



Validation of weather based forewarning model for *Helicoverpa armigera* in chickpea

D SAGAR¹, SURESH M NEBAPURE² and SUBHASH CHANDER³

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

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Integrated Pest Management (IPM) programme aims at judicious use of resources to achieve eco-friendly and economically affordable pest management programs. The prevention of pest population built up is one of the main approach, in such type of programs, where monitoring of insect pests plays very crucial role. Monitoring is indispensable in any pest management practice as it helps in efficient use of pest management inputs. Besides, pest forewarning, it facilitates timely preparedness for pest suppression. Chickpea (*Cicer arietinum* L.) is the second most important pulse crop grown globally on an area of 14 million ha across 55 countries. India is the largest producer of chickpea with a share of about 70% in area and 67% in production in the world (Dixit *et al.* 2017). In India, the area under chickpea was 8.39 million ha with a production of 7.06 million tonnes and productivity of 840 kg/ha during *rabi* 2015–16 (Anon 2017). *Helicoverpa armigera* (Hubner) is a polyphagous insect pest of many agricultural and horticultural crops across world because of its high fecundity, migratory behaviour, high adaptation to various climatic conditions and development of resistance towards wide range of insecticides (Fitt 1989). Even though *H. armigera* is a polyphagous insect pest but chickpea is the most preferred host (Tripathi and Sharma 1985). In chickpea, *H. armigera* causes loss ranging from 10–80% in terms of pod damage (Yelshetty and Sidde Gowda 1998). The study of population dynamics of the pest is important for the effective management of the pest population. Prevailing climatic conditions are known to affect the life cycle of *H. armigera* thereby affecting its distribution and abundance and also its natural enemies (Singh *et al.* 2015) in a given season at particular location.

Weather factors such as temperature, rainfall and relative humidity greatly influence the insect pest population

(Siswanto *et al.* 2008). Understanding the pest-weather relationship is of paramount importance for effective pest suppression (Das *et al.* 2008). Timely forewarning of insect-pest population would certainly be useful for determining insecticide budget, or making strategic decision (Kumar *et al.* 2018). So, there is a need to develop and validate forewarning systems, which can provide advance information for outbreak of the pest. In this context, the present investigation was undertaken to study the dynamics of *H. armigera* trap catches in chickpea and utilize them in validating the earlier developed forewarning model for *H. armigera*.

The experiment was conducted at the research farm of ICAR- Indian Agricultural Research Institute, New Delhi (28.08° N, 77.12° E, 228.61 MSL) during *rabi* 2017–18. The chickpea was sown during 47th standard meteorological week (SMW) and all the recommended agronomic practices were followed in raising the crop except plant protection measures. Monitoring of gram pod borer, *H. armigera* was done in accordance with Sagar *et al.* (2017), by using Fero-T traps @5 traps/ha with Helilure, procured from Pest Control India (PCI) Pvt Ltd, Bangalore, Karnataka and lures were replaced with new ones after every 20 days. *H. armigera* adult trap catches were recorded every week and expressed as mean number of male moths/trap/week and were square root transformed before subjecting them to correlation analysis. Weather data were obtained from the Agricultural Physics Division, ICAR-IARI, New Delhi. The relationship between male moth catches and weather parameters, viz. maximum temperature (T_{max}), minimum temperature (T_{min}), morning relative humidity (RH₁), evening relative humidity (RH₂), rainfall (RF), sunshine h (SSH) and wind velocity (WV) of current week, 1-lag, 2-lag and 3-lag weeks was computed using simple correlation co-efficient. The strength of the correlation was assessed according to Evans (1996) as 0.00 – 0.19: “very weak”; 0.20–0.39: “weak”; 0.40–0.59: “moderate”; 0.60–0.79: “strong” and 0.80–1.0: “very strong”. The following weather based forewarning model developed in our earlier study by Sagar *et al.* (2017) for *H. armigera* in chickpea at

Present address: ¹Scientist (garuda344@gmail.com, smnebapure@gmail.com), ²Principal Scientist (schanderthakur@gmail.com), Division of Entomology, IARI, PUSA Campus, New Delhi.

