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Weather-based brown planthopper prediction model at Mandya, Karnataka

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ABSTRACT

Relationship of weather parameters was explored withpeaks of brown planthopper (BPH)light trap catch data collected at Mandya (Karnataka) during 1990-2006. Peaks of BPH trap catches, observed between October 4thweekand November 3rd week during different years, exhibited significant correlation with Tmax, RH_1 and RH_2 of October 2nd week, rainfall (RF)of July 2nd week, SSH of October 1st week and Tmin of August 2nd week. Weather-based prediction model for BPH was developed by regressing peaks of BPHlight trap catcheson mean values ofdifferent weather parameters. Of the weather parameters, only Tmax, RF and RH_2 were found to be relevant through stepwise regression.Model was validated through 5-year (2002-2006) independent data withR^2=0.845 and RMSE=7.64%.

Key words*:* Brown planthopper, light trap catches, regression model, rice, weather parameters

Rice is an important crop worldwide with an area of 144.1 m ha devoted to its production and 50% of the global population being rice eaters (Barrion*et al*., 2007). It is attacked by several insect pests from nursery to harvest, which cause severe yield loss in one region of the country or another (Asghar*et al*., 2009). Brown planthopper (BPH), *Nilaparvatalugens* (Stal.) has emerged as most important pest of rice during post green revolution years throughout the country including Mandya region of Karnataka (Krishnaiah*et al*., 2008). The BPH population fluctuates according to dynamic conditions of biotic and abiotic factors (Win *et al*., 2011). Weather factors such as temperature, rainfall and relative humidity greatly influence the insect population (Heong*et al*., 2007; Siswanto*et al.,* 2008). Understanding of pest- weather relationship is of paramount importance for effective pest suppression. Besides, knowledge of the seasonal abundance and pest build up trend is essential to ensure timely preparedness to tackle impending pest problems and prevent crop losses (Das *et al.,* 2008). Pest population level may be the resultant of weather parameters of several preceding weeks or months. It thus becomes important to explore relationship of pest population with pre-season and seasonal weather parameters. Several workers have analyzed influence of weather factors on BPH population and observed temperature, humidity and rainfall to be important ones (Cheng *et al.,* 1992; Pathak and Khan, 1994; Jeyarani, 2004; Yadav*et al.,* 2010; Win *et al*., 2011). In general, pest weather relations have been analyzed through empirical models, which behave in location- specific manner (Chander, 2010).

Keeping this in view, present study was carried out to develop and validate weather based brown planthopper prediction model for the Cauvery Command areas of Mandya.

MATERIALS AND METHODS

Data on BPH light trap catches and weather parameters *viz*., maximum temperature (Tmax), minimum temperature (Tmin), rainfall (mm), morning relative humidity (RH_1), evening humidity (RH_2) and sunshine hours (SSH) for 14 years (1990-2006) for Mandya region (Long. 76.19' - 76.20' E and Lat. 12.13' - 13.4' N) of Karnataka was collected from Annual Progress Reports of Directorate of Rice Research, Hyderabad, India. Weekly weather data for nine years(1990-1992, 1994-1996 and 1998-2000)and log transformed BPH light trap catches were used for model formulation, wherein peak BPH trap catches ofdifferent years were correlated with weekly mean values of each of the weather parameters individually, beginning with 1st week of July until attainment of peakBPH catch.Weather data for three years (1993, 1997 and 2001) were not available.Most important week with respect to each of the weather factors could thus be identified and relevant values were used to develop a multiple linear pest-weather model using SAS statistical software. The model was validated through 5- year (2002-2006) independent dataset on weather and BPH trap catches. Model performance was evaluated by comparing observed and predicted BPH trap catches.

RESULTS AND DISCUSSION

Peaks of BPH light trap catches exhibited significant correlation with Tmax, RH_1 and RH_2 of October 2nd week, RF of July 2nd week, SSH of October 1st week and Tmin of August 2nd week (Table 1). The BPH light trap catches were positively correlated with Tmax, RH1, RH2 and RF while these had negative relationship with Tmin. As peaks of BPH light trap catches during different years occurred between October 4th week and December 3rd week, weather parameters only up to October3rd week were considered for developing regression relationship. Pest-weather model between BPH light trap catches and weather parameterswas established as:

$LogBPH_{Peakpop}$ = -27.582 +0.910 * Tmax (Oct. 2-week) - 0.120 * Tmin (Aug. 2-week) +0.021 * RF (July2-week) +0.028 * RH_1 (Oct. 2-week) +0.0518 * RH_2 (Oct. 2-week) -0.192*SSH (Oct.1-week)
(R^2=0.94, P=0.18) (1)

Weather parameters explained 93% variability in BPH trap catches, albeit with higher probability (P=0.18). However, removal of sunshine hours (SSH) did not result in an appreciable reduction in coefficient of determination (R^2 = 0.92), thereby indicating insignificant influence of sunshine hours (SSH) on BPH light trap catches.

