaga incertulas* and *Lycosap seudoannulata* in boro rice as influenced by meteorological parameters. Journal of Applied Biology, 15 (2): 55-59.

Banding, J. P. and Litsinger, J. A. 2005. Rice crop stage susceptibility to the rice yellow stem borer *Scirpophaga incertulas (Walker)* (Lepidoptera: Pyralidae). International Journal Pest Management, 51(1): 37-43.

Banerjee, S. N. and Pramanik, L. M. 1967. The lepidopterous stalk borers of rice and their life cycle in the tropics, The major insect pests of the rice plant, Proceedings of a Symposium, : 103–124.

Barrion, A. T., Joshi, R. C., Barrion-Dupo, A. L. A. and Sebastian, L. S. 2007. Systematics of the Phillippine rice black bug, *Scotinopharastal* (Hemiptera: Pentatomidae). In R. C. Joshi, A. T. Barrion, & L. S. Sebastian (Eds.), *Rice black bugs:* Taxonomy, ecology and management of invasive species, : 3

Bhatnagar, A. and Saxena, R. R. 1999. Environmental correlates of population buildup of rice insect pests through light trap catches. Oryza, 36: 241–245.

Bhutto, A. A., Chandio, J. I., Ursani, T. J., Dhiloo, K. H. and Khan, M. F. 2015. Light trap study to determine emergence and peak of adult moths of yellow rice stem borer & sex ratio study to collect male and female moths under field conditions. *European Academic Research*, 3(6): 6068-6078.

Butter, N. S. and Singh, D. 2005. Changing scenario of insect-pests of paddy in Punjab. 1st Congress on Insect Science,: 17-18.

Chakraborty, K. and Rath, P. C., 2013. Population dynamic of rice yellow stem borer in West Bangal. Indian journal of plant protection, 41(2): 172-174.

Chakraborty, K. and Chandra, D. D., 2011. Incidence of Adult Leaf Folder, *Cnaphalocrocis medinalis* (Lepidoptera: Pyralidae) on Paddy Crop in the Agro Climatic Conditions of the Northern Parts. World Journal of Agricultural Sciences, 7 (6): 738-742

Chaudhary, S., Raghuraman, M. and Kumar, H. 2014. Seasonal abundance of brown plant hopper *Nilaparvata lugens*. International Journal of Current Microbiology Applied Science, 3(7): 1014-1017

Chelliah, A. and Benthur, J. S. 1989. Approaches to rice management-achievements and opportunities, Oryze, 26(2): 12–26.

Chen, C. M., Liu, C. L. and Zeno, X. Z. 1968. Study on the regularity of outbreaks of the paddy borer in Hunan Province. Ecological geographical distribution. Acta Entomologica Sinica, 1: 115–124

Das, D. K., Behera, K. S., Dhandapani, A., Trivedi, T. P., Chona, N. and Bhandari, P. 2008. Development of forewarning systems of rice pests for their management,: 187–200.

Dhaliwal and Dilawari, V.K. (Eds.). Host Plant Resistance to Insects, Kalyani Publishers,: 15-18.

Dhaliwal, G. S. and Singh, J. 1983. Outbreaks of white backed planthopper and brown planthopper in the Punjab. International Rice Commn. News latter, 32 (1): 26-28.

Draper, N. R. and Smith, H. 1966. Applied regression analysis.John Wiley and Sons- New York, USA,: 171

Garg, A. K. and Sethi, G. R. 1980. Succession of insect pests in Kharif Paddy. Indian Journal Entomology, 2: 482-487.

Harinkhree, J. P., Kanadalkar, V. S. and Bhowmick, A. K. 1998. Seasonal abundance and association of light trap catches with field incidence of rice leaf folder, *Cnaphalocrocis medinalis Guenee*. Oryza, 35: 91-92.

Heong, K. L., Manza, A., Catindig, J., Villareal, S., & Jacobsen, T. 2007. Changes in pesticide use and arthropod biodiversity in the IRRI research farm. Outlooks on Pest Management, 18: 229–233.

Hussain, M., Akram M., Qaisar, A., Saghir, A., Babar, k., and. Haider, k., 2014. Impact of Environmental Factors on the Population Dynamics of Leaf Hopper *Amrasca biguttula biguttula* Ishida (Homoptera: Jassidae) on Various Transgenic Cotton Genotypes. Academic Journal of Entomology, 7 (1): 27-31

Jayakumar, M., Rajavel, M., Vijayalakshmi C. K. and Rahiman P. A. 2016. Weather based forewarning models for coffee berry borer and shot hole borer. MAUSAM, 67 (4): 879-886.

Joshi, G., Ram, L., and Singh, R. 2009. Population dynamics of paddy stem borers in relation to biotic and abiotic factors. Annals of Biology, 25: 47–51.

Justin, C. and Preetha, G. 2013. Seasonal incidence of rice yellow stem borer, Scirpophaga incertulas (Walker) in Tamil Nadu. Indian Journal of Entomology, 75(2): 109-112.

Kakde, A. M. and Patel, K. G. 2014. Seasonal Incidence of Rice Yellow Stem Borer (*Scirpophaga Incertulas Wlk.*) in relation to conventional and SRI Methods of Planting and its Correlation with Weather Parameters. Journal of Agriculture and Veterinary Science, 7(6): 05-10

Kakde, A. M. and Patel, K. G. 2015. Seasonal incidence of rice leaf folder in relation to SRI and conventional methods of planting and its correlation with weather parameters. Plant Archives 15 (1): 121-126

Kalita, H., Avasthe, R. K. and Ramesh, K. 2015. Effect of Weather Parameters on Population Build-up of Different Insect Pests of Rice and Their Natural Enemies. Indian Journal of Hill Farming, 28 (1): 69-72

Karuppaiah, V. and Sujayanad, G. K. 2012. Impact of Climate Change on Population Dynamics of Insect Pests. World Journal of Agricultural Sciences, 8 (3): 240-246

Khaliq, A., Javed, M., Sohail, M. and Sagheer, M. 2014. Environmental effects on insects and their population dynamics. Journal of Entomology and Zoology studies, 2 (2): 1–7.

