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Influence of weather on sorghum shoot fly, *Atherigona soccata* (Rondani) and models for forewarning their incidence

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ABSTRACT

Field trials were conducted at the National Research Centre for Sorghum, Hyderabad, India for four years from 2001 to 2004 to study the effect of different weather variables on shoot fly incidence under three sowing times. Observations of the shoot fly eggs and deadhearts cased by their incidence were made at 14, 21 and 28 days after crop emergence. Correlations showed mean afternoon relative humidity in the previous week and mean maximum temperature two weeks before, to have significant negative influence on egg laying. In case of deadhearts, among weather variables accumulated from date of sowing, only the vapour pressure deficit showed significant positive correlation. Age of the plant and the cumulative egg count showed a significant positive relation with per cent deadhearts. Equations developed through stepwise regression, for prediction of shoot fly eggs and deadhearts, explained 58 and 91 per cent of the variability, respectively. Validation of these models with independent data sets showed promising results.

Key words: Sorghum shoot fly, weather, forewarning models

The total sorghum area the world over is 43.7 million hectares with an annual production of 62.8 metric tonnes. In India, it is currently grown in 10.4 million hectares with an annual production of 8.0 metric tonnes (FAO, 2001). However, the sorghum yields under subsistence farming conditions are generally low (500 to 800 kg ha^{-1}). Pest damage is a major constraint in sorghum production in our country. Among the 150 species of insects reported on sorghum in different phenological stages, the shoot fly, *Atherigona soccata* (Rondani) is identified as one of the most important pests attacking the crop during seedling stage and the losses due to this pest are estimated to reach as high as 86 per cent of grain and 45 per cent of fodder yield (Sukhani and Jotwani, 1980).

The female fly lays 20-25 white cigar shaped eggs, singly on the lower surface of the leaves. After hatching, in 2-3 days, the tiny maggot enters the plant through the whorl and penetrates down the leaf sheath, cuts and feeds on the decaying tissue. The infestation results in withering and drying of the central leaf, giving it a typical "deadheart" symptom. The late-sown crop suffers greater damage because of buildup of shoot fly population on the early-sown crops.

Dubey and Yadav (1980) found high levels of relative humidity (86-88%) resulting in low intensity of shoot fly attack. Contrarily, Mote and Kadam (1986) observed positive correlations between shoot fly adults with temperature, relative humidity and rainfall and concluded that conditions of 25-27°C and 68-75 per cent RH favoured the build-up of population. Kandalkar *et al.* (2001) correlated shoot fly incidence to mateorological parameters of previous week and found only maximum and minimum temperatures to have significant negative correlation. In this paper, in addition to the influence of weather from the current and previous weeks, their cumulative effect from date of sowing and age of the plant are considered and models for forewarning shoot fly eggs and deadhearts are reported.

MATERIALS AND METHODS

Field experiments were conducted for four years from 2001 to 2004 at the National Research Centre for Sorghum (NRCS), Hyderabad. The experiment comprised three sowing times, namely, June- July as *kharif*, October- November as *rabi* and January- February as summer crop, and laid out in randomized block design with three replications. The shoot fly susceptible genotype *DJ 6514* was planted in 10 rows of 4 m length with a plant- to- plant distance of 20 cm. Standard agronomic practices including weeding were carried out. No pesticides were applied during the experimental period.

Daily weather data were recorded using an automatic weather station of Agricultural Research Station, Acharya N G Ranga Agricultural University situated adjacent to National Research Centre for Sorghum at Rajendranagar, Hyderabad. Weekly averages were worked out for weather parameters. A base temperature of 12° C was taken to calculate growing degree-days for shoot fly (Delobel, 1983). Saturated vapour pressure (SVP) in K Pa at mean air temperature T (°C) was calculated following the method of Tetens (1930).

$$SVP = \exp\left[\frac{16.78T - 117}{T + 237.3}\right]$$

Actual vapour pressure (AVP) was calculated from the SVP and mean relative humidity (RH).

