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Influence of weather factors on insect and mite pests infesting French bean (*Phaseolus vulgaris* L.), Assam, India

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ABSTRACT

A field experiment was carried out in the Integrated Crop Research (ICR) farm, Assam Agricultural University, Jorhat to determine the impact of weather parameters on insect and mite pests infesting French bean (*Phaseolus vulgaris* L.) during 2013-14 and 2014-15. The weather parameters had a significant impact on population build up of various French bean crop pests. Cutworm population found to be positive and significant correlation with morning relative humidity (r=0.573) during 2014-15 while aphid showed a positive significant correlation with maximum temperature (r=0.555) and BSSH (r=0.671) but negative with relative humidity (r= -0.562*) in 2013-14. Two spotted spider mite (TSSM) population showed a positive significant correlation with morning relative humidity (r = 0.661* and r=0.617*) in both the years and negative correlation with maximum temperature (r=0.603 and r=559) in 2013-14 and 2014-15, respectively. A negative significant correlation with maximum temperature (r=706) and positive correlation with relative humidity (r=568) with pod borer population during 2013-14. The rain fall (r=589) had a negative significant correlation with Thrips population during 2013-14. Whitefly population found to be negative significant correlation with maximum temperature (r=554 and r=553) and positive correlation with morning relative humidity (r=605 and r=674) in 2013-14 and 2014-15, respectively. This present findings will certainly be a helpful tool for profitable cultivation of French bean crop by forecasting insect and mite pests arrival as well as management point of view.

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INTRODUCTION

French bean is quite nutritious and potential source of protein carbohydrates and minerals. The mineral matter, crude fibre and ether extract are concentrated in seed while crude protein and energy are stored in the cotyledons. French bean is grown in different parts of the world for its mature dry seeds, immature/tender green or yellow pods (snap bean) and for its leaves (in Africa and Asia) to be used as vegetable. The dry seeds can also be canned and exported. In India, French bean covers an area of 2.3 million hectare with production of 1.1 million tones and productivity of 478kg ha^{-1} (Anonymous, 2005). While its cultivation is mainly restricted to hilly region of north India, its consumption is more in the plains of north and central India, where 'its demand is not fully met. The main French bean growing states in India are Maharashtra, Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Tamil Nadu (Nilgiri), Kerala (Palni hills), Karnataka (Chickmangalur) and West Bengal (Darjeeling hills) (Prasad, 2007). Recently its cultivation has been extended to northern plain zone. Chandra and Ali (1986) exploited the feasibility of growing rajmah as a potential *Rabi* crop in the plains of north India. Introduction of this non-traditional crop to north eastern plains of India as a winter crop has generated lot of interest in the farming community due to its higher productivity and responsiveness to inputs. Since it is a short duration (85-90 days) crop, it can very well fit as a component of intercropping and sequence cropping in many of the agro-climatic zones. During the last decades French bean is becoming increasingly important as a cash crop in India. It has a large export potential (Abdel- Mawgoud *et al*., 2005).

The main cultivated district of Assam is Dhubri, Borpeta, Darrang, some pockets of Kokrajhar and Barak Valley including Karimganj (Anonymous, 2014).

About 30 species of insects have been reported damaging French bean crop (Srivastava and Butani, 1998). Among the major pests reported elsewhere for beans are the bean seed fly (*Delia platura*), bean flies (*Ophiomyia* spp.), cutworms (*Agrotis* spp.), aphids (*Aphis craccivora* and *A. fabae*), leafminers (*Liriomyza* spp.), spider mites (*Tetranychus* spp.), whiteflies (*Bemisia tabaci*) and the pod borer (*Helicoverpa armigera*) (Allen *et al*., 1996). Thrips are the most important pest of French beans at flowering and harvesting (Nderitu *et al*., 2010 and Nyasani *et al*., 2012). Losses of more than 60 per cent have been reported on the marketable pods as a result of thrips damage (Nderitu *et al*., 2009). Two spotted spider mites attack French beans at seedling to maturity levels, other pests that attack French beans at different growth stages include white flies, pod borers and leaf miners (Lohr, 2006). These insect and mite pests French bean are the major constrains for getting a optimum production and profitable income among the farmers. Therefore, the present investigation was conducted to find out the impact of weather parameters on population build up of these pests on French bean crop so that proper management practices can be carried out against French bean pests complex.

MATERIAL AND METHODS

The materials used and methodology adopted for conducting the experiment is presented here.

Experimental site :

The study area is situated at 26.75°N and 94.22°E and has an average elevation of 116 meters (381ft.). The area comes under semi-arid region with summer temperature 25°-35°C and winter temperature 10°-22°C. The weather data were collected from Department of Agricultural Meteorology, Assam Agricultral University, Jorhat, Assam during the study period.

In order to study the population fluctuation of insect and mite pests in French bean, the crop was sown at the ICR Farm, Assam Agricultural University, Jorhat during the season of 2013-14 and 2014-15. A plot of measuring 15 sqm. (5m×3m) net area was taken for the purpose and replicated three times. Seeds were sown at a spacing of 20cm (plant to plant) × 30cm (row to row) distance. All other post-sowing recommended agronomical practices except plant protection were followed to raise the crop.

