INVITED ARTICLE OPEN ACCESS

Weather Based Forewarning of Rice Yellow Stem Borer, *Scirpophaga incertulas* (Walker) at Raipur (Chhattisgarh, India)

S. Vennila[1]*, D.K. Das[2], J. Singh[2], R.K. Tanwar[1], S. Sharma[3] and C. Chattopadhyay[1]

[1]ICAR-National Research Centre for Integrated Pest Management (NCIPM), New Delhi

[2]ICAR-Indian Agricultural Research Institute (IARI), New Delhi

[3]Indira Gandhi Krishi Vishwa Vidyalaya (IGKVV), Raipur

*Corresponding Author:svennila96@gmail.com

Received: 15th October, 2015

Abstract

Pest forewarning provides lead time for managing impending pest attacks, and optimizes selection of pest control options for minimizing crop loss and reducing cost of plant protection. Light trap catches of rice yellow stem borer, *Scirpophaga incertulas* (Walker) recorded using light trap deployed at IGKVV rice research farm of Raipur were 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 to 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" of National Innovations on Climate Resilient Agriculture (NICRA), and made available for use at: http://www.ncipm.org.in/nicra/WeatherPrediction.aspx. 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.

Key words: Rice, *Scirpophaga incertulas*, weather, pest severity, prediction rules,forewarning

Introduction

Rice crop is attacked and damaged by large number of insects from nursery to harvest, but only a few of them are considered to be the pests that cause economic losses by minimizing the attainable yields. Rice stem borer is an important insect pest causing severe damage to rice crop in India (Reji *et. Al.,* 2014). Among them the yellow stem borer, *Scirpophaga incertulas* (Walker) is the most damaging species of rice stem borer in tropical Asia (Cohen *et al.,* 2000). Yellow stem borer is autochthonous and monophagous on rice (*Oryza spp)* (Douglass *et al.,* 2005) and occurs both in *kharif* and *rabi* seasons. It causes yield loss up to 19 per cent in early-planted rice crop, and 38-80 per cent in the late-planted rice. *S. incertulas* infestation in nursery as well as in transplanted crop causes drying of central shoot commonly referred as 'dead heart' (DH) in young plants, and boring at heading stage usually occurs at the peduncle node leading to 'white earhead' (WEH). The initiation of their infestation and spread is greatly influenced by the environment and phenology of the crop. Forewarning on their possible initiation and outbreaks or severity levels is very important for its management (Mandal *et al.,* 2011) based on which the timing of insecticide application as a prophylactic or curative measures can be decided to protect the crop.

Landholders have long used weather and climate information based on experience and intuition for planning and decision making on crop management. Over recent times, the availability of data bases of climatic information and the predictive tools ranging from correlation analysis to computer simulation models have made possible their utility to a much wider range of stakeholders (Coughlan and Huda 2008). A weather-based pest forewarning system is an important component of integrated pest management

(IPM) which can reduce the cost of cultivation by optimizing the timing and frequency of application of pest management measures and ensures operator, consumer and environmental safety by reducing chemical usage. For the purpose of development and use of pest weather models, both meteorological and biological data are required as inputs while the output is the anticipated outbreak of pest or disease. Present study used the meteorological and *S. incertulas* data of Raipur (CG) for development of heuristic rules that have the ability to predict the expected severity for any given week associated with *kharif* season.

Materials and Methods

Standard meteorological week wise data sets of weather and *S. incertulas* moths caught in light trap of the rice research farm at Indira Gandhi Krishi Vishwa Vidyalaya, Raipur (Chhattisgarh) were assembled for the period between 2000 and 2014 (fifteen years) for development and validation of prediction rules. Weather variables *viz.,* mean maximum temperature (^{o}C), mean minimum temperature (^{o}C), mean morning relative humidity (RHI %), total rainfall (mm) and sun shine hours (h/day) from 27 to 48 SMW were considered in conjunction with *S. incertulas* weekly moth catches obtained in light trap as a tool deployed for the pest monitoring for the formulation of weather based criteria predicting the pest severity. The moth catches of *S. incertulas* were categorized to the severity levels of low, moderate and high corresponding to population levels of <100, 100-1000 and high > 1000 moths/trap/week. The data sets of weather variables and S. *incertulas* severity corresponding to years 2000 to 2011 were used for development of weather based criteria for prediction of *S. incertulas* severity. The approach to the formulation of weather based criteria was based on the iterative process wherein the range for individual weather variables and rules of prediction were varied simultaneously testing the match with the observed levels of *S. incertulas* severity. Validation of the developed weather criteria and the rules was made considering the weekly data sets of weather and moth catches of *S. incertulas* of 2011-2014 (four years). Prediction accuracy was calculated based on the number of weeks positively predicting the category of pest severity using the formulated weather criteria and the prediction rules.