Korat, D. M. and Patel, C. B. 1988. Biology of yellow rice stem borer *Scirpophaga incertulas (wlk.)* on rice. Gujarat Agriculture University Research Journal, 14(1): 11-16.

Krishi Darshika, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), 2016.

Krishnaiah, K. and Varma, N. R. G. 2012. Changing Insect Pest Scenario in the Rice Ecosystem –A National Perspective. Directorate of Rice Research Rajendranagar, Hyderabad,: 2-8.

Krishnaih, K., Pasalu, I. C., Krishnaiah, N. V. and Bentur, I. C. 1996. Integrated pest management in rice, In: Plant Protection and environment, Reddy D V S (eds) Plant Association of Indian, Hyderabad, India,: 94-104.

Kumar, A., Misra, A. K., Paidi, S. and Kumar, J. 2015. Population dynamics and management of yellow stem borer *(Scirpophaga incertulas Walker*) with insect sex-pheromone trap. International Journal of Plant Protection, 8(1): 157-161.

Lawler, A. 2009. Beyond the Yellow River: Science, 325: 930–935.

Listinger, J. A. 1979. Major insect–pests of rainfed wetland rice. Tropical Asia International Rice Research Newsletter, 4 (2): 14–15.

Maclean, J.L., Dawe, D.C., Hardy, B., Hettel, G.P. (Eds.), 2002. Rice Almanac: Source Book for the Most Important Economic Activity on Earth, 3rd edition CABI Publishing, Wallingford,: 5

Mandal, P., Roy, K. and Saha, G. 2011. Weather based prediction model of *Scirpophaga incertulas (Walk.).* Annual Plant Protection Science, 19 (1): 20-24.

Manikandan, N., Kennedy, J. S. and Geethalakshmi, V. 2013. Effect of elevated temperature on development time of rice yellow stem borer. Indian Journal of Science and Technology, 6 (12): 5563–5566.

Muralidharan, K. and Pasalu, C. 2005. Assessments of crop losses in rice ecosystems due to stem borer damage (Lepidoptera: Pyralidae). Crop Protection, 25: 409-417.

Murumkar, D.R., Indi, D.V., Gud, M.A., Shinde, S.K., Jadhav, J.D., Bavdekar, V.R. and Kadam, J.R. 2013. Weather based forewarning model for *Alternaria* leaf spot of safflower (C*arthamus tinctorius* L.) in scarcity zone of Maharashtra. Journal of Agrometeorology 15 (1): 66-70

National Bureau of Statistics of China, http:// www.stats.gov.cn/).

Nirala Y. S., Ghirtlahre, S. K., Sahu, C. M., Kerketta A. and Chandrakar G. 2015. Population Dynamics of Rice Case Worm, Nymphula Depunctalis Guenee And Rice Grasshopper, Hieroglyphus Bania Fabriciusin Relation To

Weather Parameters: A Light Trap Study. International Journal of Tropical Agriculture, 33 (2): 541-545

Pandey, V., Sharma, M. K. and Singh, R. S. 2001. Effect of weather parameters on light trap catches of yellow stemborer, *Scirpophaga incertulas*(Walker). Shashpa, 8(1): 55-57.

Patel, H. R. and Shekh, A. M. 2006. Pest epidemics and role of meteorological services: An overview. Jounral of Agrometeorology, 8 (1): 104-113.

Patel, R. K. 1972. Pest complex of paddy in M.P. Indian Journal of Entomology, 34 (1): 81.

Pathak, M. D. and Dhaliwal, G. S. 1981. Trends and strategies for rice insect problems in tropical Asia. IRRI research paper series, 64 : 1-15.

Pathak, M. D. and Khan, Z. R. 1994. Insect pests of rice. International Centre of Insect Physiology and Ecology,: 5-17

Prajneshu. 1998. A nonlinear statistical model for aphid population growth. Journal of the Indian Society of Agricultural Statistics, 51: 73-80.

Prasad, C. S. and Tiwari, G. N. 2010. Monitoring and Forewarning of *Helicoverpa Armigera, Leucinodes Orbonalis, Scirpophaga Incertulas* and *Spodoptera Litura.* Progresive Agriculture, 10 (3): 27-31.

Prasad, S. S., Gupta. P. K. and Kanaujia, B. L. 200. Simulation study on yield loss due to *Scirpophaga incertulas* on semi deep water rice. Annual Plant Protection Science, 15: 491-492.

Prasannakumar, N. R., Chander, S. and Kumar, L. V. 2015. Development of weather based rice yellow stem borer prediction model for the Cauvery command rice areas, Karnataka, India. Research Article Cogent Food & Agriculture, 1: 1-7.

Rahaman, M. M., Islam, K. S., Jahan M. and Mamun M. A. A. 2014. Relative abundance of stem borer species and natural enemies in rice ecosystem. Journal of Bangladesh Agriculture University, 12 (2): 267–272.

Ram, M., Sachan, S. K. and Singh, G. 2014. Study on population build up of rice leaf folder, *Cnaphalocrocis medinalis (Guenee)* in relation to weather factors. International Journal of Advanced Research, 2(10): 75-77.

Ramasubramaniun, V., Sharma, M. K. and Walia, S. S. 2006. Statistical Models for forewarning Incidence of Major Pests of Paddy. Abstract Statistical Application, 4: 1-81.

Ramya, M., Kennedy, J.S., Lakshmi, V. G., Lakshmanan, A., Manikandan, N. and Sekhar, N. U. 2012. Impact of elevated temperature on major pests of rice. Climarice technical Brief,: 1-6

Rao, B. B., Rao, V. U. M., Nair, L., Prasad, Y. G., Ramaraj, A. P. and Chattopdhyay, C. 2014. Development of Forewarning models. Journal of Environmental Biology, 35: 683-688.

Rao, P. S. P. 1974. Recent ecological studies on rice pest-stem borers, gall midge, rice hispa. In Proceedings International Rice Research Institute, Los Banos, Philippines, (mimeo), 10: 15-22

Reji, S., Chander, S., and Kamble, K. 2014. Predictive zoneing of rice stem borer damage in southern India through spatial interpolation of weather-based modal, Journal of environmental biology, 35: 923-928.

