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Influence of Weather Parameters on the Incidence of Maize Stem Borer, *Chilo Partellus (Swinhoe)*

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ABSTRACT

Field experiments were conducted on *C. partellus* with reference to its population dynamics on maize during four seasons *viz*., *Kharif* 2014, *Rabi* 2014-15, *Kharif* 2015 and *Rabi* 2015-16 at Agricultural Research Station, Darsi, Prakasam dist. The highest stem borer infestation during *Kharif* season with mean population of 2.86 larvae / plant was recorded during 40th standard week. Plant infestation was high during 45th standard week (40.75%). While during *Rabi* season, peak larval population of *C. partellus* (2.42 larvae / plant) was noticed during 4th standard week. Maximum numbers of plants (71.51%) were infested during 11th standard week. Larval population (r = -0.571) and plant infestation (r = -0.891) by *C. partellus* exhibited significant negative correlation with minimum temperature on average basis of two years during *Kharif*. Maximum temperature had significant positive correlation with plant infestation (r = 0.934) on average basis of both study years in *Rabi* season. Morning (r = 0.753) and evening relative humidity (r = 0.639) showed significant positive correlation with plant infestation on cumulative basis of *Kharif* 2014 and 2015, while evening relative humidity (r = -0.747) showed significant negative correlation during *Rabi* 2014-15 and 2015-16 pooled analysis.

Key words: *Chilo partellus, correlation, maize, regression, weather parameters.*

Maize (*Zea mays* Linn.) is one of the most important cereal crops next to wheat and rice in terms of total production in the world, ranks third in area and first in production in the world. Today, it is one of the important coarse cereal crops grown in different agro-climatic conditions in India. The country's productivity of maize is 2583 kg ha^{-1} (Yadav, 2015) in spite of diverse cultivation area. The demand for maize is ballooning day by day because of its vast landscape of uses from food to animal feed. The definite options to fulfil the ever increasing demand of maize grain and to increase status quo of grain productivity are to diminish the production constraints as well as intensifying the cropping pattern.

In India, maize can be grown all three seasons *viz*., *Kharif*, *Rabi* and *summer*; however, both biotic and abiotic factors have played a decisive role for grain production. Of the biotic constraints, stem borers *viz*., maize stem borer, *Chilo partellus*, pink stem borer, *Sesamia inferens* are frequently noticeable species. Among them, *C. partellus* is most destructive pest in maize (Kumar, 1997). Feeding and stem tunneling by borer larvae on maize plants results in crop losses as a consequence of destruction of the growing point, early leaf senescence, interference with translocation of metabolites, and nutrients that result in malformation of the grain, stem breakage, plant stunting, lodging, and direct damage to cobs (Kfir *et al*., 2002). Regarding the destructiveness of maize stem borer in maize can be expressed in terms of leaf feeding, whorl and stalk infestation, tunnel length measurement per plant, and exit holes on stalk in which various studies found 4% to 62% of damage level (Siddalingappa, 2008; Zahid, 2009; Birader, 2010). A weather parameter may have role to fluctuate such variation in damage level.

The climatic factors exercise a dominating influence on the development, longevity, reproduction and fecundity of insect pests. It is well known that densities of pest populations fluctuate with the prevailing weather conditions such as temperature, moisture, light and wind *etc*. The chance of an insect population to survive and reproduce depends primarily upon environmental factors. The incidence of *C. partellus* starts in late summer season when the average temperature ranges between 30-35 ^{oC} and increase gradually with increase of temperature resulting in high infestation during ensuing *Kharif* season (Jalali and Singh, 2002). The damage to *Kharif* maize crop is severe during the rainy period in the month of August and declined gradually in September and October (Singh and Sharma, 1984). Thus, we may need to manipulate our crops and cropping pattern to cope the negative impact of changing scenario of climates and insect-pest biology.

A rigorous study requires understanding the relationship between weather factors and population dynamics of insect-pest as well as performance of crops in terms of grain harvest. Thus, this study aimed to investigate severity of stem borer damage in maize and to correlate the stem borer damage parameters corresponding with weather factors.

MATERIAL AND METHODS

The field and laboratory experiments were conducted on *C. partellus*, with reference to its population dynamics on maize during four seasons *viz*., *Kharif* 2014, *Rabi* 2014-15, *Kharif* 2015 and *Rabi* 2015-16. The maize long duration hybrid, 30V92 was sown with the spacing of 60 x 20 cm between row to row and plant to plant in the last week of July (30th standard week) during *Kharif* 2014 and 2015 and in last week of November (48th standard week) during *Rabi* 2014-15 and 2015-16, respectively covering an area of 0.1 ha. All the agronomical practices were followed as per the recommendations of ANGRAU in raising the crop during the experimental period.