All the insect and mite pests was recorded at weekly interval starting from 15 days after germination and continued till harvest of the crop by following the standard procedure. Aphid, *A. craccivora* population was recorded on ten randomly selected twigs by following the procedure of Banerjee and Pramanik (1964) with little modification where from each tagged plant, mean number of aphids per 5 cm twig was worked out. Thrips, *Scirtothrips dorsalis* population was assessed from randomly selecting ten plants on each plot by following the procedure described by Nderitu *et al*. (2010). In case of two spotted spider mite (TSSM), *Tetranychus urticae* population of mite per leaf was recorded from every tagged plant. The mean values of each pest for respective week were calculated and the data obtained was presented in tabular form.

The influence of various weather parameters on abundance of insect and mite pests in French bean, data on various weather parameters recorded at the weather observatory, Assam Agricultural University, Jorhat was collected and correlated with the population of insect and mite pests.

Statistical analysis :

The experiment was conducted in a Randomized Block Design (RBD) with three replications and collected data were correlated by using SPSS-16 computer based software.

Correlation studies :

A simple correlation analysis was made between the mean population of insect and mite pest and weather factors like temperature (maximum and minimum), relative humidity (morning and evening), total rainfall and bright sunshine hours. To calculate correlation co-efficient (r) the following standard statistical formula was adopted.

$$r = \frac{\sum xy \frac{\sum x \sum y}{N}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{N}\right)\left(\sum y^2 - \frac{(\sum y)^2}{N}\right)}}$$

where,

r = Co-efficient of correlation

N = Number of observation

x = Mean population

y = Independent variables.

Then the correlation co-efficient (r) was tested for significant or non-significance by Fisher 't' which is defined as follows:

$$t = \frac{r}{\sqrt{(1-r^2)}} \text{ X } \sqrt{n-2} \text{ with (n-2) d.f.}$$

For correlation studies, weekly average values of the environmental factors were taken into consideration to know their influence on the insect and mite pest population.

Simple regression analysis :

Simple regression analysis line was fitted to know the impact of independent variables (weather factors) on the dependent variable (pest population).

The regression line was given by the equation:

$$Y = a + bx$$

where,

Y = Dependent variable

x = Independent variable

a = Intercept.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads:

Correlation of major insect and mite pests with the weather parameters :

Simple correlation studies were carried out between the population of the major insect pest and two spotted spider mite with weather parameters *viz.*, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall (RF) and bright sunshine hours (BSSH) during 2013-14 and 2014-15 (Table 1).

The co-efficients of correlation studies are presented in Table 1. The data indicated that population build up of cutworm showed non-significant negative correlation with maximum temperature (r=-0.193), minimum temperature (r=-0.206), evening relative humidity (r=-0.213) and rainfall (r=-0.324). Morning relative humidity (r=0.135) and bright sunshine hours

Table 1 : Correlation of insect and mite pests population in french bean crop with weather parameters

Insect and mite pests	Weather parameters											
	Temp. max. (°C)		Temp. min. (°C)		Morning RH (%)		Evening RH (%)		Av. RF (mm)		BSSH (hrs/day)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Cutworm	-0.193	-0.288	-0.206	-0.119	0.135	0.573*	-0.213	0.189	-0.324	-0.273	0.026	-0.313
Aphid	0.555*	0.167	0.251	0.056	-0.562*	-0.378	-0.502	-0.013	-0.427	-0.001	0.671*	0.066
TSSM	-0.603*	-0.559*	-0.471	-0.432	0.661*	0.617*	0.265	-0.080	-0.298	-0.431	-0.347	-0.469
Pod borer	-0.706*	-0.489	-0.480	-0.368	0.568*	0.553*	0.282	-0.177	-0.226	-0.178	-0.534	-0.258
Thrips	0.179	0.153	-0.071	-0.099	-0.046	-0.123	-0.348	-0.132	-0.589*	-0.065	0.295	0.062
Whitefly	-0.554*	-0.553*	-0.356	-0.313	0.605*	0.674*	0.314	0.095	-0.251	-0.374	-0.342	-0.456

* Significant at 5 per cent level (r=0.55)

(r=0.026) had positively correlated with weather parameters and was not significant during 2013-14. However, population build up cutworm had significant positive correlation with morning relative humidity (r=0.573*) and positive non-significant with evening relative humidity (r=0.189). Whereas a non-significant negative correlation with maximum temperature (r=-0.288), minimum temperature (r=-0.119), bright sunshine hours (-0.313) and rainfall (r=-0.273) during 2014-15 (Table 1). Thus, there was a significant impact of these factors on the population build up of cutworm and these weather parameters suppress the growth and development of the pest. This finding was in conformity with the result of Selvaraj *et al.* (2010) who reported that cutworm population had positive correlation with morning relative humidity and bright sunshine hours where as maximum temperature, minimum temperature, evening relative humidity and rainfall had a non-significant and negative impact on cut worm population in cotton. Similar to the present findings, Zag and Kushwaha (1983) reported that the population of *Spodoptera litura* had negatively correlated with maximum temperature in cabbage crop. The minimum temperature and evening relative humidity showed negative and non-significant association with *S. litura* infesting castor crop (Thanki *et al.*, 2003) confirmed this present result. The finding is also in conformity with that the minimum temperature, evening relative humidity and rainfall exhibited non-significant and negative relationship with population of *S. litura* in onion crop (Sailaja *et al.*, 2006).