ICAR-IARI, Delhi was used for validation and the model was validated with the trap catch data of 2017–18 season.

$$Y = -10.69 - 0.685 * TMAX + 1.21 * TMIN + 0.177 * RH_1 + 0.038 * RH_2 + 1.11 * SSH - 0.25 * RF - 0.99 * WV (R^2=0.85)$$

Model accuracy was also evaluated by comparing the root mean-square error (RMSE), mean bias error (MBE) and mean absolute error (MAE) of the predicted and observed data sets of trap catches according to Willmott (1982).

The pheromone trap catch data revealed that the adult moth activity of *H. armigera* in chickpea commenced in 52nd SMW (last week of December) and trap catches reached peak during 15th SMW with 183.0 moths/trap/week in the month of April and thereafter, the moth activity declined (Fig 1). The present study results are in conformity with the findings of Ahmed and Khalique (2002) who reported 4th March $\pm$ 6 days, 13th April $\pm$ 4 days and 7th June $\pm$ 16 days to be the predicted dates for start, peak and end of trap catch populations of *H. armigera*, respectively, according to calendar date method for chickpea.

Relationship between the male moth population and weather factors of current and preceding weeks revealed that the male moth population had significant positive and very strong correlation with maximum temperature ($r=0.816^{**}$) and minimum temperature ($r=0.820^{**}$) of 1-lag week, while it had significant negative and strong correlation with morning ($r=-0.774^{**}$) and evening relative humidity ($r=-0.655^{**}$) of 1- and 2-lag week, respectively (Table 1).

Table 1 Correlation co-efficient between pheromone trap catches of *Helicoverpa armigera* and weather parameters in chickpea during 2017–18

Weather parameter	Current week	1-Lag week	2-Lag week	3-Lag week
Tmax	0.736**	0.816**	0.784**	0.781**
Tmin	0.785**	0.820**	0.759**	0.770**
RH1	-0.702**	-0.774**	-0.624**	-0.317
RH2	-0.498*	-0.585*	-0.655**	-0.618**
RF	0.775**	0.510*	0.061	-0.114
SSH	0.412	0.607*	0.706**	0.674**
WV	0.491*	0.485*	0.556*	0.449

n=17 ($r=0.482$ @ 5%, $r=0.606$ @ 1%), *Correlation is significant at 0.05 level of significance (Two-tailed); **Correlation is significant at 0.01 level of significance (Two-tailed). Tmax, Maximum temperature ($^{\circ}$ C); Tmin, Minimum temperature ($^{\circ}$ C); RH1, Morning Relative humidity (%); RH2, Evening Relative humidity (%); RF, Rainfall (mm); SSH, Sunshine h (h/day); WV, Wind velocity (km/h).

The rainfall of current week ($r=0.775^{**}$) and sunshine h/day of 2-lag week ($r=0.706^{**}$) had a significant positive and strong association with *H. armigera* male moth catches. On the other hand, the wind velocity of 2-lag week ($r=0.556^{*}$) showed positive and moderate correlation with the pest trap catch data. The present findings are in agreement with Pandey *et al.* (2012) where, the maximum and minimum temperature had significant positive correlation and relative