The observations on population dynamics of *C. partellus* larvae, number of plants damaged were recorded at weekly intervals. At each observation, 20 plants from each of the four corners leaving the boarder rows and another 20 plants at the centre were selected to record the incidence of *C. partellus*. The number of plants infested by stem borer was expressed as per cent of the proportion of the total number of plants observed at each sampling time. Observations were taken from one week after seedling emergence *i.e*., 32nd standard week during *Kharif* 2014 and 2015 and continued up to first week of November (45th standard week). During *Rabi* 2014-15 and 2015-16 observations started from 50th standard week and was continued till the disappearance of the pest or harvest of the crop in the field *i.e.,* 11th standard week.

Meteorological observations relevant to ambient temperature, relative humidity and rainfall were recorded from the meteorological observatory, Agricultural Research Station, Darsi to study the influence of weather factors on the incidence of *C.partellus*. The data was processed for weekly averages. Simple correlation was worked out between infestation of *C. partellus* and the weather factors for four seasons of the year 2014-15 and 2015-16 individually as well as on cumulative basis during the crop growth period from August to March. The combined effect of the meteorological factors like temperatures, relative humidity and rainfall on the larval incidence and infestation of *C. partellus* on 30V92 maize hybrid was determined separately as well as on cumulative basis using multiple linear regression models equation of type 1 *viz*., Yi = a + b1x1 + b2x2 + - - - + bnxn where *C. partellus* larval incidence and infestation was taken as the responsive variable (Y) and the meteorological factors as predictor variables were used to represent the equation.

RESULTS AND DISCUSSION

Larval incidence and plant infestation (%) caused by stem borer, *C. partellus* in maize during *Kharif* 2014 and 2015

The initial occurrence of *C. partellus* larvae during *Kharif* 2014 was noticed during 32nd standard week (1st week of August, 2014) at 14 days after crop emergence (DAE) with 0.13 larvae / plant. There after the larval population gradually increased and reached the peak during 40th standard week (1st week of October, 2014) at 70 DAE with a mean number of 3.07 larvae / plant. The peak larval incidence of *C. partellus* during *Kharif* 2015 was observed during 40th std. week (1st week of October, 2015) at 70 DAE with 2.64 larvae / plant.

The plant infestation by *C. partellus* during *Kharif* 2014 was started from 14 DAE during 32nd standard week and this infestation increased consequently on the subsequent dates of observation and reached to the peak *i. e.* 35.78 per cent at 91 DAE during 43rd standard week. During *Kharif* 2015 a continuously increasing trend in plant infestation was observed till maturity of the crop. The plant infestation reached its peak level *i.e*., 46.88 per cent during 45th standard week (Fig. 1).

Larval incidence and plant infestation (%) caused by stem borer, *C. partellus* in maize during *Rabi* 2014-15 and 2015-16

The larval incidence of *C. partellus* during *Rabi* 2014-15 reached to a peak by 5th standard week (1st week of February, 2015) at 63 DAE with a mean number of 2.33 larvae / plant and there after declined gradually to a minimum by 11th standard week (2nd week of March, 2015). The plant infestation reached its peak level at the crop maturity (66.71%) at 105 DAE (11th standard week).

The larval population of *C. partellus* during *Rabi* 2015-16 increased gradually and the peak incidence was recorded during 3rd standard week (3rd week of January, 2016) with a mean number of 2.73 larvae / plant coinciding with tasselling stage of maize. The crop suffered less due to *C. partellus* in the early stage of the crop, later a gradual increase was observed and attained its peak in the plant infestation at the end of the crop season by 11th standard week at 105 DAE with a mean infestation of 76.32 per cent (Fig. 2).

Studies on population dynamics of maize stem borer indicated that the larval population were more in October during *Kharif* season whereas, in *Rabi* it was in February. Initial stem borer density may have been responsible for the high variability in stem borer densities. The initial stem borer density may vary due to the presence of stems and stubbles of the previous season or due to the presence of wild host plants near the maize field. Stem borers can survive the dry period in stems and stubbles as diapausing larvae (Kfir *et al*., 2002). They complete their development after the first rains and will be able to infest the newly emerged maize crop. Stem borers also overcome the dry period by moving to grasses *viz*., *Sorghum arundinaceum* (Desv.) (Wild Sorghum), *Panicum maximum* (Guinea grass) and *Pennisetum purpureum* (Napier grass) that are common in the study area. Hence, the larval population was more during *Kharif* than in *Rabi* which is in close agreement with the report of Mohan *et al*. (1990) and Divya *et al*. (2009).