$LogBPH_{Peakpop}$ = -19.670 +0.712 * Tmax (Oct. 2-week) - 0.140 * Tmin (Aug. 2-week) +0.0214* RF (July2-week) - 0.008 * RH_1 (Oct. 2-week) + 0.062 * RH_2 (Oct. 2-week) (R^2=0.92, P=0.067) (2)

Sunshine hours did not influence BPH light trap catches perhaps because BPH confine them to plant stems and leaf sheaths and these do not get exposed to direct sunlight due to dense rice planting. By stepwise regression, RH_2, RF and Tmax were found to be important factors that influenced BPH light trap catches as their exclusion from analysis resulted in poorer R^2 values of 0.80 (P= 0.010), 0.46 (P=0.16) and 0.26 (P=0.4), respectively.

Yadav*et al*. (2010) found temperature and evening relative humidity to be important factors that influenced the BPH light trap catches, while Cheng *et al*. (1992) observed only temperature to be major factor responsible for the population dynamics of BPH. However, in present study along with Tmax and RH_2, the rainfall also played a significant role in influencing trap catches. Rainfall has earlier been found to profoundly influence BPH build up by creating favourable high humidity (Krishnaiah*et al*., 2008; Varma*et al.,* 2008).

Exclusion of RH_1 during regressiondid not cause any reduction in R^2(0.92), suggesting insignificant role of RH_1on BPH light trap catches.

$LogBPH_{Peakpop}$ = -19.718+0.691*Tmax (Oct. 2-week) - 0.132 *Tmin (Aug. 2-week) +0.021 * RF (July2-week) +0.0510*RH_2 (Oct. 2-week) (R^2=0.92; P=0.017) (3)

The RH_1, which is generally high, might not be beyond critical limit for BPH development, whereas RH_2 beingnormally low might prove critical for BPH and rainfall might play important role in ensuring higher RH_2.

FurtherwithTminexclusion, model with Tmax, rainfall and RH_2could account for 90% variability in BPH trap catches, thereby suggesting insignificant role of Tmin too.

$LogBPH_{Peakpop}$ = -23.289+0.741 * Tmax (Oct. 2-week) +0.021 * RF (July 2-week) +0.051 *RH_2(Oct.2-week)
(R^2=0.90, P=0.006) (4)

Regression equation (4) was accepted as final model because equation (1), (2) and (3) included either all or fewer of SSH, RH_1 and Tmin that were subsequently observed not to have influenced BPH light trap catches. Besides, significance of 'F' for these regression equations was lower (P = 0.017-0.18) thanP= 0.006 for equation (4). The pest-weather model was validated satisfactorily (R^2= 0.845; RMSE=7.64%) with independent 5- year datafrom 2002-2006on weather and BPH trap catches (Fig.1).

Pest weather model clearly suggested the Tmax, RF and RH_2 to be important weather parameters that influenced BPH light trap catches at Mandya, Karnataka. Besides, satisfactory validation of the model endorsed importance of these parameters in affecting BPH population

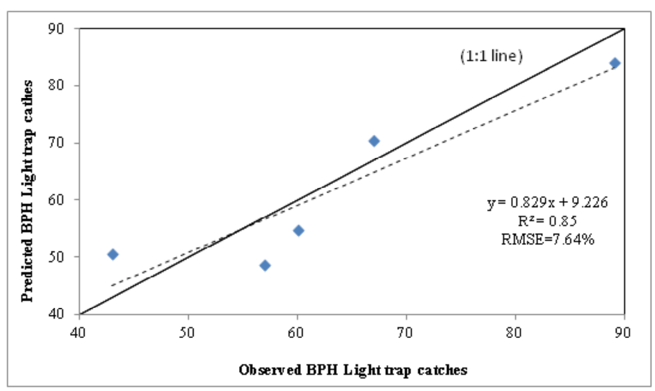

Fig.1. Validation of brown planthopper (BPH) –weather model developed at Mandya, Karnataka

Table 1: Correlation coefficient between yearly peaks of BPH light trap catches and weather parameters (prior to peak catches)during nine years at Mandya, Karnataka