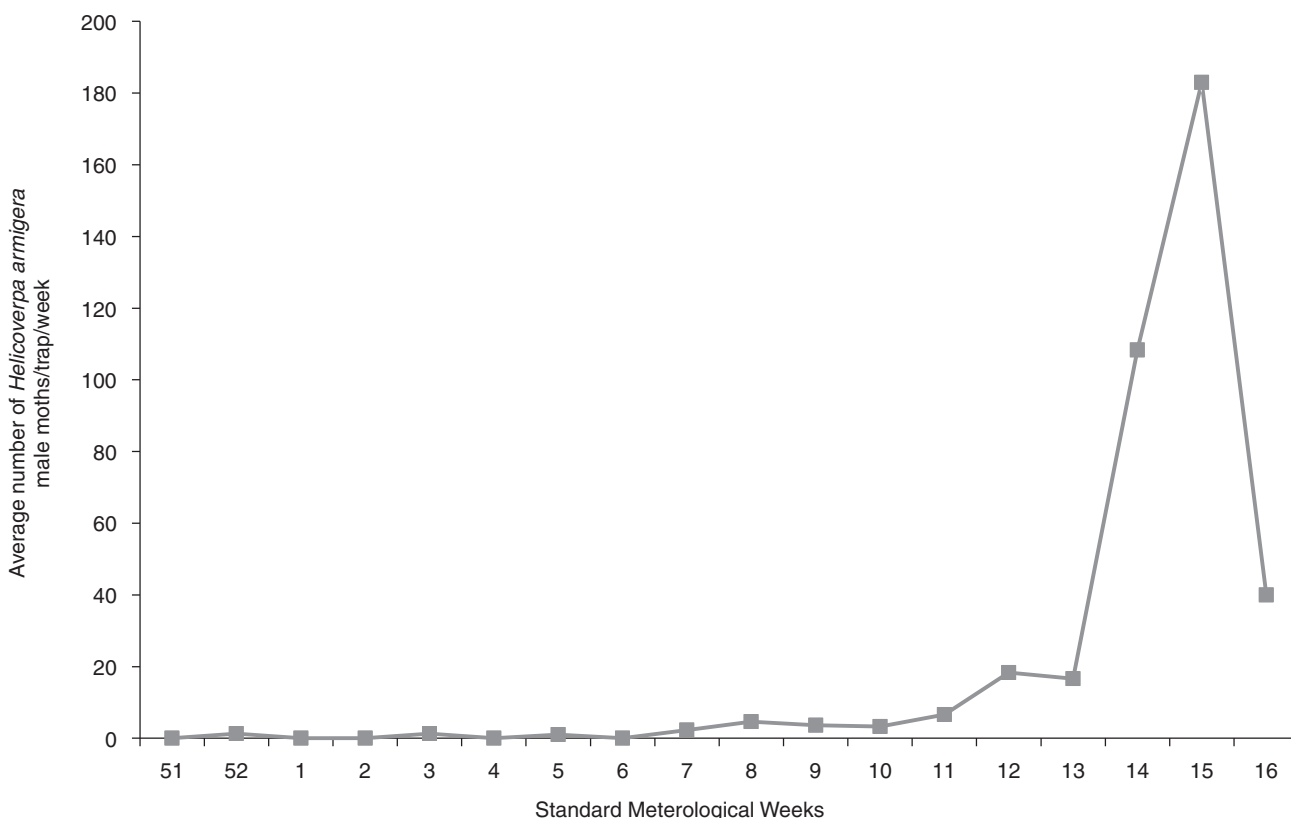


Fig 1 Dynamics of *Helicoverpa armigera* pheromone trap catches in chickpea during rabi 2017–18.