The results of current study revealed that the mean plant infestation due to *C. partellus* was more in October compared to January. Jalali and Singh (2002) also found that highest stem borer infestation of 39 per cent and 31.70 per cent in fodder maize during 1994 and 1995 of *Kharif* season, respectively. Similarly, sweet sorghum (SSV-74 and SSV-84) varieties sown in the month of August suffers heavily due to stem borer in the month of October (Deepthi, 2007). Highest incidence of maize stem borer *C. partellus* ranging from 4.0 to 18 per cent, 10.0 to 22.0 per cent and 8.5 to 20.0 per cent at College of Agriculture Shimoga, Attibele village of Shikaripur taluk and Abbalgere village of Shimoga taluk, respectively was observed during first fortnight of September (Siddalingappa, 2008) and higher number of pin holes in maize due to stem borer was noticed during the month of August (Birader 2010). The maximum incidence of the pest during October month as revealed in the present study is also in line with the reports of Manjunath (2013) and Meti *et al*. (2014).

Correlation coefficients between larval population of *C. partellus* and weather parameters

Minimum temperature showed significant and negative correlation with larval population of *C. partellus* during *Kharif* 2014, whereas evening relative humidity exerted positive and significant effect and rainfall showed negative and significant correlation with the larval population of *C. partellus* during *Kharif* 2015. Minimum temperature on average basis of two years data during *Kharif* season ($r = -0.571$) showed significant and negative correlation with the larval population of *C. partellus*. A negative and significant correlation was found to exist between minimum temperature and larval population of *C. partellus* during *Rabi* 2014-15, while in *Rabi* 2015-16 a significant negative correlation was found with evening relative humidity (Table 1).

Correlation coefficients between plant infestations (%) caused by *Chilo partellus* (Swinhoe) and weather parameters

Minimum temperature showed significant negative correlation, morning relative humidity showed significant positive correlation with the plant infestation caused by *C. partellus* during *Kharif* 2014, whereas minimum temperature showed significant negative correlation and evening relative humidity showed significant positive correlation with plant infestation caused by *C. partellus* during *Kharif* 2015. On cumulative basis of *Kharif* 2014 and 2015, minimum temperature and rainfall exerted significant negative impact, morning and evening relative humidity showed significant positive correlation with the plant infestation caused by *C. partellus*.

Maximum temperature showed significant positive correlation and evening relative humidity showed significant negative correlation during *Rabi* 2014-15, while maximum and minimum temperature showed significant positive correlation during *Rabi*

2015-16 with plant infestation caused by *C. partellus*. On average basis of two years data maximum temperature showed significant positive correlation and evening relative humidity showed significant negative correlation with plant infestation caused by *C. partellus* (Table 1).

Dharmasena (2002) and Zahid (2009) also reported that per cent stem damage caused by *C. partellus* was negatively correlated with the humidity as reported in this study during *rabi* and found a significant positive correlation between relative humidity and plant infestation during *Kharif* as reported by Siddalingappa (2008) and Meti *et al*. (2014). The present findings are also in full agreement with those of Kandalkar and Men (2004) and Patel *et al*. (2016) who reported that minimum temperature showed significant and negative correlation with stem borer damage as observed in the present study during *Kharif* whereas the same factor showed significant positive correlation during *Rabi* as reported by Dharmasena (2002), Siddalingappa (2008), Zahid (2009) and Meti *et al*. (2014). In the present studies the minimum temperature during *Kharif* 2014, 2015 and on cumulative basis showed significant negative correlation and significant positive correlation during *Rabi* 2015-16 with the plant infestation caused by *C. partellus*. These findings can be partially compared with those of Kandalkar *et al*. (2002) who reported that mean temperature showed significant and negative correlation with leaf injury caused by *C. partellus*.

Multiple linear regression models between larval population of *C. partellus* and weather parameters during *Kharif* 2014 and 2015

Minimum temperature (38.1%) during *Kharif* 2014, morning and evening relative humidity (43.1%) during *Kharif* 2015 and minimum temperature on average basis of both year *Kharif* season data showed maximum contribution (37.7%) in changing larval population of *C. partellus*. The multiple linear regression equation on an average basis of both the years after step down elimination was $Y = 10.002 + 0.224\ X_1 - 0.425\ X_2 - 0.070\ X_3 + 0.027\ X_4 - 0.056\ X_5$. This explains that when there was an unit increase of minimum temperature, morning relative humidity and rainfall, the population was lowered by 0.425, 0.070 and 0.056 units, respectively and with one unit increase in maximum temperature and evening relative humidity the population increased by 0.224 and 0.027 units (Table 2)

Multiple linear regression models between larval population of *C. partellus* and weather parameters during *Rabi* 2014-15 and 2015-16