The results revealed that maximum temperature (r=0.555*) and bright sunshine hours (BSSH) (r=0.671*) showed significant positive association with the aphid population, while morning relative humidity (r= -0.562*) manifested significant negative correlation and rain fall (r=-0.427) as well as evening relative humidity (r= -0.502) exhibited non-significant negative correlation with aphid population during 2013-14 (Table 1). During 2014-15, maximum temperature (r=0.167) and bright sunshine hours (BSSH) (r=0.066) showed non-significant positive association with the aphid population, while morning relative humidity (r= -0.378) and rainfall (r= -0.001) manifested non-significant negative correlation with aphid population.

This indicated that an increase in maximum temperature and bright sunshine hours leads to increase in aphid population whereas aphid population decreases with high morning relative humidity. Similar to the present finding, Nasir and Ahmed (2001) reported that maximum and minimum temperature had a positive correlation in causing fluctuation in aphid population. Such observation was also made by Aheer *et al.* (2008) and Tomar (2010) who found significant positive correlation between aphid population density and maximum temperature. Similarly, Wains *et al.* (2010) also reported a positive correlation of aphid population with maximum temperature and a negative correlation with relative humidity in bread wheat. Again there is a non-significant negative correlation was observed in rainfall (r=-0.427) and evening relative humidity (r=-0.502) with aphids population. Similarly, Wains *et al.* (2008) also reported a negative correlation with rainfall in bread wheat.

Maximum temperature had significant negative influence on the TSSM population (r=-0.603* and r=-0.559*), while minimum temperature, BSSH and average rainfall showed non-significant negative correlation with weather parameters (r = -0.471 and r=-0.469, r = -0.347 and r=-0.347, r =-0.298 and r=-0.431), respectively for both the period. Morning relative humidity and evening relative humidity exerted significant (r = 0.661* and r=0.617*) and non-significant (r = 0.265 and r=0.080) positive correlation with TSSM population during 2013-14 and 2014-15, respectively. This shows the significant impact of temperature in the mite population where the mite population decreases with the increase in temperature. Similar results were reported by Pathipati *et al.* (2014) in chilli. A significantly positive correlation was observed between mite and the morning relative humidity (r=0.661*, r=0.617*) during 2013-14 and 2014-15, respectively which showed that the mite population increases under high humid condition and tends to increase under high humidity. The present findings conformity by the report of Hole and Salunkhe (1997) that *T. urticae* had a significant positive correlation with the relative humidity. However, a non-significant negative correlation was observed between the TSS mite population and rainfall (r=-0.298, r=-0.431), minimum temperature (r=-0.471, r=-0.432) and bright sunshine hours (r=-0.347, r=-0.469) during 2013-14 and 2014-15, respectively which indicates that increase in these parameters would lead to decrease in the mite population. Meena *et al.* (2012) also reported that rainfall had a non-significant negative relation with the *T. urticae* population.

Relationship between thrips population and weather parameters indicated that none of the parameter found playing significant role in build up of the thrips population accept rainfall with significant negative correlation co-efficient (0.-589*). The result revealed that thrips population and weather parameters indicated that maximum temperature and bright sunshine hours had a non-significant but positive correlation (r=0.153 and r=0.062, respectively) in buildup of the thrips population. Whereas minimum temperature, morning relative humidity, evening relative humidity and rainfall showed non-significant negative correlation (r=-0.099, r=-0.123, r =-0.132 and r=-0.065, respectively) with thrips population during 2014-15. This indicated that population build up of thrips was adversely affected by rainfall but increase temperature favoured the growth and development. The reports of Patel *et al.* (2009) regarding negative relationship between thrips population and relative humidity supported the results of present investigation. This pattern of relationship was also reported by Meena *et al*. (2013). Similar results were also reported by Vanisree *et al*. (2011).

The effect of the weather factors and pod borer population revealed that a significant positive correlation existed with morning relative humidity (r=0.568* and r=0.553*) for both the period and significant negative correlation was recorded with maximum temperature (r=-0.706*), whereas non-significant negative correlation was recorded with minimum temperature (r=-0.480 and r= -0.368) rainfall (r=-0.226 and r=-0.178) and bright sunshine hours (r=-0.534 and r=-0.258) during 2013-14 and 2014-15, respectively. This finding are in accordance with the results obtained by Pathipati *et al.* (2014) that maximum temperature, minimum temperature, rainfall and morning relative humidity has a negative correlation with pod borer population whereas morning relative humidity has positive correlation with pod borer population in chilli.

Maximum temperature showed a significant negative correlation (r= -0.554* and r= -0.553*) with population of whitefly during 2013-14 and 2014-15, respectively. Morning relative humidity exhibited significant positive correlation (r=0.605* and r=0.674*), whereas minimum temperature (r= -0.356 and r= -0.313), rainfall (r= -0.251 and r= -0.374) and Sunshine hours (r= -0.342 and r= -0.456) had non-significant and negative correlation with whitefly. Evening relative humidity showed non-significant (r =0.314 and r=0.095), but positive influence on whitefly population, respectively for both the period. This result is in conformity with the report of Jakhar and Chaudhary (2013) that maximum temperature had significant negative correlation and relative humidity had significant positive correlation with whitefly population whereas minimum temperature and bright sunshine hours had non-significant and negative correlation with whitefly population build up in French bean. Patel *et al*. (2010) also reported that bright sunshine hour had a non-significant negative correlation with whitefly population in cowpea.

Regression studies of different pests population with weather factors :

The analysis of the significant relationship between the pest population and weather factors were performed by taking the mean values of pest population and weekly average of various weather factors *viz*., temperature (maximum and minimum), relative humidity (morning and evening), rainfall and bright sunshine hours, to draw the simple linear regression lines.