Results and Discussion

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). Many studies also have worked out the relationship between weather parameters and their influence on the abundance and distribution of crop pests to develop weather-based pest forecasting models for use in regional crop protection (Lingappa *et al.,* 2003; Chattopadhyay *et al*., 2011 and Olatinwo *et al*., 2011). Weather based prediction for forewarning of pest is an important component of IPM practices to adopt management of pests according to predicted severity in turn to avoid excess use of pesticides on crops. While the tropical and sub-tropical crop of rice grows well under the temperature regimes of 20° to 40°C with an optimum 30°C during day time and 20°C during night time such warm weather is reported to be the main factor for high population buildup of yellow stem borer *S. incertulas*. Nandihalli *et al.,*1990 reported negative and positive relations of light trap catches of *S. incertulas* at Raichur to maximum temperature and evening relative humidity, and minimum temperature and morning relative humidity, respectively. The lower and upper threshold temperatures for *S. incertulas* reported are 10–15°C and 35–40°C, respectively. Present study attempted to develop simple rules with higher prediction accuracy as the mathematical models are often cumbersome for use with decision support system.

Weather based criteria and prediction rules for *S. incertulas*

Initial fixing of weather criteria considering congenial conditions for development of *S. incertulas* based on reports followed by the iterative approach of varying the range of weather variables for matching the observed severity through the satisfaction of rules using long term historical data has been found to be a logical and highly satisfactory approach. The weather criteria (Table 1) and classification of pest severity (Table 2), and the rules fulfilling more than three, three and less than three criteria predicting high, moderate and low severity levels, respectively of *S. incertulas* were developed for Raipur (CG) based on eleven years (2000-2010) data. While fulfilling all of these weather criteria indicate the high severity of *S. incertulas*, and the converse holds true for the low severity. Das *et al*., (2012) using the similar approach of the present study predicted the severity of *S. incertulas* at Aduthurai with weather criteria of mean maximum

temperature (30-32°C), mean minimum temperature (20-22°C), mean morning relative humidity (90-93%), total rainfall (0-10 mm) and mean sunshine hours 8-9 h/day combined with moth catches/week/trap of <100, 100-200 and >200 corresponding to low, moderate and high severity. While the rules of prediction were the same, the prediction accuracy obtained was >90%. It is to be noted that the range of weather parameters favourable for stem borer and severity levels at each site is different. Reji *et al*. (2014) used multiple linear regression analysis to formulate pest-weather models for three sites of Southern India *viz.,* Warangal, Coimbatore and Pattambi wherein positive influence of temperature and relative humidity at Warangal, and negative relations of both weather parameters at other two locations were found for the stem borer damage thus reiterating the differing influence of the same weather variable differently at different places. Hence there is definite need for location specific predictions made available for use in pest forewarning.

Validation of weather based forewarning of *S. incertulas*

The severity of *S. incertulas* depended on the moth abundance in traps on weekly basis categorized as low, moderate and high based on historical data of the pest for that region. Based on the weather criteria and the rules developed, severity of *S. incertulas* was predicted for forewarning during each of the 16 SMWs (27-42) for *Kharif* season of 2011 – 2014. Exact predictions as that of the observed pest severity as well as biologically significant predictions wherein 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.,* 2011, 2012 2013and 2014 were 100, 90 100 and 95%, respectively with a mean of 96.3%. Although overlaps of weather factors are common to a certain extent between locations and cropping systems, there is need for use of location specific relations between weather and *S. incertulas* severity for robust forewarning as well as its management. It is to be noted that the developed weather criteria and the *S. incertulas* severity *vis a vis* prediction rules have been incorporated for use with real time weather data uploaded at weekly interval from Raipur through http://www.ncipm.org.in/nicra/WeatherPrediction.aspx. While the prediction requested for the weeks prior to current SMW present results under validation the current SMW request would give the prediction result that can be disseminated at times of high severity to the farmers.