Minimum temperature during *Rabi* 2014-15, maximum and minimum temperatures during *Rabi* 2015-16 and also on cumulative basis showed 42.8%, 59.9% and 52.8% contribution, respectively on the larval population of *C. partellus*. The multiple linear regression equation after step down elimination on the cumulative effect of both study years obtained was $Y = 1.113 + 0.175\ X_1 - 0.290\ X_2 + 0.009\ X_3 + 0.009\ X_4 - 0.241\ X_5$. This indicated when there was one unit increase in maximum temperature, morning and evening relative humidity, population of *C. partellus* increased by 0.175 and 0.009 units and one unit increase in minimum temperature and rainfall, the population of *C. partellus* decreased by 0.290 and 0.241 units, respectively (Table 2).

Multiple linear regression models between plant infestations (%) caused by *C. partellus* and weather parameters during *Kharif* 2014 and 2015

Minimum temperature, morning and evening relative humidity (93.7%) during *Kharif* 2014, minimum temperature (33.5%) during *Kharif* 2015 and also on cumulative basis of both study years (80.0%) showed significant impact on the plant infestation caused by *C. partellus*. The multiple linear regression equation after step down elimination on cumulative basis of two study years was $Y = 152.034 + 0.410\ X_1 - 6.229^*\ X_2 + 0.838\ X_3 - 0.850\ X_4 - 0.272\ X_5$ which explained when there was an unit increase of minimum temperature, evening relative humidity and rainfall, the plant infestation was lowered by 6.229, 0.850 and 0.272 per cent, and one unit increase in maximum temperature and morning relative humidity the plant infestation increased by 0.410 and 0.838 per cent, respectively (Table 3).

Multiple linear regression models between plant infestations (%) caused by *C. partellus* and weather parameters during *Rabi* 2014-15 and 2015-16

Maximum and minimum temperatures during *Rabi* 2014-15 (72.5%), *Rabi* 2015-16 (92.3%) and maximum temperature (87.8%) on cumulative basis showed maximum contribution in changing plant infestation caused by *C. partellus*. The coefficient of determination value on pooled basis of two study years was calculated to be 0.910 when the effect of all the factors was computed together with an overall possible contribution of 91 per cent to be induced by these factors significantly. The multiple linear regression equation after step down elimination obtained was $Y = -143.404 + 4.009 X_1 + 2.723 X_2 + 0.381 X_3 - 0.644 X_4 - 1.993 X_5$. Accordingly when there was one unit increase in maximum temperature, minimum temperature and morning relative humidity plant infestation increased by 4.009, 2.723 and 0.381 per cent and one unit increase in evening relative humidity and rainfall, the plant infestation lowered by 0.644 and 1.993 per cent, respectively (Table 3).

Relationship between larval population and plant infestation by *C. partellus*

Larval population of *C. partellus* showed positive and significant correlation during both study years of *Kharif* 2014 (r = 0.629) and *Kharif* 2015 (r = 0.765) separately as well as on cumulative basis (r = 0.723). Whereas, larval population during *Rabi* 2014-15, 2015-16 and on cumulative basis of both study years, showed non-significant positive correlation with the plant infestation (Table 4).

The multiple linear regression equation for *Kharif* 2014 was $Y = 0.403 + 0.041^*X_1$ indicating every unit increase in *C. partellus* larval population increased plant infestation by 0.041 per cent with the significant influence to the extent of 38.2 per cent ($R^2 = 0.382$). The multiple linear regression equation in *Kharif* 2015 was $Y = 0.292 + 0.045^*X_1$ indicating an unit increase in *C. partellus* larval population increased plant infestation by 0.045 units, with the significant influence to the extent of 57.4 per cent ($R^2 = 0.574$). The multiple linear regression equation for the pooled data of *Kharif* 2014 and 2015 was $Y = 0.278 + 0.049^*X_1$ which indicated an increase in *C. partellus* larval population, increased the plant infestation by 0.049 units and the influence was significant to an extent of 52.3 per cent ($R^2 = 0.523$).

The multiple linear regression equation for *Rabi* 2014-15 was $Y = 0.703 + 0.011 X_1$ indicating every unit increase in *C. partellus* larval population increased plant infestation by 0.011 per cent with the influence to the extent of 19.1 per cent ($R^2 = 0.191$). The multiple linear regression equation in *Rabi* 2015-16 was $Y = 1.440 + 0.009 X_1$ indicating an unit increase in *C. partellus* larval population increased plant infestation by 0.009 units, with the influence to the extent of 0.9 per cent ($R^2 = 0.009$). The multiple linear regression equation for the pooled data of *Rabi* 2014-15 and 2015-16 was $Y = 1.081 + 0.003 X_1$ which indicated an increase in *C. partellus* larval population, increased the plant infestation by 0.003 units and the influence was to an extent of 6.4 per cent ($R^2 = 0.064$).