The relationship between morning relative humidity and cutworm was found to be significant with correlation co-efficient (r=0.573*) and regression co-efficient (R^2=0.328) in an increasing tendency during 2014-15 and can be expressed by Y=-11.92+0.1492x that is the magnitude of the relationship (Fig.1).

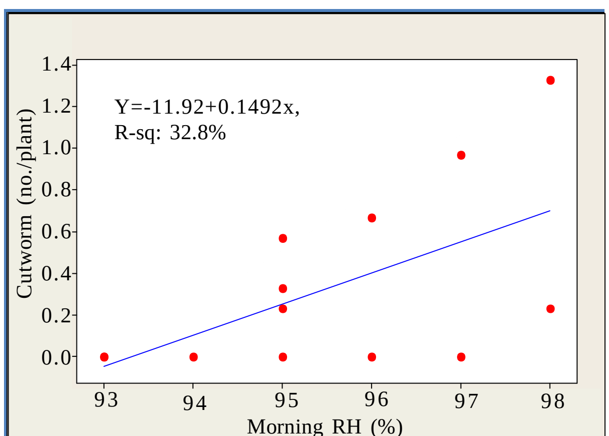

Fig. 1 : Relationship of cutworm with morning relative humidity (%), 2014-15

Maximum temperature displayed an increasing trend in aphid population with regression co-efficient (R^2

= 0.308) along with statistically significant correlation co-efficient (r = 0.555*) and can be expressed by Y= -2.561 + 0.1217x. Bright sunshine hours also displayed a significant and positive correlation (r=0.671*) on aphid population with an increasing tendency (R^2=0.450) and the expression of the relationship was Y=- 0.2539 + 0.1673 x. On the other hand, morning relative humidity revealed a very strong opposite trend to aphid population

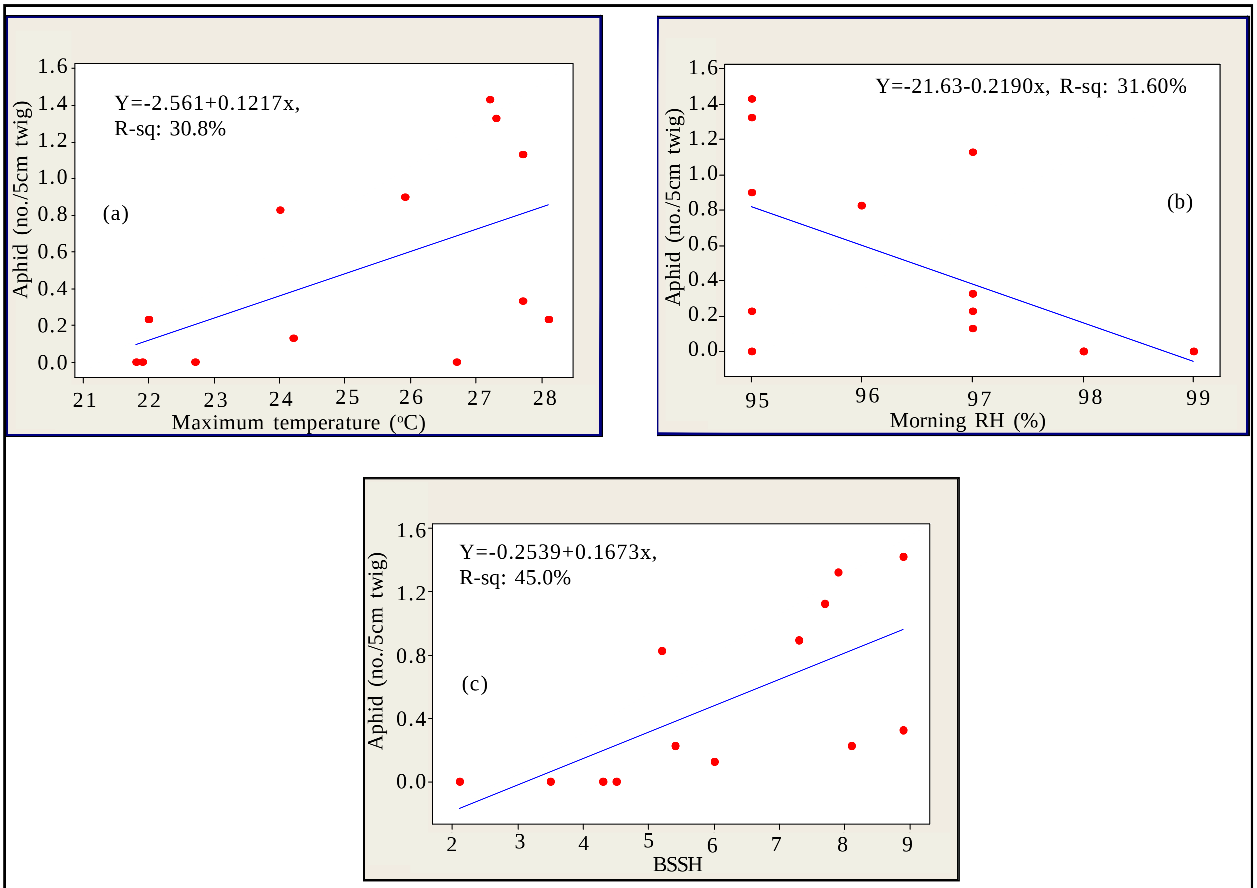

Fig. 2 (a-c): Relationship of aphid with maximum temperature (°C), morning relative humidity (%) and BSSH (hrs/day), 2013-14