Week	Tmax	Tmin	RF	RH_1	RH_2	SSH
Jul-1	0.12	0.12	-0.16	0.35	0.06	0.23
Jul-II	0.38	0.41	**0.72**	0.30	-0.14	-0.21
Jul-III	0.03	0.10	-0.01	0.39	0.12	-0.50
Jul-IV	0.27	0.08	-0.32	0.42	0.25	-0.42
Aug-I	0.42	-0.30	-0.01	0.45	0.22	-0.15
Aug-II	0.10	**-0.63**	-0.13	0.45	0.28	-0.20
Aug-III	0.07	-0.05	-0.22	0.32	-0.06	-0.43
Aug-IV	0.23	-0.16	-0.32	0.40	0.00	0.41
Sep-I	0.25	-0.47	0.20	0.39	-0.10	-0.32
Sep-II	0.12	-0.32	0.13	0.53	-0.06	-0.07
Sep-III	0.34	-0.40	0.38	0.52	0.15	-0.54
Sep-IV	0.30	-0.14	-0.28	0.51	0.11	-0.13
Oct-I	0.12	-0.41	0.46	0.47	-0.16	**0.55**
Oct-II	**0.69**	-0.14	0.15	**0.74**	**0.34**	0.34
Oct-III	0.55	-0.50	0.27	0.48	-0.21	-0.03
Oct-IV	0.23	-0.27	-0.17	0.44	-0.07	-0.58
Nov-I	0.25	-0.25	-0.32	0.50	0.12	0.04
Nov-II	-0.46	-0.78	0.19	0.55	0.12	-0.55
Nov-III	0.36	-0.24	-0.33	0.49	-0.11	0.35
Nov-IV	0.37	0.52	-0.22	0.52	0.11	0.81
Dec-I	0.23	-0.12	-0.26	0.56	-0.04	0.42
Dec-II	0.45	-0.49	-0.39	0.49	-0.53	0.33
Dec-III	0.59	-0.42	-0.25	0.34	-0.51	0.53
Dec-IV	0.52	-0.12	-0.25	0.19	-0.13	0.24

dynamics.BPHlight trap catches indirectly represented its population level on crops. Following population build up and deterioration in crop condition, production of winged forms takes place for intra-field and inter-field migration. Insects are cold-blooded animals and ambient temperature plays very important role in their development. Higher the temperature within favourable range of the species, quicker is the development. Positive role of Tmax in influencing BPH light trap catches is thus understandable, while Tmin did not affect them. Besides, Tmax might act as a source of heat energy for insects to take flight during night, while Tmin, which occurs during early morning, might not influence BPH activity during ensuing night. Chander and Palta (2010) found that weekly mean Tmax and Tmin during June-August over 10 years from 1998-2008 under Delhi conditions did not differ during BPH outbreak and non-outbreak years. However, difference in Tmax relationship with BPH population at Mandya and Delhi could arise due to regional environmental variability. Rainfall affected BPH light trap catches directly as well indirectly through relative humidity. Rainfall during July 2nd week significantly influenced BPH peak populations that were realized between October 4th and November 3rd week during different years. Initial monsoon rains might help in better build-up of BPH population, which could then boost pest population manyfolds during ensuing generations, thereby affecting peak of pestpopulation. Higher rainfall during July 2nd week might thus relate positively to peak of BPH population. Chander and Palta (2010) observed that early commencement of rainfall in summer and its intermittent distribution with more number of rainy days that led to higher relative humidity could contribute to BPH outbreak. Relationship between October end peak of BPH population and July 2nd week rainfall existed despite lengthy lag period. Such relationships have been observed earlier too (http://www.imdagrimet.gov.in/node/397), wherein incidence of sorghum ear-head bug in Karnatakawas influenced by Tmax (32 standard week), Tmin (50 week), RH_1 (47 week), RH_2 (50 week), RF (34 week) and SSH (50 week), whiledamage due to sugarcane stem borer in Andhra Pradesh was affected by Tmax (40 week), RH_1 (47 week), RH_2 (40 week) and rainfall (15 week). Therefore, it seemed that weather parameter value of longer past could influence peak of pest populationthrough effect on pest survival during preceding generations.

Although empirical pest-weather models have significantly contributed in understanding pest population dynamics but these are influenced by local conditions and thus behave in a location-specific manner (Pinnschmidt*et al.,* 1995; Teng*et al*., 1998). The pest population is thus shown to be affected by different factors at various locations.

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