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Fig. 1 Incidence of *C. partellus* in maize during *Kharif* 2014 and 2015

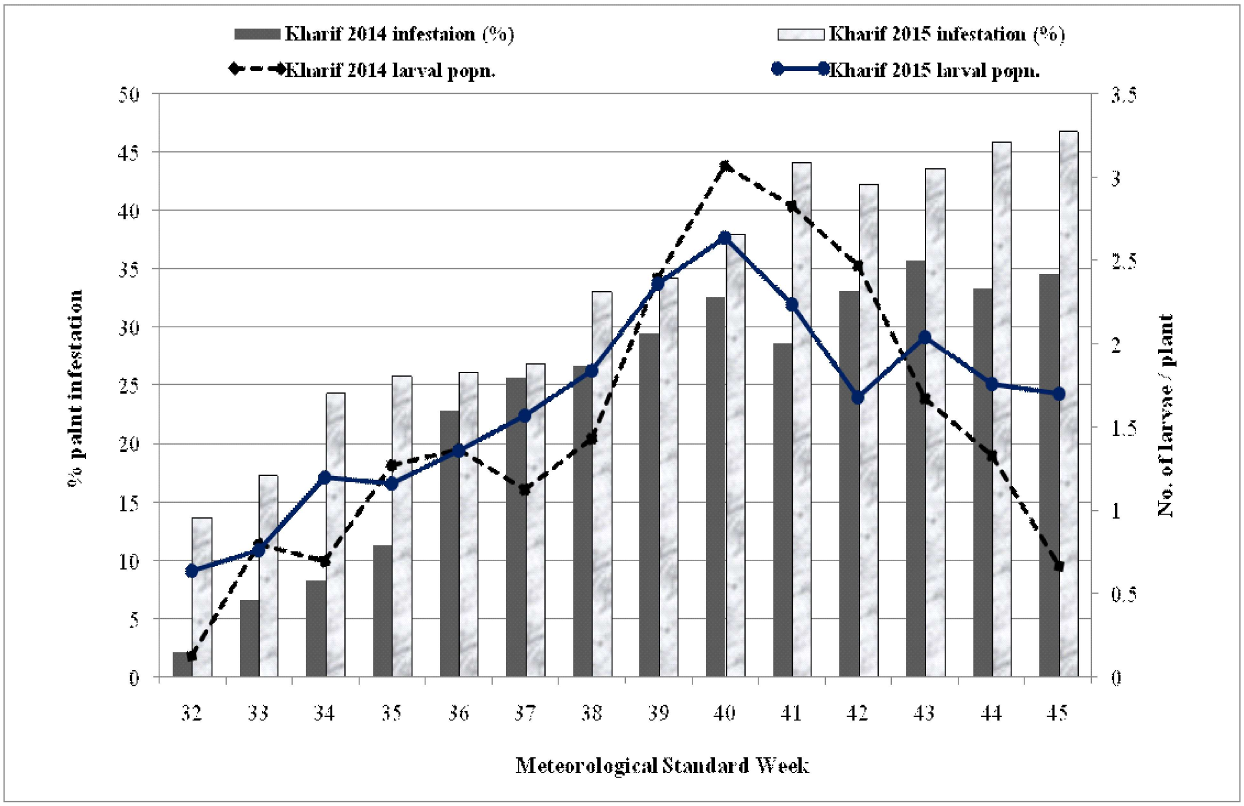

Fig. 2 Incidence of *C. partellus* in maize during *Rabi* 2014-15 and 2015-16

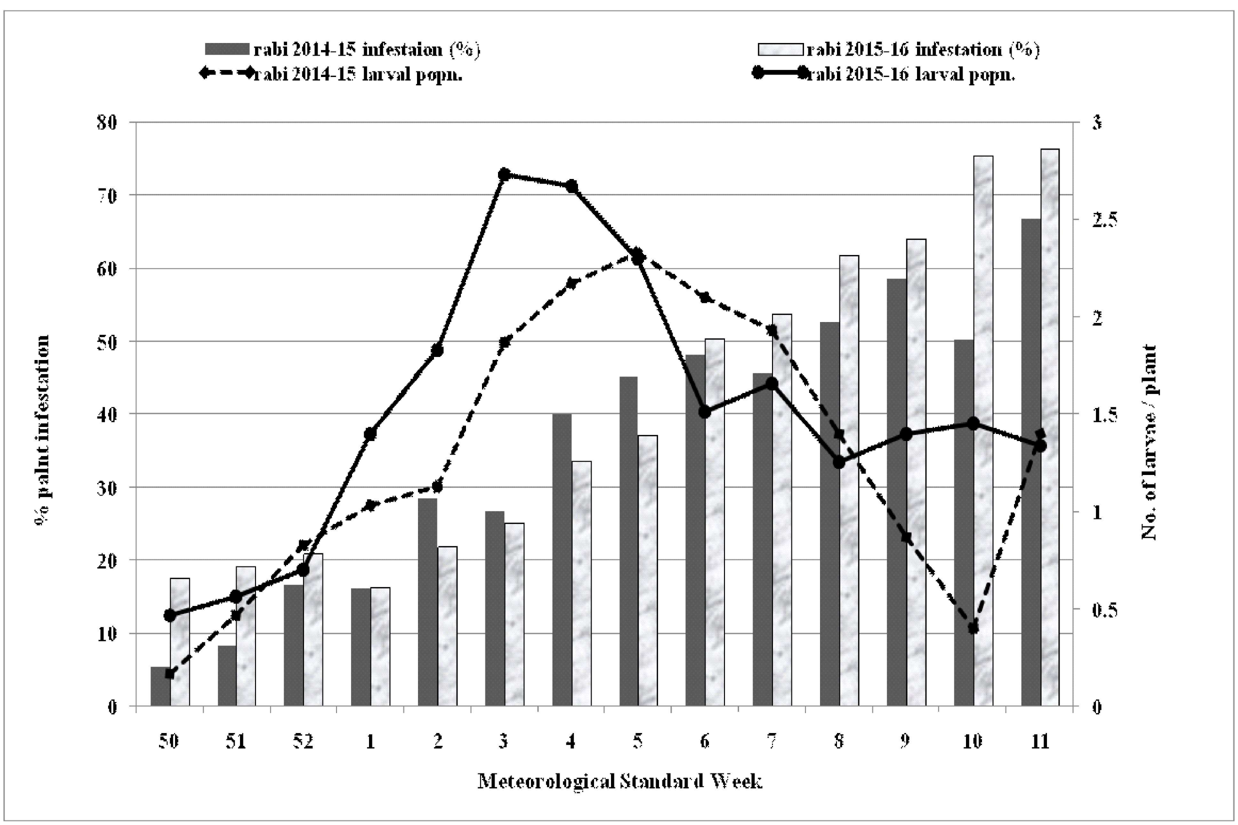

Table 1 Correlation between larval population, plant infestation by *C. partellus* and weather parameters

Year	Correlation coefficient (r) values				
	Max. Temp. (^{o}C)	Min. Temp. (^{o}C)	Morning RH (%)	Evening RH (%)	Rainfall (mm)
C. partellus larval population					
Kharif 2014	-0.146	-0.630*	0.528	0.321	-0.037
Kharif 2015	-0.055	-0.388	0.279	0.575*	-0.555*
Pooled	-0.078	-0.571*	0.507	0.519	-0.478
Rabi 2014-15	-0.059	-0.591*	0.194	-0.054	-0.421
Rabi 2015-16	0.477	-0.316	-0.459	-0.660*	—
Pooled	0.248	-0.480	-0.118	-0.478	-0.273
Plant infestations (%)					
Kharif 2014	-0.072	-0.814*	0.700*	0.410	-0.307
Kharif 2015	-0.321	-0.649*	0.526	0.651*	-0.411
Pooled	-0.340	-0.891*	0.753*	0.639*	-0.531*
Rabi 2014-15	0.736*	-0.036	0.233	-0.684*	0.142
Rabi 2015-16	0.820*	0.766*	-0.006	-0.487	—
Pooled	0.934*	0.484	0.235	-0.747*	0.285

* Significant at $P < 0.05$

Table 2. Multiple linear regression models between larval population of *C. partellus* and weather parameters during *Kharif* 2014, 2015, *Rabi* 2014-15 and 2015-16