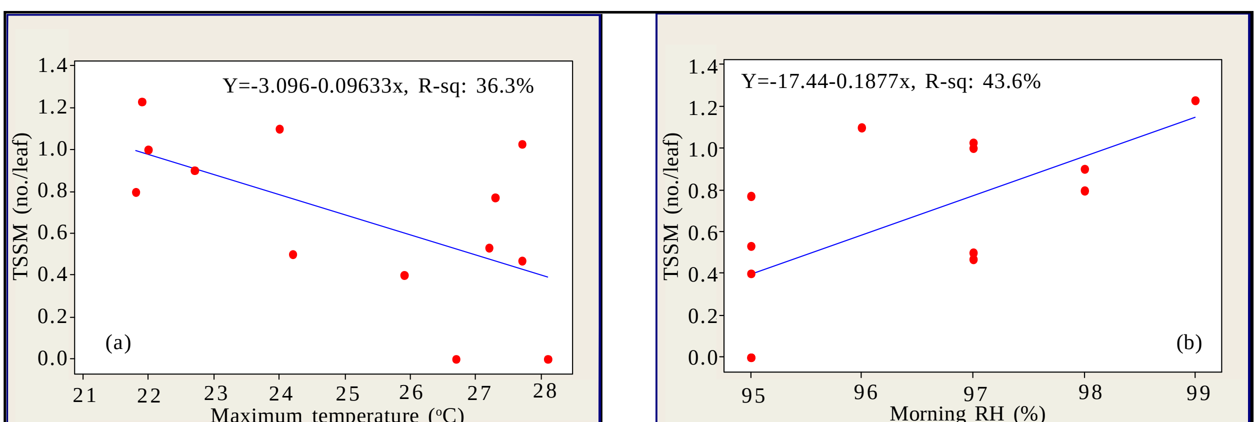

Fig. 3 (a and b) : Relationship of two spotted spider mite with maximum temperature (°C) and morning relative humidity (%), 2013-14

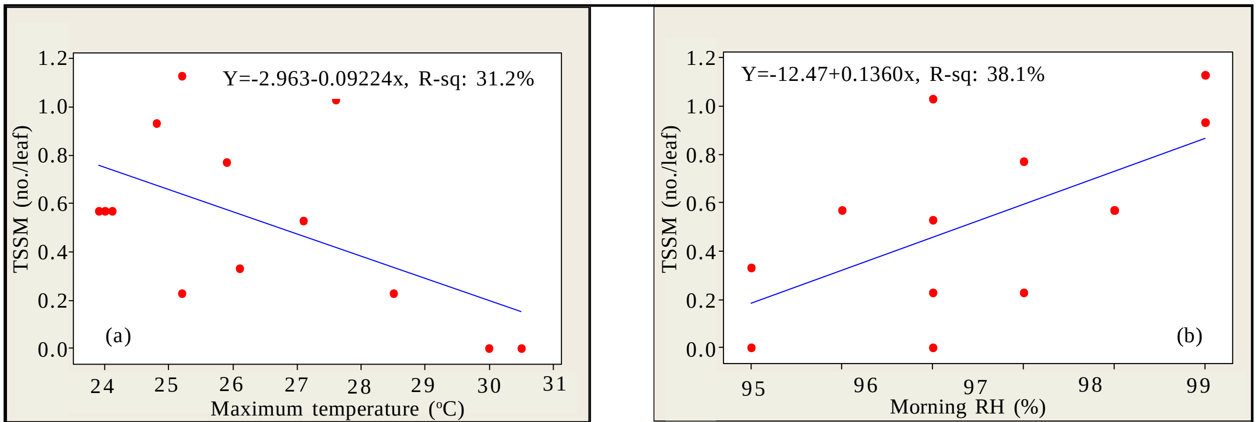

Fig. 4 (a and b) : Relationship of two spotted spider mite with maximum temperature (°C) and morning relative humidity (%), 2014-15

(R^2=0.316) which was soundly confirmed by a significant negative correlation co-efficient (r=-0.562*) and expressed by Y= 21.63- 0.2190x (Fig. 2 a and c) during 2013-14.

A statistically significant positive correlation co-efficient (r=0.661*) and regression co-efficient (R^2= 0.436) of morning relative humidity with TSSM population was achieved and can be expressed by Y=-17.44-0.1877x during 2013-14. Maximum temperature revealed a strong positive trend to TSSM population (R^2=0.363) which was soundly confirmed by a significant negative correlation co-efficient (r=-0.603*) and can be expressed by Y= 3.096- 0.09633x (Fig.3 a and b).

Morning relative humidity had statistically significant positive correlation co-efficient (r=0.617*) and regression co-efficient (R^2=0.381) with TSSM population and can be expressed by Y=12.47+0.1360 x during 2014-15. However, Maximum temperature revealed a strong positive trend to TSSM population (R^2=0.312) which was soundly confirmed by a significant negative correlation co-efficient (r=-0.559*) and can be expressed by Y=2.963-0.09224x (Fig.4a and b). This expressed the magnitude of this association.