Sabale, J. P., Das C. and Samui, R.P. 2010. Influence of weather factors on light trap catches of green leaf hopper. Journal of Agrometeorology, 12 (1): 108-110

Sahoo, S. K., Saha, A. and Jha, S. 2016. Influence of weather parameters on the population dynamics of insect-pests of mango. Journal of Agrometeorology, 18 (1): 71-75

Samui, R. P., Chhattopadhayay, N., Sabale, J. P. 2007. Weather based forewarning of leaf folder attack on kharif rice and operational crop protection. Mausam, 58(4): 525-536.

Sastri, A.S.R.A.S., Ganguli, J. and Naidu, D. 2008. Development of weather based forewarning systems for pest and diseases under Chhattisgarh conditions. Souvenir, National Conference on pest Management Strategies for Food Security, 2: 35-41.

Shah, S. A. H., Arain, M. S., Shah, J. and Baloch, A. S. 2015. Influence of biotic and abiotic factors on population dynamics of mustard aphid, lipaphis erysimi (kalt) on late sown crop. Journal Entomology, 30 (1): 55-68

Shamim, M., Shekh, A.M., Patel, V.J., Dodia, J.F., Korat, D.M. and Mehta, A.M. 2009. Effect of weather parameters on population dynamics of green leaf hopper and white backed plant hopper in paddy grown. Journal of Agrometeorology, 11 (2): 172-174(a)

Sharma, D. R., Singh, D. P., Singh, J. and Dhaliwal, G. S. 1996. Extent of damage and pattern of emergence from over-wintering larvae of rice stem borer in Punjab. Indian Jounral Ecology, 23: 104-108.

Sharma, M. K., Atsedewoin, A. and Fanta, S. 2011. Forewarning models of the insects of paddy crop. International Journal of Biodiversity and Conservation, 3(8): 367-375.

Sharma, M.K., Pandey, V., Singh, R. S. and Singh, R. A. 2004. A study on light trap catches of some rice pests in relation to meteorological factors. Ethiopia Journal of Science, 27(2):165–170

Singh, A.K., Rai, A.K. and Khan, M.A. 2002. Influence of weather factors on light trap catches of yellow stem borer in kharif season. Indian Jounral of Entomology, 64(4): 510-517.

Singh, J., Dhaliwal, G. S. and Sidhu, G. S. 1993. Advances in insect resistance in rice,: 2-78.

Singh, J., Sarao, P. S., Singh, H. and Suri, K. S. 2007. Population fluctuation studies on insect pests of rice in Punjab. Journal of Insect Science, 20 (2): 179-83.

Singh, P., Chander, S., Husain, M., Pal, V. and Singh, P. 2016. Development of a Forewarning model to predict rice leaf folder (Cnaphlocrocis Medinalis Guenee). Springer,: 1-6.

Singh, R. A., Singh, R. B. and Singh, G. 2005. Drought-induced shifting of stem borer species in shallow deep water rice. International Rice Research Notes, 30(2): 24.

Singh, S. P., Sekhon, B. S., Brar, J. S., Dhaliwal, L. K., and Chahal, S. K. 2009. Effect of weather parameters and plant geometry on sucking pests dynamics in Bt and non Bt cotton. In 4th National Seminaron agro-meteorology-needs approaches and linkages for rural development,: 12–13.

Singh, S., Kaur, P., Kumar, V. and Singh, H. 2012. Incidence of insect pest damage in rice crop in relation to meteorological parameters in Punjab – a plant clinic data based case study. Journal of Agrometeorology, 14(1): 50-53.

Siswanto, R. M., Dzolkhifli, O. and Elna, K. 2008. Population fluctuation of *Helopeltisantonii Signoret* on cashew *Anacarcium occidentalle L.* in Java Indonesia. Pertanika Journal of Tropical Agriculture Science, 31: 191–196.

Sondgerath, D. and Muller, P. W. 1996. A model for the development of the cabbage root fly (Delia radicum L.) based on the extended Leslie model. Ecological Modelling, 91: 67-76.

Srivastava, R., Gupta, C., Gupta, H., Singh, N. and Kumar, N. 2015. Mathematical modelling of crop yield forecasting and forewarning of Pest/Diseases. International Conference of Advance Research and Innovation,: 417-419.

Upadhyay, V. K. and Sharma, M. K. 2004. Effect of weather parameters on light trap catches of Green leafhopper. Journal of Entomology, 11: 2.

Venkataraman, S. and Krishnan, A. 1992. “Crops and weather”. ICAR Publications,: 586.

Vennila, S., Das, D.K., Singh, J., Tanwar, R. K., Sharma S. and Chattopadhyay C. 2015. Weather Based Forewarning of Rice Yellow Stem Borer, *Scirpophaga incertulas (Walker).* Journal of Rice Research, 8 (2): 1-4.

Yadav, D. S. and Chander, S. 2010. Establishment of Brown Planthopper, *Nilaparvata Lugens (Stal)* Population - Weather Model. Indian Journal of Entomology, 72(1): 53-56.

Yadav, D.S., Chander, S. and Selvaraj, K. 2010. Agro-ecological zoning of brown plant hopper (*Nilaparvata lugens (Stal)* incidence on rice (*Oryza sativa L.).* Journal of Scientific and Industrial Research, 69: 818-822.

Yang, L., Peng, L., Zhong, F. and Zhang, Y. 2009. A study of paddy stem borer (*Scirpophaga Incertulas*) population dynamics and its influence factors base on stepwise regress analysis. Computer and Computing Technologies in Agriculture II, (2): 1519-1526.