Regression equation	Standard Error	Coefficient of Determination (R^2)	Regression equation	Standard Error	Coefficient of Determination (R^2)
Kharif 2014			Rabi 2014-15		
$Y = 2.843 - 0.044 X_1$	0.905	0.023^{NS}	$Y = 1.789 - 0.013 X_1$	0.736	0.004^{NS}
$Y = 7.401 + 0.020 X_1 - 0.276^* X_2$	0.737	0.404^{NS}	$Y = 4.408 + 0.086 X_1 - 0.275^* X_2$	0.581	0.428**
$Y = 4.452 + 0.001 X_1 - 0.202 X_2 + 0.024 X_3$	0.739	0.454^{NS}	$Y = 3.006 + 0.067 X_1 - 0.299^* X_2 + 0.034 X_3$	0.544	0.533**
$Y = 4.559 + 0.001 X_1 - 0.228 X_2 + 0.058 X_3 - 0.036 X_4$	0.728	0.529^{NS}	$Y = 2.387 + 0.097 X_1 - 0.317^* X_2 + 0.022 X_3 + 0.002 X_4$	0.566	0.552^{NS}
$Y = 5.277 + 0.014 X_1 - 0.261 X_2 + 0.059 X_3 - 0.044 X_4 + 0.035 X_5$	0.762	0.536^{NS}	$Y = 0.965 + 0.047 X_1 - 0.216 X_2 + 0.051^* X_3 - 0.012 X_4 - 0.302 X_5$	0.488	0.716**
Kharif 2015			Rabi 2015-16		
$Y = 2.265 - 0.018 X_1$	0.601	0.003^{NS}	$Y = -1.311 + 0.081 X_1$	0.646	0.224^{NS}
$Y = 3.676 + 0.151 X_1 - 0.276 X_2$	0.545	0.241^{NS}	$Y = 1.396 + 0.130^* X_1 - 0.203^* X_2$	0.513	0.547**
$Y = 3.180 + 0.145 X_1 - 0.263 X_2 + 0.002 X_3$	0.577	0.244^{NS}	$Y = 3.535 + 0.113^* X_1 - 0.194^* X_2 - 0.021 X_3$	0.514	0.599**
$Y = -0.405 + 0.079 X_1 - 0.054 X_2 - 0.096^* X_3 + 0.140^* X_4$	0.399	0.675**	$Y = 5.960 + 0.048 X_1 - 0.125 X_2 - 0.028 X_3 - 0.020 X_4$	0.533	0.595^{NS}
$Y = -0.904 + 0.086 X_1 - 0.041 X_2 - 0.105^* X_3 + 0.159^* X_4 + 0.002 X_5$	0.410	0.682**	$Y = 5.960 + 0.048 X_1 - 0.125 X_2 - 0.028 X_3 - 0.020 X_4 + 0.000 X_5$	0.562	0.595^{NS}
Cumulative			Cumulative		
$Y = 2.532 - 0.037 X_1$	0.721	0.009^{NS}	$Y = -0.388 + 0.059 X_1$	0.666	0.064^{NS}
$Y = 5.714 + 0.115 X_1 - 0.317^* X_2$	0.597	0.386^{NS}	$Y = 2.984 + 0.130^* X_1 - 0.280^* X_2$	0.495	0.528**
$Y = 5.161 + 0.106 X_1 - 0.306 X_2 + 0.007 X_3$	0.623	0.384^{NS}	$Y = 2.565 + 0.130^* X_1 - 0.298^* X_2 + 0.007 X_3$	0.527	0.528^{NS}
$Y = 4.997 + 0.110 X_1 - 0.299 X_2 - 0.005 X_3 + 0.012 X_4$	0.653	0.397^{NS}	$Y = 1.220 + 0.189 X_1 - 0.335^* X_2 + 0.006 X_3 + 0.010 X_4$	0.546	0.530^{NS}
$Y = 10.002 + 0.224 X_1 - 0.425 X_2 - 0.070 X_3 + 0.027 X_4 - 0.056 X_5$	0.618	0.523^{NS}	$Y = 1.113 + 0.175 X_1 - 0.290 X_2 + 0.009 X_3 + 0.009 X_4 - 0.241 X_5$	0.549	0.579^{NS}

X_1- Max. Temp.(°C), X_2- Min. Temp.(°C), X_3- Morning RH (%), X_4- Evening RH (%), X_5- Rainfall
NS = Non-significant, * = Significant at 5% level, ** Significant at $P < 0.05$

Table 3. Multiple linear regression models between plant infestation (%) by *C. partellus* and weather parameters during *Kharif* 2014, 2015, *Rabi* 2014-15 and 2015-16