The relationship between rainfall and thrips was found to be significant, negative and linear (r= -0.589). The regression of thrips population could be expressed by the equation Y= 0.5690- 0.1117x with regression co-efficient (R^2) was 0.347 that expressed magnitude of this association (Fig. 5).

The regression equation Y=-14.18+0.1495x and Y=-11.90+0.1270x fitted to pod borer damage and morning relative humidity in 2013-14 and 2014-15, respectively

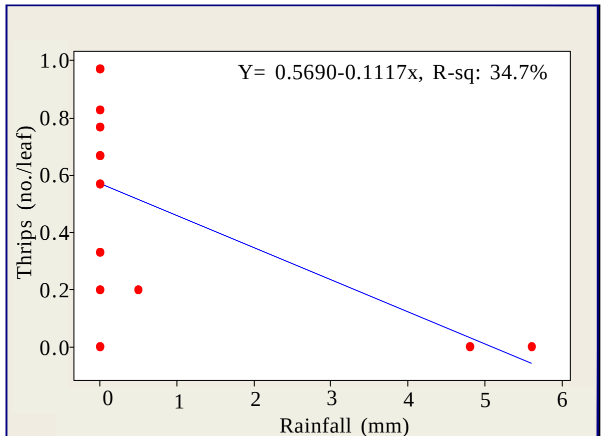

Fig. 5 : Relationship of thrips with rainfall (mm), 2013-14

(Fig. 6b and Fig.7). The co-efficient of determination (R^2) were 0.322 and 0.306 showing thereby that as much as 32.2 per cent and 30.6 per cent variation in the pod borer population during 2013-14 and 2014-15, respectively were due to the effect of morning relative humidity. Whereas maximum temperature had a significant negative correlation (r=-0.706*) and regression co-efficient (R^2) was 0.498 with pod borer which indicates 49.8 per cent variation in the population of pod borer and can be expressed as Y = 2.866 - 0.1046 x (Fig. 6a).

Morning relative humidity had statistically significant positive correlation co-efficient (r=0.605* and r=0.674**) and regression co-efficient (R^2=0.365 and R^2=0.454) with whitefly population and can be expressed by Y=-18.38+0.1966 x and Y=-15.40+0.1667x for the year 2013-14 and 2014-15, respectively (Fig. 8b and 9b). On the other hand, Maximum temperature revealed a very

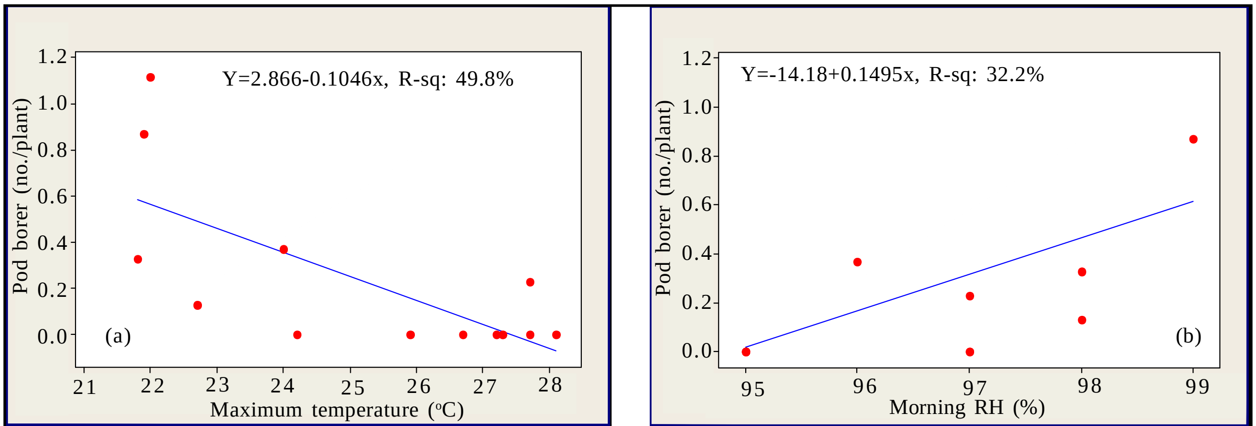

Fig. 6 (a and b) : **Relationship of pod borer with maximum temperature (^{0}C) (a) and morning relative humidity (%) (b), 2013-14**

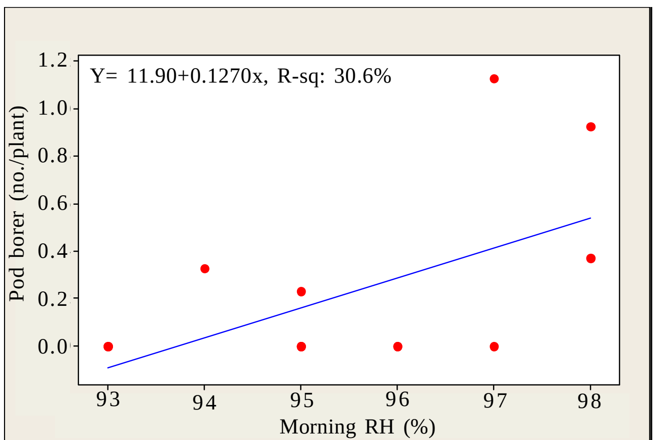

Fig. 7 : **Relationship of pod borer with morning relative humidity (%), 2014-15**

