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Predicting the occurrence of *A. craccivora* using a degree day concept in lucerne

J. B. SINGH, PRADEEP SAXENA and PRADEEP BEHARI

ICAR-Indian Grassland and Fodder Research Insitute, Jhansi-284003, U.P.

Email: jbs_igfri@rediffmail.com

ABSTRACT

A degree day model was developed to predict the occurrence of *Aphis craccivora*in Lucerne using 3 years (2007-2009) data and validated with two years (2013-2014) data collected at research farm of ICAR-IGFRI Jhansi.The study indicated that the peak population of the aphid species can be predicted using heat accumulation starting with December 1st. Mean degree day (DD) required for aphids incidence was estimated to be 76 ± 4 degree days in lucerne fields. The peak aphids population was found at 199 accumulated degree days. The polynomial model fitted explains 72 per cent of the variability in lucerne aphids population. The model performance indicators viz mean absolute deviation, standard error, etc were within the acceptable range and the predictive capability of the model was fairly close to the observed values.

Key words: *Aphis craccivora,* pest management, population dynamics, thermal requirements,Lucerne

Lucerne (*Medicago sativa* L.) is a high protein forage legume(Sharma, 2013), and well adapted to a wide range of climate and soil conditions. It is recognized as providing the best food value for all classes of livestock. Lucerne green fodder contains 20.2% crude protein, 16.2% digestable crude protein, 30.1% crude fibre, 1.24% calcium, 0.35% Phosphrous and metabolic energy 2.17 M cal kg^{-1} (Banerjee, 1978). In India, it is grown in Gujrat, Maharastra, Rajasthan, Punjab and west Uttar Pradesh, occupying about 1 m ha area(Hazara, 1995).

Aphis craccivora Koch. (Hemiptera: Aphididae) variously known as the cowpea aphid or black aphid as a cosmopolitan pest attacks several host species and considered as a major pest of economically important crops such as lucerne and cowpea in subtropical and tropical regions (Pettersson *et al.*,1998; Saxena *et al*., 2002). The cowpea aphid prefers to feed on leaves near plant apex/terminals and on stems. Heavy infestations of aphids in crop resulting into wilting of foliage and stunting of crop plants. Due to high aphid infestation, there will also be problem in bailing hay, deterioration in forage quality and regrowth will also get affected. *A. craccivora* causes direct damage to crop by stunting and distorting growth. The damaging populations of aphids are most common from December to March during growth of the lucerne crop.

Environmental factors affect yield losses due to direct feeding damage, which is related to aphid population development. Meteorological factors, especially temperature, are the main environmental variables acting on aphids, associated to the occurrence of population peaks (Asin and Pons, 2001). Several authors (Chattopadhyay *et al*., 2005; Klueken *et al*., 2009) have predicted aphid occurrence by meteorological factors. Degree day models relate insect development to environmental temperature and do not operate on a calendar day basis but on physiological time, which considers a degree day as a unit (Gomez *et al*., 2009). Degree day concepts have been widely used to predict the occurrence of insects (Chakravarty & Gautam, 2004; Singh *et al*., 2009; Das, 2011) helping to improve the decisions associated with pest control in integrated pest management programs. It is prerequisite to determine the right timing of attack in relation to weather factors for an efficient control of aphids, which may enable the prediction of insect occurrence and allow growers to take timely action for efficient crop management (Chattopadhyay *et al*., 2005). The present study attempts to predict the occurrence of *A. craccivora*in lucerne crop using a degreeday concept in central Indian region.

MATERIALS AND METHODS

The field experiment was conducted for three consecutive (2007-08 to 2009-10) *rabi* season at the Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi (25^{o} 27' N, 8^{o} 35' E, 271 m amsl). The experiment was conducted with two varieties of lucerne (Anand-2 and RL-88) with four replications in plot size of 4 x 3m. The crop was sown in the last week of October to first week of November in lines 30 cm apart. A basal recommended