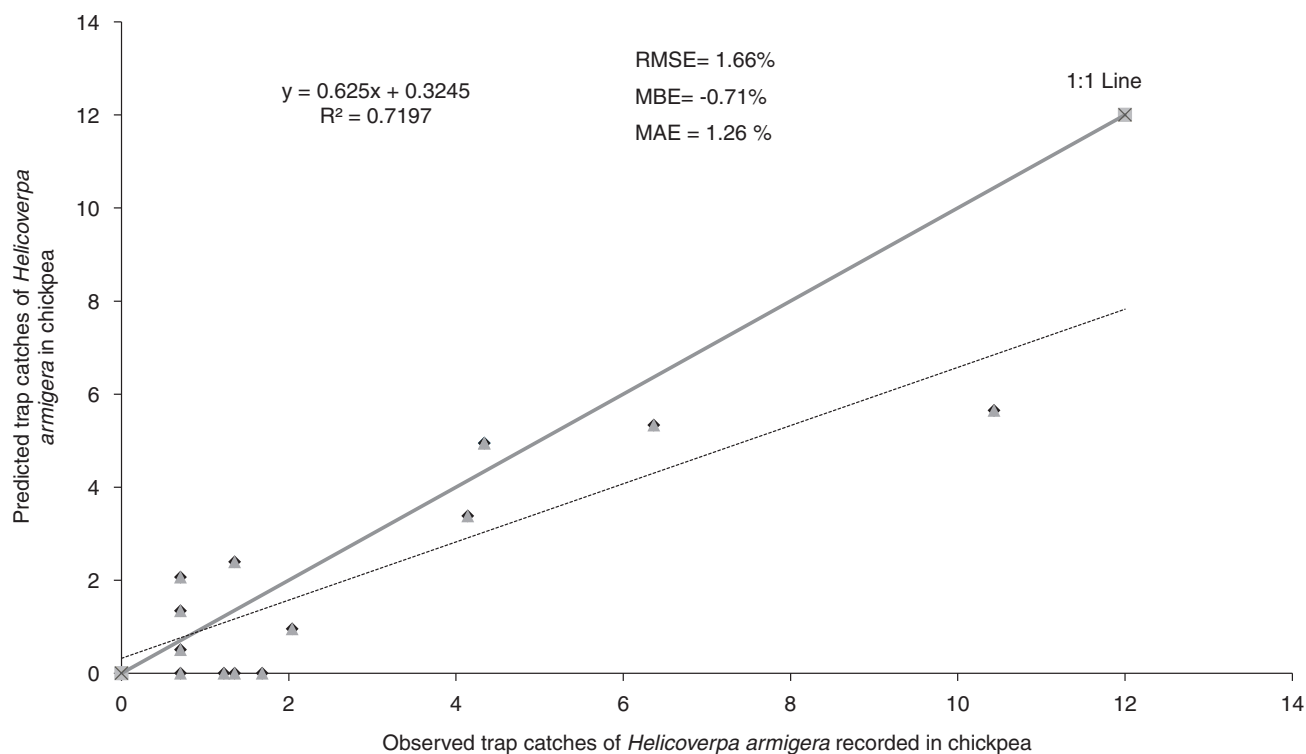


Fig 2 Validation of *Helicoverpa armigera* weather based forewarning model in chickpea during *rabi* 2017–18.

humidity had negative correlation with male moth catches and larval population of *H. armigera* in chickpea. In contrast to our findings, Ugale *et al.* (2011) who reported *H. armigera* moth emergence in chickpea was found to be negatively and significantly correlated with the maximum and minimum temperature. Matti *et al.* (2017) studied the association between the *H. armigera* larval population and weather factors and opined that minimum temperature, wind speed, morning and evening relative humidity showed negative association, while maximum temperature had positive and non-significant relationship with *H. armigera* larval population.

The weather based forewarning model was revalidated to judge the repeatability of model accuracy to predict the *H. armigera* adult population based on the weather parameters and the model was validated satisfactorily ($R^2 = 0.719$, RMSE=1.66%, MBE=-0.71% and MAE=1.26%) (Fig 2) with 2017–18 weather data and *H. armigera* trap catches indicating that this model can be precisely used to predict *H. armigera* population for New Delhi weather conditions. Pest-weather models have also earlier been developed and validated for rice yellow stem borer (Prasannakumar *et al.* 2015), guava fruit fly (Sharma *et al.* 2015) and sucking pests of cotton, viz. aphids, thrips and leafhoppers (Kumar *et al.* 2018). The weather based forewarning model for *H. armigera* was validated satisfactorily, it can be used to predict likely population of the pest under New Delhi weather conditions that will facilitate timely preparedness against the pest by the farmers. Even though the model is empirical, but it will be worthwhile to attempt its application under other similar weather conditions.

SUMMARY

Weather based forewarning model for *Helicoverpa armigera* developed earlier was validated by recording the activity of *H. armigera* through pheromone trap catches in chickpea sown during *rabi* 2017–18 at IARI, New Delhi. The moth activity of *H. armigera* commenced in 52nd SMW (last week of December) and peak trap catch was during 15th SMW with 183moths/trap/week in April. The male moth population had significant positive and very strong correlation with maximum temperature ($r=0.816^{**}$) and minimum temperature ($r=0.820^{**}$) of 1-lag week and significant negative correlation with morning ($r=-0.774^{**}$) and evening relative humidity ($r=-0.655^{**}$) of 1-and 2-lag week respectively. The repeatability of model accuracy to predict the *H. armigera* adult population was validated satisfactorily ($R^2 = 0.719$, RMSE=1.66%, MBE=-0.71% and MAE=1.26%) with 2017–18 weather data and *H. armigera* trap catches.