APPENDIX

Appendix – A

Table: Weekly weather parameters for Nineteen years

Week No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Rain-Fall (mm)	RH-I (%)	RH-II (%)	Sun Shine (hours)
Weekly meteorological data :1998							
27	Jul 02-08	29.0	24.2	077.0	91	86	00.2
28	09-15	30.6	24.8	091.8	90	78	02.8
29	16-22	32.4	24.8	017.0	93	68	05.4
30	23-29	33.5	24.8	037.0	93	69	05.0
31	30-05	31.0	24.9	035.0	93	77	04.2
32	Aug 06-12	30.8	24.6	085.0	94	80	02.3
33	13-19	30.5	24.0	025.6	93	79	02.7
34	20-26	32.5	24.7	029.0	92	69	05.8
35	27-02	30.8	24.5	086.0	93	80	02.1
36	Sep 03-09	31.2	24.3	035.8	96	77	03.1
37	10-16	29.7	24.2	036.8	93	78	03.1
38	17-23	32.1	25.1	023.4	93	73	06.3
39	24-30	33.0	24.9	013.4	91	67	08.1
40	Oct 01-07	31.6	23.5	054.2	92	72	06.9
41	08-14	32.2	23.8	001.2	89	66	09.1
42	15-21	30.7	23.4	001.4	91	71	05.2
43	22-28	28.9	21.5	041.6	95	68	04.7
44	29-04	29.1	20.9	005.2	92	66	05.2
45	Nov 05-11	29.7	20.1	047.2	92	67	05.6
46	12-18	26.4	17.6	015.4	94	69	05.3
47	19-25	27.9	15.5	000.0	92	52	06.6
48	26-02	27.4	09.7	000.0	95	36	09.5
Weekly meteorological data :1999							
27	Jul 02-08	30.6	25.3	004.4	77	52	04.2
28	09-15	34.9	24.7	048.8	85	73	02.0
29	16-22	31.9	23.8	062.8	91	81	00.7
30	23-29	29.2	23.4	019.3	89	86	00.1
31	30-05	27.8	23.7	041.4	90	74	03.1
32	Aug 06-12	30.5	23.9	087.2	90	84	01.0
33	13-19	27.6	24.0	027.0	90	73	02.4
34	20-26	30.5	24.5	042.4	92	84	01.5
35	27-02	29.6	23.2	262.8	94	86	01.2
36	Sep 03-09	28.9	24.3	003.0	91	77	03.1
37	10-16	30.5	23.9	031.2	93	84	02.5
38	17-23	28.7	23.1	134.1	94	88	00.8
39	24-30	27.6	23.6	057.0	92	75	05.8
40	Oct 01-07	30.5	23.4	012.6	91	72	07.1
41	08-14	31.3	23.0	001.2	94	61	07.8
42	15-21	31.5	21.1	001.0	94	60	08.4
43	22-28	30.0	20.2	006.2	93	60	07.4
44	29-04	30.3	20.5	000.0	90	60	07.3
45	Nov 05-11	30.1	18.5	000.0	90	47	08.8
46	12-18	31.7	12.0	000.0	90	40	09.7
47	19-25	29.8	09.9	000.0	92	31	08.8
48	26-02	27.6	10.3	000.0	92	33	09.2

Week No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Rain-Fall (mm)	RH-I (%)	RH-II (%)	Sun Shine (hours)
Weekly meteorological data :2000							
27	Jul 02-08	30.6	25.5	084.6	84	56	8.2
28	09-15	35.0	24.3	013.6	93	79	1.2
29	16-22	29.9	23.6	058.2	92	81	2.3
30	23-29	27.8	23.7	217.0	92	72	2.7
31	30-05	29.8	25.4	109.6	89	64	5.9
32	Aug 06-12	32.3	24.7	024.8	90	74	3.0
33	13-19	31.3	24.2	021.2	90	80	2.4
34	20-26	29.9	24.7	147.6	90	75	4.2
35	27-02	30.6	24.6	083.4	91	80	2.3
36	Sep 03-09	29.9	24.0	073.0	92	74	2.5
37	10-16	29.6	23.8	021.2	90	70	5.8
38	17-23	31.7	24.5	029.4	91	67	7.3
39	24-30	32.6	22.6	003.2	92	62	6.3
40	Oct 01-07	32.5	22.1	020.4	89	50	9.1
41	08-14	33.4	21.6	000.0	90	44	8.8
42	15-21	34.1	19.7	000.8	87	44	7.5
43	22-28	33.1	17.7	009.0	86	35	9.5
44	29-04	34.8	17.3	000.0	86	37	9.7
45	Nov 05-11	31.8	14.2	000.0	88	25	9.8
46	12-18	32.2	13.0	000.0	84	23	9.7
47	19-25	31.7	13.7	003.4	86	28	9.4
48	26-02	32.0	13.9	013.8	80	31	9.0
Weekly meteorological data :2001							
27	Jul 02-08	30.6	24.9	80.5	91	73	3.2
28	09-15	32.2	24.0	76.1	94	84	0.1
29	16-22	27.3	24.1	66.9	93	88	0.0
30	23-29	27.2	24.8	50.2	92	73	1.7
31	30-05	30.3	25.3	04.2	92	71	2.8
32	Aug 06-12	31.7	25.4	34.2	95	75	5.2
33	13-19	31.4	24.6	49.5	92	83	1.3
34	20-26	29.0	24.7	120.2	95	87	1.9
35	27-02	29.9	24.8	10.9	88	69	5.6
36	Sep 03-09	30.9	24.5	43.1	92	69	4.7
37	10-16	32.2	24.2	11.3	93	67	6.7
38	17-23	33.2	24.4	00.2	93	57	7.6
39	24-30	33.6	24.3	41.5	90	65	8.4
40	Oct 01-07	33.2	24.5	52.3	93	74	3.3
41	08-14	31.0	23.9	34.5	93	60	8.3
42	15-21	32.6	20.4	00.0	88	47	8.4
43	22-28	31.9	18.1	00.0	92	40	9.0
44	29-04	32.0	18.5	09.6	90	40	9.2
45	Nov 05-11	32.3	17.4	00.0	89	33	7.6
46	12-18	31.4	18.4	00.0	88	50	5.4
47	19-25	30.3	13.7	00.0	89	32	9.0
48	26-02	30.4	11.7	00.0	88	29	7.9
Weekly meteorological data :2002							
27	Jul 02-08	28.3	27.2	002.2	72	46	3.4
28	09-15	35.7	25.8	008.0	75	53	4.8
29	16-22	36.3	24.6	042.6	90	72	2.1
30	23-29	31.1	25.6	000.0	82	55	5.9
31	30-05	33.4	24.7	075.8	90	71	3.1
32	Aug 06-12	33.0	24.5	051.5	92	76	2.8
33	13-19	31.0	23.1	165.6	94	89	0.1
34	20-26	27.0	23.9	043.3	91	78	2.8