Table 1: The accumulated degree day for black aphid incidence on lucerne

Years	Accmulated degree day
2007-08	84
2008-09	80
2009-10	64
Mean + SD	76 ± 4

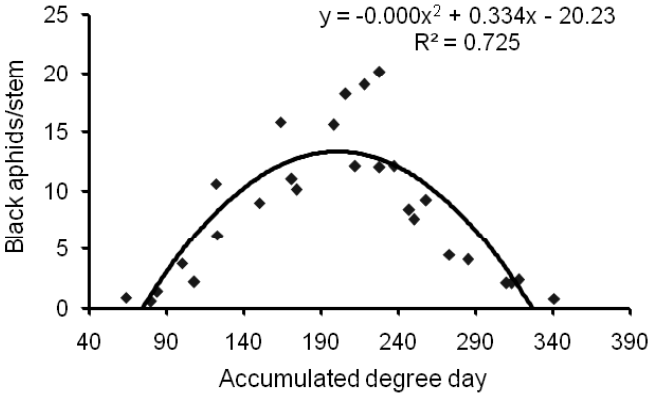

Fig.1: Lucerne aphids population during crop growth period

fertilizer dose of 20 kg N, 80 kg P_2O_5 and 40 kg K_2O was applied at the time of sowing. Standard agronomic practices were followed but no pesticides were applied.

The aphids population were counted at weekly intervals starting from the first appearance of aphids till their complete disappearance. The daily temperature data were obtained from IGFRI meteorological observatory near experimental plots. Degree-days (DD) summations were computed using the lower development threshold as 10^0C.

RESULTS AND DISCUSSION

In the present study, it is observed that the lucerne aphids incidence starts during the second week of December. The aphid population varied during different years. The degree-days (DD) accumulation starting from December 1 in different years showed that the mean degree day (DD) required for aphids incidence was 76 ± 4 degree days. It was also observed that higher the rate of accumulated degree day (DD), lower the aphid population and vice-versa (Table 1).

The aphids population with respect to DD accumulation during the crop growth period is illustrated in Fig.1. The aphids initial population ranged between 0.6 and1.4 aphids/stem during different years. Further, as the

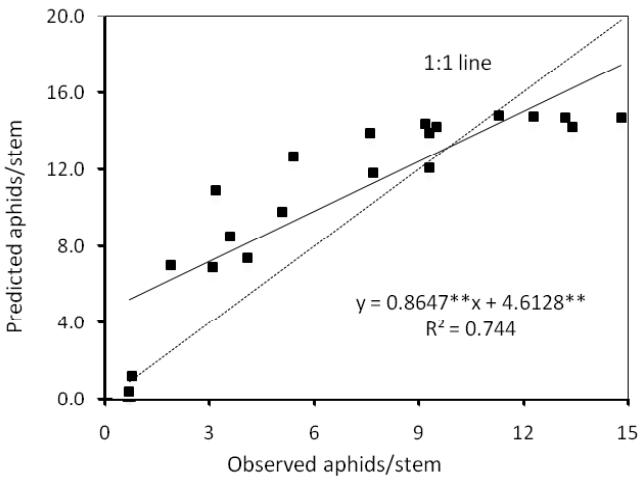

Fig. 2: Predicted vs observed aphids population

accumulation of DD advances, the aphid population starts increasing and attains a peak value ranging from 15.6 to 20.1 aphids/stem. The aphid population starts decreasing gradually as the season advances and by 1rd week of February, the population touches to a low value. A degree day (DD) based equation was developed for predicting lucerne aphids population during the crop growth period

$$Y = -0.0008^{**} DD^2 + 0.3348^{**} DD - 20.232^{**}$$

$$(R^2=0.725^{**}; P \leq 0.01)$$

where,Y= lucerne aphids population and DD= Accumulated degree days from December 1. All the terms of the polynomials were significant at ($P \leq 0.01$) indicated the existence between lucerne aphids population and accumulated degree day. The polynomial model fitted above explains 72 per cent of the variability in lucerne aphids population during the crop growth period. From this equation, maximum (d^2y/dx^2 = -ve) aphids population was found at accumulated DD=199.

The above model was validated with independent data set of 2013-14 and 2014-15. The predicted and observed values of aphid population indicate that there is a straight line relationship (Fig. 2) and the population are more or less in good agreement (R^2=0.74, P<0.01) which shows that the model performed fairly well.To judge the predictive capability of the developed model, several performance indicators viz. standard error (SE), mean absolute deviation (MAD), absolute prediction error (APE) and coefficient of variation of the residual error (CVRE) were estimated. The values of standard error (SE=2.29), mean absolute deviation (MAD=3.7), absolute prediction error (APE=0.50) and coefficient of variation of the residual error (CVRE=0.58) are within the acceptable range.

Therefore, on the basis of all these performance indicators, it can be inferred that the developed degree day model displays healthier prediction capabilities and it can be utilized for the prediction of lucerne aphids' population for the central and northern region very well. Further, they would have greater impact of control measures, as a result of advance preparation and better timing of control measures. This information would be useful in monitoring the aphids activity and evolving an integrated pest management (IPM) scheme for lucerne management in central region.

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