Regression Equation	Standard Error	Coefficient of Determination (R^2)	Regression Equation	Standard Error	Coefficient of Determination (R^2)
Kharif 2014			Rabi 2014-15		
$Y = 32.071 - 0.278 X_1$	12.015	0.009^{NS}	$Y = -131.391 + 5.548^* X_1$	13.750	0.537**
$Y = 114.479 + 0.990 X_1 - 4.972^* X_2$	6.686	0.715**	$Y = -83.427 + 7.333^* X_1 - 4.952^* X_2$	11.109	0.725**
$Y = 65.607 + 0.683 X_1 - 3.850^* X_2 + 0.423 X_3$	6.001	0.799**	$Y = -99.929 + 7.178^* X_1 - 5.265^* X_2 + 0.363 X_3$	11.191	0.746**
$Y = 67.363 + 0.625 X_1 - 4.224^* X_2 + 1.016^* X_3 - 0.691^* X_4$	3.936	0.917^{NS}	$Y = -59.448 + 5.208^* X_1 - 3.763 X_2 + 0.579 X_3 - 0.605 X_4$	9.651	0.828**
$Y = 54.696 + 0.415 X_1 - 3.657^* X_2 + 1.038^* X_3 - 0.589^* X_4 - 0.640 X_5$	3.657	0.937**	$Y = -79.467 + 4.489^* X_1 - 2.307 X_2 + 0.933^* X_3 - 0.898^* X_4 - 4.281 X_5$	8.894	0.871**
Kharif 2015			Rabi 2015-16		
$Y = 99.663 - 2.116 X_1$	10.691	0.106^{NS}	$Y = -115.535 + 4.802^* X_1$	12.894	0.686**
$Y = 130.680 + 1.619 X_1 - 6.119^* X_2$	8.833	0.441**	$Y = -185.428 + 3.572^* X_1 + 5.379^* X_2$	7.574	0.906^{NS}
$Y = 84.100 + 1.465 X_1 - 5.043 X_2 + 0.305 X_3$	8.980	0.476^{NS}	$Y = -238.744 + 3.993^* X_1 + 4.958^* X_2 + 0.570 X_3$	6.745	0.923^{NS}
$Y = 60.757 + 1.016 X_1 - 3.677 X_2 - 0.335 X_3 + 0.910 X_4$	8.983	0.525^{NS}	$Y = -212.902 + 3.188 X_1 + 5.708 X_2 + 0.511 X_3 - .210 X_4$	7.083	0.929^{NS}
$Y = 71.127 + 0.978 X_1 - 3.840 X_2 - 0.218 X_3 + 0.693 X_4 - 0.061 X_5$	9.494	0.537^{NS}	$Y = -212.902 + 3.188 X_1 + 5.708 X_2 + 0.511 X_3 - 0.210 X_4 + 0.000 X_5$	7.508	0.929**
Cumulative			Cumulative		
$Y = 95.794 - 2.178 X_1$	10.726	0.124^{NS}	$Y = -166.819 + 6.546^* X_1$	7.407	0.878^{NS}
$Y = 162.780 + 0.944 X_1 - 6.738^* X_2$	5.214	0.800**	$Y = -175.464 + 6.337^* X_1 + 0.732 X_2$	7.631	0.880^{NS}
$Y = 113.778 + 0.152 X_1 - 5.043^* X_2 + 0.415 X_3$	5.104	0.838**	$Y = -197.581 + 6.339^* X_1 + 0.424 X_2 + 0.357 X_3$	7.808	0.881^{NS}
$Y = 125.611 - 0.147 X_1 - 5.511^* X_2 + 1.206^* X_3 - 0.929^* X_4$	4.214	0.891**	$Y = -142.512 + 4.164 X_1 + 2.344 X_2 + 0.366 X_3 - 0.575 X_4$	7.609	0.906**
$Y = 152.034 + 0.410 X_1 - 6.229^* X_2 + 0.838 X_3 - 0.850 X_4 - 0.272 X_5$	4.116	0.915**	$Y = -143.404 + 4.009 X_1 + 2.723 X_2 + 0.381 X_3 - 0.644 X_4 - 1.993 X_5$	7.927	0.910**

X_1- Max. Temp.(°C), X_2- Min. Temp.(°C), X_3- Morning RH (%), X_4- Evening RH (%), X_5- Rainfall
NS = Non-significant, * = Significant at 5% level, ** Significant at $P < 0.05$

Table 4 Multiple linear regression equations between larval population and plant infestation (%) by *C. partellus*

Season & Year	Correlation for *C. partellus* larvae vs Plant infestation (%)	Regression Equation	Standard Error	Coefficient of Determination (R^2)	t- value	p value
Kharif 2014	0.629*	$0.403 + 0.041*X_1$	0.714	0.382**	2.765	0.011
Kharif 2015	0.765*	$0.292 + 0.045*X_1$	0.392	0.574**	4.057	0.005
Pooled	0.723*	$0.278 + 0.049*X_1$	0.503	0.523**	3.609	0.005
Rabi 2014-15	0.448	$0.703 + 0.011 X_1$	0.659	0.191	1.711	0.117
Rabi 2015-16	0.060	$1.440 + 0.009 X_1$	0.721	0.009	0.217	0.835
Pooled	0.259	$1.081 + 0.003 X_1$	0.665	0.064	0.910	0.371

X_1- Plant infestation (%)
* = Significant at 5% level
** Significant at P < 0.05

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