Conclusions

The criteria of higher severity of yellow stem borer *S. incertulas* were at Raipur (CG) are: maximum temperature (30-34°C), minimum temperature (22 -23°C), morning relative humidity (89- 92%), and total rainfall (up to10 mm) and sunshine hour 8-9 h /day on weekly basis. The application of model available through http://www.ncipm.org.in/nicra/WeatherPrediction.aspx for forewarning of yellow stem borer severity and its integration with in agro-advisory for the region would facilitate timely pest management practices.

Acknowledgements

Research work is an output of the project on " Pest Dynamics in relation to Climate Change (Target crop: Rice)" under the National Innovations on Climate Resilient Agriculture (NICRA) funded by Indian Council of Agricultural Research (ICAR), New Delhi under NCIPM, New Delhi.

References

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.

Chattopadhyay, N., Samui, R.P., Rathore, L.S. 2011. Strategies for Minimizing Crop Loss due to Pest and Disease Incidences by *Adoption of Weather-Based Plant Protection Techniques Challenges and Opportunities in Agro meteorology* pp ٢٤٣-٢٣٥.

Cohen, M.B., Romena, A.M. and Gould, F. 2000. Dispersal by larvae of the stem borers *Scirpophaga incertulas* (Lepidoptera: Pyralidae) and *Chilo suppressalis* (Lepidoptera: Crambidae) in plots of transplanted rice. *Environmetal Entomology* 29:958-971.

Coughlan, K.J. and Huda, A.K.S. 2008. Use of weather and climate information for agricultural planning and decision making. *Journal of Agrometeorology*:249-260.

Das, D.K., Singh, J., Bentur, J.S., Ramasubramanian, G.V., Vennila, S., Tanwar, R.K., Jhanshilakshmi, V., Sampathkumar, M., Mishra, A. and Shahi, M. 2012. "Weather based prediction of rice yellow stem borer, *Scirophaga incertulas* (Walker) at Aduthurai, Tamil Nadu" in *3rd National symposium on Agriculture Production Protection in Context of Climate Change* (03-05 Nov) at BAU, Jharkhand. 116.

Douglass, E., Stevenson, G., Runjie, Z. and Marvin, K.H.

2005. Physiological time model of *Scirpophaga incertulas* (Lepidoptera: Pyralidae) in Rice in Guandong Province, People's Republic of China. *Journal of Economic Entomology* 98(4):1179-1186.

Lingappa, S., Yelshetty, S. and Venkatesh, H. 2003. Weather Based Forewarning System for the Pest and Disease Management, *Journal of Indian Society of Agricultural Statistics* 56(I):88-99.

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

Nandihalli, B.S., Patil, B.V. and Huger, P. 1990. Influence of weather factors on the light trap catches of yellow rice borer under Tungabhadra project area. *Indian Journal of Ecology* 17(1):90-93.

Oletinwo, R.O., Prabha, T., Paz, J.O., Relay, G.G. and Hoogenboom, G. 2011. The weather research and forecasting (WRF) model: Application in prediction of TSWV – vectors population. *Journal of Applied Biology* 35 (1):81-90.

Reji, G., Chander, S. and Kamble, K. 2014. Predictive zoning of rice stem borer damage in southern India through spatial interpolation of weather-based models. *Journal of Environmental Biology* 35(1):923-928.

Table 1. Weather based criteria for forewarning severity of *S. incertulas*

Weather variables (on weekly basis)	Criteria
Maximum temperature (^{o}C)	30-34
Minimum temperature (^{o}C)	22-23
Morning relative humidity (%)	89-92
Evening relative humidity (%)	40-50
Total rainfall (mm)	up to 10
Sunshine hours (h/day)	6-9

Table 2. Severity levels and prediction rules forewarning of *S. incertulas*

Population of *S. incertulas* numbers (moth catches/ week/ trap)	Level of severity	No. of weather criteria satisfied	Predicted severity
> 1000	High	More than three	High
100 - 1000	Moderate	Three	Moderate
<100	Low	Less than three	Low