35	27-02	28.9	24.4	051.0	93	75	2.9
36	Sep 03-09	30.0	24.1	040.0	91	77	3.3
37	10-16	29.8	24.1	020.6	92	69	5.1
38	17-23	30.5	23.8	000.0	91	59	9.5
39	24-30	31.9	23.2	006.0	89	60	8.7
40	Oct 01-07	32.1	21.9	000.0	90	48	10.0
41	08-14	33.6	23.1	000.0	86	60	8.9
42	15-21	32.2	21.3	023.2	93	60	7.1
43	22-28	30.9	18.4	000.0	92	42	9.2
44	29-04	31.5	15.9	000.0	90	36	9.4
45	Nov 05-11	31.9	16.2	000.0	90	41	8.0
46	12-18	30.1	14.4	000.0	89	36	9.1
47	19-25	29.8	11.9	000.0	89	30	9.3
48	26-02	29.8	10.9	000.0	87	25	9.6
Weekly meteorological data :2003							
27	Jul 02-08	30.0	24.9	045.4	92	68	4.6
28	09-15	32.3	25.0	046.1	92	74	2.6
29	16-22	31.6	24.9	020.8	92	73	5.4
30	23-29	31.7	24.2	256.4	92	80	2.1
31	30-05	30.1	24.6	072.2	93	80	1.9
32	Aug 06-12	29.7	25.4	128.8	92	84	4.6
33	13-19	31.4	23.9	102.8	94	80	1.1
34	20-26	29.4	24.8	095.8	92	78	3.0
35	27-02	30.5	24.1	210.3	94	86	1.3
36	Sep 03-09	28.6	23.8	061.1	93	86	0.4
37	10-16	27.3	24.0	027.2	93	81	2.1
38	17-23	28.6	24.2	072.4	94	79	4.5
39	24-30	31.1	24.0	070.5	92	72	6.3
40	Oct 01-07	31.2	22.8	020.2	92	67	7.6
41	08-14	31.1	21.8	036.2	93	63	5.6
42	15-21	29.8	21.0	000.0	92	61	8.6
43	22-28	30.9	20.6	054.8	93	74	4.7
44	29-04	27.8	20.6	014.4	94	55	7.8
45	Nov 05-11	30.7	15.8	000.0	92	38	9.4
46	12-18	30.4	14.0	000.0	91	35	9.5
47	19-25	29.4	15.5	000.0	93	42	9.1
48	26-02	30.4	14.8	000.0	94	45	8.5
Weekly meteorological data :2004							
27	Jul 02-08	29.5	25.3	42.8	91	73	4.4
28	09-15	32.7	23.3	169.2	90	67	4.1
29	16-22	32.6	24.9	38.0	90	77	5.0
30	23-29	31.4	24.0	117.4	95	81	2.7
31	30-05	31.1	24.6	33.8	92	79	2.6
32	Aug 06-12	29.5	23.8	58.2	93	91	0.3
33	13-19	27.2	24.7	8.6	91	78	1.5
34	20-26	29.0	24.2	63.2	94	80	2.6
35	27-02	29.4	24.6	3.6	89	69	5.4
36	Sep 03-09	31.3	24.6	21.2	92	70	6.2
37	10-16	32.2	24.1	43.4	92	66	6.5
38	17-23	32.7	24.6	1.6	92	68	7.5
39	24-30	32.2	24.4	68.4	95	69	5.6
40	Oct 01-07	31.8	23.4	17.4	92	70	6.6
41	08-14	31.2	22.1	2.8	95	57	8.6
42	15-21	32.4	16.9	0.0	94	42	9.8
43	22-28	29.4	16.0	0.0	93	38	9.4
44	29-04	30.3	14.5	0.0	91	31	9.6
45	Nov 05-11	30.0	15.4	0.0	92	40	8.3
46	12-18	29.8	16.4	0.0	90	34	8.3
47	19-25	31.3	11.9	0.0	88	24	9.4

48	26-02	30.5	11.5	0.0	91	30	8.6
Weekly meteorological data :2005							
27	Jul 02-08	28.8	20.9	53.3	88	72	1.9
28	09-15	30.0	24.5	99.1	95	80	2.9
29	16-22	31.2	25.1	28.8	91	70	5.5
30	23-29	32.7	24.1	193.0	95	83	0.7
31	30-05	28.9	24.2	224.0	92	87	0.9
32	Aug 06-12	28.1	24.3	70.6	91	73	3.1
33	13-19	28.9	24.4	100.4	95	84	1.5
34	20-26	29.5	24.1	120.7	92	74	2.0
35	27-02	28.8	25.9	1.0	91	61	6.1
36	Sep 03-09	33.5	25.3	7.4	91	72	5.9
37	10-16	32.8	24.2	252.2	93	81	2.6
38	17-23	29.5	24.4	17.2	89	74	3.5
39	24-30	29.8	23.9	0.0	90	64	7.8
40	Oct 01-07	31.0	23.2	0.0	92	55	6.5
41	08-14	31.9	22.0	0.0	93	59	8.6
42	15-21	31.9	22.3	121.8	96	76	3.0
43	22-28	28.8	21.3	0.0	93	60	6.9
44	29-04	29.3	17.7	0.0	87	44	6.4
45	Nov 05-11	29.7	13.0	0.0	91	29	9.3
46	12-18	28.4	11.9	0.0	90	25	9.7
47	19-25	29.4	10.9	0.0	92	24	9.0
48	26-02	29.5	12.9	0.0	91	32	8.8
Weekly meteorological data :2006							
27	Jul 02-08	28.8	25.5	55.4	85	69	2.3
28	09-15	30.6	26.0	18.1	82	62	2.3
29	16-22	32.5	23.8	159.2	93	84	0.3
30	23-29	28.0	24.1	129.1	94	77	3.1
31	30-05	29.7	24.2	45.3	92	79	1.3
32	Aug 06-12	28.9	24.2	7.0	89	75	6.3
33	13-19	29.5	24.2	266.8	93	80	2.3
34	20-26	29.1	24.6	30.8	93	81	1.9
35	27-02	29.2	23.7	60.1	92	75	1.8
36	Sep 03-09	28.4	25.1	114.4	94	71	7.0
37	10-16	31.3	24.6	72.2	94	77	4.9
38	17-23	32.0	24.4	11.6	90	70	6.7
39	24-30	30.9	23.1	34.0	90	64	7.7
40	Oct 01-07	31.5	23.7	5.9	94	63	7.7
41	08-14	31.8	23.0	0.0	91	43	8.6
42	15-21	33.7	20.8	0.0	93	46	9.0
43	22-28	33.3	18.8	0.0	90	47	9.3
44	29-04	31.3	20.8	1.6	93	65	2.8
45	Nov 05-11	27.8	18.3	0.0	92	43	5.6
46	12-18	29.6	14.6	0.0	91	35	9.0
47	19-25	29.4	15.2	0.0	89	31	8.4
48	26-02	31.0	18.0	0.0	87	41	7.2
Weekly meteorological data :2007							
27	Jul 02-08	30.7	24.9	80.6	85	77	2.5
28	09-15	29.9	24.8	74.6	92	79	2.5
29	16-22	30.2	25.5	10.2	89	70	1.6
30	23-29	31.9	24.5	95.1	92	69	4.2
31	30-05	32.1	25.3	10.2	90	69	3.4
32	Aug 06-12	31.8	24.9	110.9	92	83	2.3
33	13-19	29.7	24.6	04.6	91	73	1.6
34	20-26	29.4	24.5	67.0	95	79	5.6
35	27-02	30.2	25.3	61.3	94	79	3.6
36	Sep 03-09	30.0	24.3	91.7	94	80	2.5
37	10-16	30.2	24.7	34.8	94	73	3.9
38	17-23	31.2	24.2	23.6	90	72	7.0
39	24-30	31.5	24.0	45.0	94	73	4.1