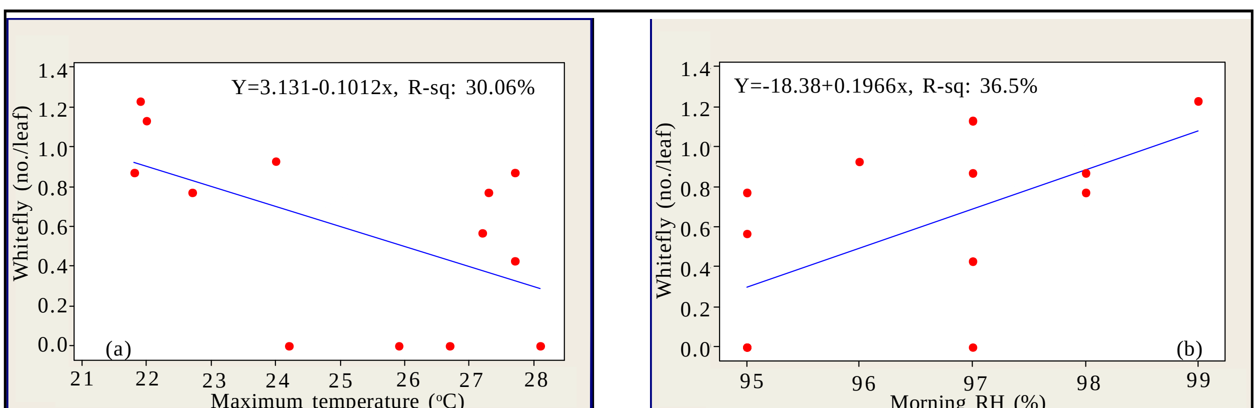

Fig. 8 (a and b) : **Relationship of whitefly with maximum temperature (^{0}C) and morning relative humidity (%), 2013-2014**

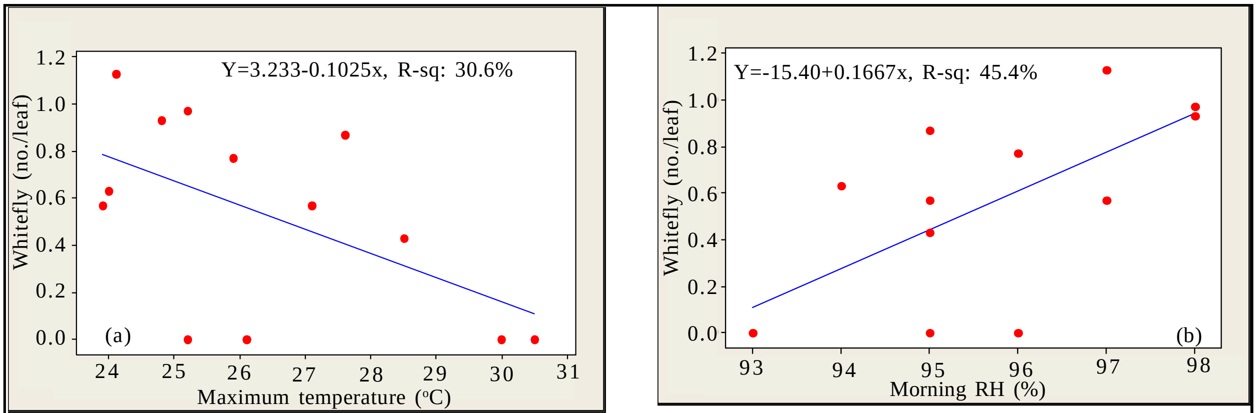

Fig. 9 (a and b) : Relationship of whitefly with maximum temperature (°C) and morning relative humidity (%) 2014-15

strong positive trend to whitefly population (R^2=0.301 and R^2=0.306) which was soundly confirmed by a significant negative correlation co-efficient (r=-0.554* and r=-0.553*) and can be expressed by Y= 3.131-0.1012 x and Y=3.233-0.1025x in the year 2013-14 and 2014-15, respectively (Fig. 8a and 9a). This expressed the magnitude of this association.

Conclusion :

It can be concluded that the present correlation studies between weather parameters and population of French bean insect and mite pests complex varied with different degree of relationship and these parameters had a great influence on population build up of these pests. The regression study indicated the strength of relationship between certain insect pest and weather factors. The present findings could be tools for insect and mite pests forecasting well in advance and management point of view.

REFERENCES

Abdel-Mawgoud, A.M.R., El- Desuki, M., Salman, S.R. and Abo-Hussein, S.D. (2005). Performance of some snap bean varieties as affected by different levels of mineral fertilizers. *J. Agron.*, **4**(3): 242-247.

Aheer, G.M., Ali, A. and Munir, M. (2008). Abiotic factors effect on population fluctuation of alate aphids in wheat. *J. Agric. Res.*, **46**(4): 367–371.

Allen, D.J., Ampofo, J.K.O. and Wortmann, C.S. (1996). *Pests, diseases and nutritional disorders of the common bean in Africa*. A field Guide. A CIAT/CTA Publication, (ISBN: 958 9439 55 1).

Anonymous (2005). *Annual report*, Directorate of statistics and Economics. Government of India.

Anonymous (2014). *Annual report* 2013-14, Deptt of Agriculture, Hailakandi, Assam. pp. 8.

Banerjee, S.N. and Pramanik, L.M. (1964). Field experiments on the control of mustard aphid, *Lipaphis erysimi* (Kalt.) in West Bengal. *Indian Oilseed J.*, **8**(2): 116-118.