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REFERENCES

- Ahmed K and Khalique F. 2002. Forecasting adult populations of *Helicoverpa armigera* on chickpea using pheromone trap. *Pakistan Journal of Biological Sciences* 5: 830–4.
- Anonymous 2017. Project Co-ordinator's Report 2016–17. All

- Indian Co-ordinated Research project on chickpea, ICAR-Indian Institute of Pulses Research, pp 1–53.
- 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, pp 187–200. *Rice Pest Management*. (Eds) Prakash A, Sasmal, A, Rao J, Tewari S N, Behera K S, Singh S K and Nandagopal V. Cuttack: Applied Zoologist Research Association.
- Dixit G P, Sarvjreet Singh, Jayalakshmi V, Srivastava A K and Gaur P M. 2017. Chickpea improvement – Accomplishments, challenges and strategies. (In) Proceedings of National symposium on Pulses for Nutritional Security and Agricultural Sustainability, IIPR, Kanpur, p 45.
- Evans J D. 1996. *Straight Forward Statistics for the Behavioural Sciences*. Pacific Grove, CA: Brooks/cole Publishing.
- Fitt G P. 1989. The ecology of *Heliothis* species in relation to agroecosystem. *Annual Review of Entomology* **34**: 17–52.
- Kumar A, Nemade P W, Sharma R, Tanwar R K, Chattopadhyay C, Wanjari S S and Rathod T H. 2018. Statistical forewarning models for sucking pests of cotton in Maharashtra. *Journal of Agrometeorology* **20**(1): 62–5.
- Matti P V, Shekharappa, Balikai R A and Nargund V B. 2017. Prediction models for *Helicoverpa armigera* (Hubner) based on abiotic factors in chickpea ruling variety JG-11. *International Journal of Plant Protection* **10**(2): 344–8.
- Pandey B M, Tripathi M K and Vijay Lakshmi 2012. Seasonal incidence of gram pod borer, *Helicoverpa armigera* (Hub.) on chickpea in Varanasi area. *Journal of Experimental Zoology India* **15**(2): 667–9.
- Prasannakumar N R, Chander S and Vijay Kumar L. 2015. Development of weather based rice yellow stem borer prediction model for the Cauvery command rice areas, Karnataka, India. *Cogent Food and Agriculture* **1**: 995281 (DOI: 10.1080/23311932.2014.995281).
- Sagar D, Nebapure S M and Chander S. 2017. Development and validation of weather based prediction model for *Helicoverpa armigera* in chickpea. *Journal of Agrometeorology* **19**(4): 328–33.
- Sharma K, Sharma R K, Chander S and Jilu V. 2015. Effects of weather parameters on guava fruit fly (*Bactrocera zonata*) population at IARI, New Delhi. *Journal of Agrometeorology* **17**(2): 227–29.
- Singh D, Singh S K and Vennila S. 2015. Weather parameters influence population and larval parasitization of *Helicoverpa armigera* (Hubner) in chickpea ecosystem. *Legume Research* **38**(3): 402–6.
- Siswanto, Rita M, Dzolkhifli O and Elna K. 2008. Population fluctuation of *Helopeltis antonii* Signoret on Cashew *Anacardium occidentale* L. in Java Indonesia. *Pertanika Journal of Tropical Agricultural Sciences* **31**: 191–6.
- Tripathi S R and Sharma S K. 1985. Population dynamics of *Heliothis armigera* (Hubner) (Lepidoptera Noctuidae) on gram in the Terai belt of N. E. Uttar Pradesh. *Giornale Italiano di Entomology* **2**: 347–53.
- Ugale T B, Toke N R and Shirsath M S. 2011. Population dynamics of gram pod borer, *Helicoverpa armigera* (Hubner). *International Journal of Plant Protection* **4**(1): 204–6.
- Willmott C J. 1982. Some comments on the evaluation of model performance. *Bulletin American Meteorological Society* **63**: 1309–13.
- Yelshetty S and Sidde Gowda D K. 1998. Progress in pulse entomological research of Gulbarga. (In) proceedings of Seminar on progress and perspectives for sustainable agriculture in North Karnataka, Dharwad, Karnataka, 20th March 1998.