40	Oct 01-07	30.0	24.1	29.0	91	68	5.4
41	08-14	31.4	20.6	00.0	91	44	7.6
42	15-21	31.6	19.4	00.0	93	42	9.0
43	22-28	30.8	16.0	00.0	93	36	9.6
44	29-04	30.8	20.9	07.4	93	57	7.0
45	Nov 05-11	30.5	15.6	00.0	93	36	8.9
46	12-18	30.7	14.2	00.0	89	39	8.9
47	19-25	29.7	11.6	00.0	89	29	8.5
48	26-02	28.0	11.1	00.0	91	27	8.3
		28.4					
Weekly meteorological data :2008							
27	Jul 02-08	30.5	24.7	22.2	86	64	2.8
28	09-15	31.8	24.9	30.4	88	64	4.2
29	16-22	31.7	24.7	58.0	89	61	3.4
30	23-29	33.0	24.6	12.4	94	75	1.8
31	30-05	31.1	24.9	39.5	93	81	1.5
32	Aug 06-12	28.9	25.0	71.9	92	71	1.8
33	13-19	30.0	24.7	50.8	92	74	3.1
34	20-26	30.5	25.1	35.8	91	70	3.1
35	27-02	30.8	24.4	43.4	93	80	3.9
36	Sep 03-09	30.2	23.9	22.2	92	72	5.6
37	10-16	31.9	24.6	24.6	92	69	5.8
38	17-23	31.0	23.9	165.4	93	75	4.2
39	24-30	30.5	23.2	00.0	89	59	8.8
40	Oct 01-07	31.8	23.7	12.6	94	66	7.1
41	08-14	32.2	22.1	00.0	92	47	3.8
42	15-21	32.9	19.8	00.0	88	39	4.4
43	22-28	32.0	17.4	00.0	85	36	7.7
44	29-04	30.6	15.4	00.0	91	28	7.7
45	Nov 05-11	31.8	16.2	00.0	89	37	7.2
46	12-18	31.1	17.5	00.0	89	47	5.1
47	19-25	29.1	16.7	00.0	90	41	3.8
48	26-02	30.9	13.0	00.0	86	37	8.3
Weekly meteorological data :2009							
27	Jul 02-08	30.5	25.7	59.7	90	67	2.9
28	09-15	33.0	24.8	334.0	91	80	0.5
29	16-22	29.4	25.0	227.6	89	81	1.3
30	23-29	28.7	25.3	13.0	85	73	3.8
31	30-05	29.8	26.6	2.0	81	57	6.4
32	Aug 06-12	32.9	25.4	99.6	87	74	3.8
33	13-19	31.8	25.4	50.2	93	77	3.2
34	20-26	30.7	24.4	99.2	93	78	3.1
35	27-02	30.2	25.2	17.2	95	83	3.9
36	Sep 03-09	30.8	25.3	17.2	95	83	3.9
37	10-16	31.2	24.7	8.6	92	62	6.6
38	17-23	32.2	25.8	.4	92	62	7.7
39	24-30	33.0	25.1	6.4	90	65	4.3
40	Oct 01-07	32.9	24.8	50.8	92	79	4.4
41	08-14	30.6	22.1	00.8	93	53	6.9
42	15-21	31.9	20.0	00.0	92	41	9.2
43	22-28	32.7	15.3	00.0	94	25	9.3
44	29-04	31.3	16.7	00.0	92	34	7.6
45	Nov 05-11	30.7	20.9	00.0	90	56	4.6
46	12-18	30.4	21.6	49.5	91	68	3.6
47	19-25	29.8	13.0	00.0	93	40	7.8
48	26-02	26.4	10.8	00.0	93	32	8.9
Weekly meteorological data :2010							
27	Jul 02-08	26.9	25.1	78.2	92	82	2.1
28	09-15	31.2	24.5	55.9	92	82	2.3
29	16-22	30.4	26.0	26.7	90	72	5.7