Chandra, S. and Ali, M. (1986). *Technical Bulletin* No.1. Directorate of Pulses Research, Kanpur, pp.14-15.

Hole, U.B. and Salunkhe, G.N. (1997). Incidence of mites in relation to meteorological parameters on rose. *J. Maharashtra Agril. Univ.*, **22**(2): 226-230.

Jakhar, B.L. and Chaudhary, F.K. (2013). Influence of abiotic factors on incidence of sucking pest in French bean. *AGRES.*, **2**(1): 68-71.

Lohr, B. (2006). *High value crops research and development: The ICIPE experience*. International Centre of Insect Physiology and Ecology, Nairobi, Kenya.

Meena, N.K., Pant, R.P. and Medhi, R.P. (2012). Evaluation of insecticides and biopesticides for the management of two spotted spider mite, *Tetranychus urticae* in orchid (*Cymbidium* H. C. Aurora). *Pestology*, **36**(10): 40-45.

Meena, N.K., Barman, R.D. and Medhi, R.P. (2013). Biology and seasonal abundance of the two-spotted spider mite, *Tetranychus urticae*, on orchids and rose. *Phytoparasitica*, **41**: 597-609.

Nasir, S. and Ahmad, F. (2001). Correlation between wheat aphid population and abiotic factors. *Pak. Entomol.*, **23**(1): 23-25.

Nderitu, J.H., Mwangi, F., Nyamasyo, G. and Kasina, M. (2009). Evaluation of cropping systems as a strategy for managing snap bean flower thrips in Kenya. *Internat. J. Sustain. Crop Produc.*, **4**(6): 22-25.

Nderitu, J.H., Mwangi, F., Nyamasyo, G. and Kasina, M. (2010). Utilization of synthetic and botanical insecticides to manage thrips (Thysan.: Thrip.) on snap beans (Fabaceae) in Kenya. *Internat. J. Sustain. Crop Produc.*, **5**(1):1-4.

Nyasani, J.O., Meyhofer, R., Subramanian, S. and Poehling, H.M. (2012). Feeding and oviposition preference of *Frankliniella occidentalis* for crops and weeds in Kenyan French beans fields. *J. Appl. Entomol.*, **137**: 204-213.

Patel, B.H., Koshiya, D.J. and Korat, D.M. (2009). Population dynamics of chilli thrips, *Scirtothrips dorsalis* Hood in relation to weather parameters. *Karnataka J. Agric. Sci.*, **22** (1): 108-110.

Patel, S.K., Patel, B.H., Korat, D.M. and Dabhi, M.R. (2010). Seasonal incidence of major insect pests of cowpea, *Vigna unguiculata* (Linn.) Walpers in relation to weather parameters. *Karnataka J. Agril. Sci*., **23**: 497-499.

Pathipati, V.L., Vijayalakshmi, T. and Naram Naidu, L. (2014). Seasonal incidence of major insect pests of chilli in relation to weather parameters in Andhra Pradesh. *Pest Manag. Hort. Ecosyst.*, **20**(1): 36-40.

Prasad, K. (2007). Studies on two spotted red spider mite, *Tetranychus urticae* (Acari: Tetranychidae) on carnation. *J. Acarol.*, **16**(1-2): 55-56.

Sailaja Rani, Z., Subba Rao, D.V., Arjuna Rao, P., Madhumati, T. and Srinivasa Rao, V. (2006). Effect of weather parameters on the population dynamics of *Spodoptera litura* (F.) and *Spodoptera exigua* (Hb.) on onion. *Andhra Agric. J.*, **53**: 1- 2.

Selvaraj, S., Adiroubane, D., Ramesh, V. and Narayanan, A. L. (2010). Impact of ecological factors on incidence and development of tobacco cut worm, *Spodoptera litura* Fabricius on cotton. *J. Biopesticides*, **3**(1): 43-46.

Srivastava, K.P. and Butani, D.K. (1998). *Pest management in vegetables* (Part-I), Published by Research Periodicals and Book Publishing House, P.O. Box 720728, Houston, Texas-77272, USA.

Thanki, K.V., Patel, G.P. and Patel, J.R. (2003). Population dynamics of *Spodoptera litura* on castor, *Ricinus communis. Indian J. Entomol.*, **65** (3): 347- 350.

Tomar, S.P.S. (2010). Impact of weather parameters on aphid population in cotton. *Indian J. Agric. Res.*, **44**(2): 125-130.

Vanisree, K., Rajashekar, P., Ramachandar, Rao G. and Srinivasa, Rao. V. (2011). Seasonal incidence of thrips and its natural enemies on chilli (*Capsicum annuum* L.) in Andhra Pradesh. *Andhra Agric. J.*, **58** (2): 185-191.

Wains, M.S., Rehman, Aziz-ur., Latif, M. and Hussain, M. (2008). Aphid dynamics in wheat as affected by weather and crop planting time. *J. Agric. Res.*, **46**(4): 361–366.

Wains, M.S., Ali, M.A., Hussain, M., Anwar, J., Zulkiffal, M. and Sabir, W. (2010). Aphid dynamics in relation to meteorological factors and various management practices in bread wheat. *J. Plant Protec. Res.*, **50**(3): 385- 392.

Zag, G.M. and Kushwaha, K.S. (1983). Quantitative incidence of tobacco caterpillar, *Spodoptera litura* and related natural enemies in Cole crops. *Indian J. Entomol.*, **45**: 201-202.