30	23-29	32.8	24.9	277.8	93	79	2.6
31	30-05	29.6	25.6	19.2	91	78	3.0
32	Aug 06-12	30.3	24.9	41.2	93	77	2.7
33	13-19	30.1	26.0	8.4	92	71	6.5
34	20-26	32.8	26.0	30.0	92	70	5.6
35	27-02	31.9	25.2	71.4	94	82	3.6
36	Sep 03-09	30.3	25.3	129.6	93	77	5.2
37	10-16	31.0	25.0	51.0	94	72	5.8
38	17-23	31.7	24.7	141.0	95	73	3.9
39	24-30	30.2	24.5	5.8	90	54	8.3
40	Oct 01-07	32.2	24.3	0.0	88	56	8.8
41	08-14	32.0	22.7	10.2	88	50	7.9
42	15-21	31.8	23.9	8.4	92	69	13.5
43	22-28	30.3	20.5	46.0	94	52	8.5
44	29-04	31.2	19.2	0.7	92	56	2.8
45	Nov 05-11	26.5	20.6	0.0	90	55	7.3
46	12-18	29.5	20.6	6.5	93	34	7.9
47	19-25	31.5	18.1	0.0	88	37	9.3
48	26-02	31.6	18.7	0.0	89	43	7.5
Weekly meteorological data :2011							
27	Jul 02-08	31.7	25.1	23.4	86	67	4.8
28	09-15	33.4	25.5	58.0	90	67	5.3
29	16-22	32.6	24.1	206.0	94	82	1.8
30	23-29	29.7	25.2	50.8	88	66	4.5
31	30-05	30.7	25.8	75.0	92	77	5.4
32	Aug 06-12	32.2	24.7	93.0	95	82	0.6
33	13-19	28.9	24.6	73.9	94	76	3.3
34	20-26	30.1	24.5	59.6	92	75	5.0
35	27-02	30.8	24.6	150.1	96	82	2.5
36	Sep 03-09	29.4	24.4	226.0	95	90	1.6
37	10-16	28.3	24.4	67.0	95	80	3.2
38	17-23	30.1	24.0	69.2	94	65	5.2
39	24-30	31.0	23.8	2.4	89	52	5.8
40	Oct 01-07	31.2	21.8	0.0	90	43	8.8
41	08-14	32.4	24.0	24.8	92	57	7.3
42	15-21	32.4	20.8	0.0	90	37	9.1
43	22-28	32.6	17.7	0.0	92	35	8.7
44	29-04	31.8	15.2	0.0	91	27	9.0
45	Nov 05-11	30.8	15.8	0.0	90	28	8.1
46	12-18	32.2	15.7	0.0	88	30	8.0
47	19-25	31.2	15.2	0.0	87	33	8.9
48	26-02	30.2	14.7	0.0	88	35	7.8
Weekly meteorological data :2012							
27	Jul 02-08	29.9	25.0	72.9	91	81	2.3
28	09-15	30.3	25.5	73.6	91	69	4.0
29	16-22	31.7	24.5	341.4	93	83	1.1
30	23-29	29.9	24.1	60.3	92	88	0.7
31	30-05	27.6	23.2	271.1	95	91	0.0
32	Aug 06-12	25.8	24.8	106.8	93	79	1.3
33	13-19	28.8	25.3	33.2	90	78	3.5
34	20-26	30.2	24.5	127.6	93	78	3.1
35	27-02	29.6	25.8	55.6	92	74	4.7
36	Sep 03-09	31.1	25.1	74.4	93	75	2.5
37	10-16	30.3	24.7	42.6	93	74	4.0
38	17-23	30.4	24.6	84.4	95	73	4.3
39	24-30	31.4	24.4	2.8	90	54	8.3
40	Oct 01-07	32.2	23.9	9.2	91	56	7.6
41	08-14	31.9	20.2	0.0	89	45	8.0
42	15-21	31.0	19.5	0.0	88	37	8.6
43	22-28	31.9	18.4	0.0	85	38	6.9
44	29-04	31.6	18.4	27.3	92	59	4.9

45	Nov 05-11	28.9	17.3	5.6	95	45	6.6
46	12-18	28.5	12.7	0.0	90	33	9.1
47	19-25	28.4	16.4	0.0	84	43	7.3
48	26-02	29.6	14.3	0.0	89	35	8.4
Weekly meteorological data :2013							
27	Jul 02-08	30.1	24.5	73.5	90	70	4.4
28	09-15	31.3	24.3	144.4	93	78	3.9
29	16-22	31.2	25.3	44.6	95	74	2.3
30	23-29	30.5	24.7	88.2	92	83	0.7
31	30-05	28.4	23.9	255.8	95	84	1.3
32	Aug 06-12	28.3	24.7	87.4	93	76	3.3
33	13-19	31.1	24.3	177.0	95	80	3.3
34	20-26	31.3	23.8	60.5	92	84	1.5
35	27-02	27.9	24.5	120.8	95	80	3.1
36	Sep 03-09	29.3	24.8	54.8	93	76	4.2
37	10-16	31.1	25.2	11.6	92	73	6.2
38	17-23	31.9	24.1	92.6	93	77	2.5
39	24-30	29.9	24.9	28.6	93	68	6.3
40	Oct 01-07	32.0	24.1	45.2	95	75	4.2
41	08-14	30.1	23.3	8.6	89	71	3.5
42	15-21	30.2	21.4	0.0	91	56	8.6
43	22-28	30.7	22.6	32.6	96	73	2.1
44	29-04	28.8	17.3	0.0	92	38	8.9
45	Nov 05-11	30.5	16.7	0.0	91	37	8.2
46	12-18	30.0	13.2	0.0	91	36	7.6
47	19-25	27.5	16.7	0.0	87	40	7.3
48	26-02	30.3	15.6	0.0	83	35	8.4
Weekly meteorological data :2014							
27	Jul 02-08	30.0	27.0	9.0	72	44	5.3
28	09-15	37.7	23.8	152.8	92	72	4.1
29	16-22	34.3	24.6	260.2	95	88	0.5
30	23-29	28.5	23.8	37.2	95	82	1.6
31	30-05	28.7	24.8	136.0	95	86	1.9
32	Aug 06-12	29.8	24.8	42.1	91	71	2.8
33	13-19	30.2	25.3	45.0	91	70	5.5
34	20-26	31.8	25.1	25.8	92	73	3.4
35	27-02	32.3	25.0	84.8	91	76	3.6
36	Sep 03-09	31.8	24.2	79.5	94	83	0.5
37	10-16	28.3	24.3	41.0	95	79	3.4
38	17-23	30.5	24.6	57.6	94	68	4.4
39	24-30	32.1	24.0	0.0	93	57	8.3
40	Oct 01-07	33.4	24.0	0.0	91	57	8.3
41	08-14	33.2	23.6	52.2	89	66	4.9
42	15-21	30.4	22.5	1.2	91	56	8.4
43	22-28	31.5	19.4	5.4	92	52	5.9
44	29-04	29.1	16.9	0.0	94	37	8.0
45	Nov 05-11	30.1	17.6	0.0	88	44	7.8
46	12-18	30.7	19.3	0.0	84	35	6.8
47	19-25	31.4	11.9	0.0	91	28	8.5
48	26-02	29.3	12.5	0.0	90	26	8.6
Weekly meteorological data :2015							
27	Jul 02-08	30.2	25.2	41.8	79	64	5.9
28	09-15	33.6	25.2	72.8	89	80	1.7
29	16-22	31.2	25.6	7.8	91	71	2.4
30	23-29	31.8	25.1	43.6	90	70	3.4
31	30-05	30.7	25.2	48.7	86	69	4.6
32	Aug 06-12	31.2	24.7	36.6	94	73	2.5

33	13-19	30.8	25.3	126.4	94	73	4.1
34	20-26	31.7	25.9	23.6	87	65	6.5
35	27-02	32.3	25.0	37.9	94	80	1.2
36	Sep 03-09	30.8	25.5	10.0	93	64	6.9
37	10-16	33.0	25.4	68.4	93	62	6.8
38	17-23	33.5	25.1	135.4	94	78	3.1
39	24-30	30.1	24.6	0.0	92	57	7.2
40	Oct 01-07	32.5	24.4	0.0	92	51	7.7
41	08-14	33.7	22.2	0.0	89	47	8.7
42	15-21	33.9	22.8	0.0	91	45	8.7
43	22-28	33.4	21.3	0.0	90	37	8.2
44	29-04	33.7	19.4	0.0	90	55	6.7
45	Nov 05-11	30.0	18.8	0.0	91	37	7.8
46	12-18	31.7	16.3	0.0	89	33	7.5
47	19-25	31.7	15.5	0.0	88	36	8.3
48	26-02	30.6	16.7	0.0	87	34	7.5
Weekly meteorological data :2016							
27	Jul 02-08	31.9	24.5	107.6	95	83	1.9
28	09-15	31.0	25.1	59.0	91	80	1.5
29	16-22	29.3	24.5	207.0	94	79	0.9
30	23-29	30.6	25.4	56.2	91	69	5.8
31	30-05	31.9	25.3	28.0	92	81	2.9
32	Aug 06-12	30.7	28.6	22.0	91	77	1.6
33	13-19	32.3	21.6	11.6	89	77	1.3
34	20-26	28.7	25.6	4.2	90	70	5.2
35	27-02	31.9	26.0	22.2	90	67	4.8
36	Sep 03-09	32.2	25.3	62.8	87	68	1.4
37	10-16	30.7	24.3	132.8	95	80	3.3
38	17-23	31.1	24.9	91.6	94	69	6.2
39	24-30	32.2	24.5	134.6	97	89	3.4
40	Oct 01-07	30.0	24.8	48.2	95	72	4.5
41	08-14	26.5	22.9	9.2	94	50	5.6
42	15-21	31.5	19.0	0.0	90	35	10.0
43	22-28	31.6	18.1	0.0	89	36	9.5
44	29-04	31.5	19.8	0.0	85	51	8.0
45	Nov 05-11	30.6	15.7	0.0	88	29	8.5
46	12-18	30.2	14.4	0.0	89	35	7.8
47	19-25	29.0	11.3	0.0	89	25	8.5
48	26-02	30.0	13.0	0.0	88	27	8.5

Appendix –B

Table : Weekly count for yellow stem borer.

Week/ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
27	25	16	8	5	0	8	11	1	0	8	7	4	3	15	45	48	59	26	18
28	6	4	24	9	0	7	16	10	1	2	0	3	1	12	31	29	39	12	4
29	0	0	5	5	0	6	10	10	1	0	1	4	0	7	30	20	6	2	8
30	0	2	7	15	0	3	9	9	1	2	0	1	0	19	19	12	9	5	11
31	0	0	11	11	4	0	4	10	0	17	17	3	10	13	4	35	13	10	13
32	2	0	21	13	1	2	9	11	0	48	5	6	17	15	21	19	23	9	10
33	15	8	7	8	0	0	17	9	3	19	3	6	25	50	50	51	27	13	10
34	8	10	8	5	4	7	9	55	13	13	2	10	12	31	78	14	29	8	8
35	5	12	28	23	6	4	13	288	27	11	24	4	15	26	87	35	20	12	19
36	5	3	14	309	27	0	28	132	27	22	7	8	10	12	53	27	21	19	36
37	17	12	26	856	16	0	146	85	24	149	33	10	104	6	19	101	31	6	60
38	74	50	152	2858	42	0	1761	50	31	191	9	9	247	18	98	76	91	152	89
39	561	130	2725	1554	108	19	1134	109	53	187	11	17	266	609	502	109	287	125	272
40	287	357	1457	830	61	0	936	133	58	136	6	15	75	1603	399	53	104	158	60
41	103	353	102	179	571	0	0	0	77	0	8	21	51	438	231	73	91	74	17

42	92	289	136	509	22	0	477	87	77	109	25	15	15	127	191	26	114	70	68
43	182	179	18	2130	29	0	243	61	71	44	21	25	12	90	191	64	100	68	71
44	649	91	43	4036	16	39	118	64	48	45	22	11	61	56	102	188	138	56	59
45	0	0	51	2005	11	185	220	55	40	76	31	9	69	20	112	175	137	106	56
46	285	852	20	1700	4	35	51	78	20	30	23	17	141	37	22	74	156	84	31
47	428	672	4	1400	4	1	98	23	33	14	26	8	9	28	119	76	39	52	23
48	14	113	0	32	1	14	37	28	27	30	113	0	17	18	43	95	44	68	32

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