AVP = (SVP * mean RH /100

Vapour pressure deficit (VPD) = SVP - AVP

The observations on shoot fly eggs and deadhearts were recorded at 14, 21 and 28 days after germination in each date of planting. Shoot fly takes 17 to 21 days to complete one life cycle i.e. from egg stage to adult. Keeping this in view, the weekly pest data was correlated with one and two previous week's weather in addition to current week's weather data to identify the significant weather factors responsible for shoot fly multiplication. The stepwise regression analysis for shoot fly eggs was carried out with weekly weather variables and plant age in days after emergence as dependent variables. In case of deadhearts, cumulative values of all the weather variables on daily basis, starting from the date of sowing and cumulative egg count at weekly intervals starting from 14 days after emergence were used to develop regression models. The models were developed using the data from the first three years i.e., 2001 to 2003 and they were validated using the independent data of 2004.

RESULTS AND DISCUSSION

Shoot fly eggs:

In the present study, correlations of egg count with weather variables of the previous one and two weeks was found more significant than with weather of current week (Table 1). Mean afternoon relative humidity (at 1400 LMT) in the previous week and mean maximum temperature two weeks before, were found to have significant negative influence on egg count. Whereas, sunshine hours in the previous week showed significant positive relationship. Naitham and Sukhani (1985) found that oviposition by shoot fly was negatively correlated with soil moisture, followed by air temperature and relative humidity; rainfall had an adverse effect on oviposition. But Ogwaro (1979) recorded maximum emergence of shoot fly adults 4-6 weeks after peak rainfall. Delobel and Lubega (1984) showed that rainfall early in the season did not adversely affect survival of eggs, since they were protected on the underside of leaves. The present study showed a negative influence of rainfall on shootfly eggs in all the weeks under study, but statistically, not significant.

Age of the plant was found to have profound influence on oviposition by shoot fly in the present study, which is in conformity with Dubey and Yadav (1980) and Ogwaro and Kokwaro (1981). They reported that two to three week old sorghum plants were the most preferred stage for survival of eggs and development of larva in shoot fly. Stepwise regression analysis in the present study had selected only mean afternoon relative humidity and sunshine hours in the previous week along with age of the plant in days after emergence. These three parameters accounted for 58 per cent of variation in egg count. The equation developed with one week's lead time for forecast is as follows

$$Eggs = -5.58 + 0.046\,(ERH\_1) + 0.39\,(SSH\_1) + 0.11\cdot(DAE) \qquad (R^2 = 0.58)$$

where,

- Eggs : Shoot fly eggs per plant in the coming week
- ERH_1 : Mean afternoon relative humidity of previous week
- SSH_1 : Mean sunshine hours of previous week
- DAE : Age of the crop in days after emergence

Validation of the above model is shown in Fig.1. The predicted and observed values are more or less in good agreement except for February 2003 planting, where prediction values are lower than actuals. With an independent data set for the year 2004, the predicted shoot fly egg counts were close to observed values.

Deadhearts

In the present analysis, the cumulative values of weather, plant age and egg count were found to be more reliable indicators for shoot fly damage (observed as deadhearts) than their weekly averages. Among the weather variables, only the VPD was found to have significant positive correlation with deadhearts; age of the plant and the cumulative egg count had a high positive correlation on per cent deadhearts (Table 1). Significant positive correlation of egg counts with mean weekly sunshine hours one week before, and positive influence of VPD on deadheart formation indicated that bright days with relatively dry weather may be more congenial for shoot fly attack. Venkatesh and Balikai (2002) found that in *rabi* sorghum, rainfall received one week after emergence and higher day temperatures two weeks after emergence reduced shoot fly infestation at four weeks after emergence. Victor *et al.* (2003), observed occurrence of wet week (> 30mm rain in a week) within 30 days from sowing, to promote the incidence of shoot fly. The following stepwise regression was derived for deadhearts.

$$DH\% = -23.53 + 17.4\,(Cu\ Egg) + 0.34\,(GDD) - 0.36\,(Cu\ RF) - 0.18\,(Cu\ VPD) \qquad (R^2 = 0.91)$$

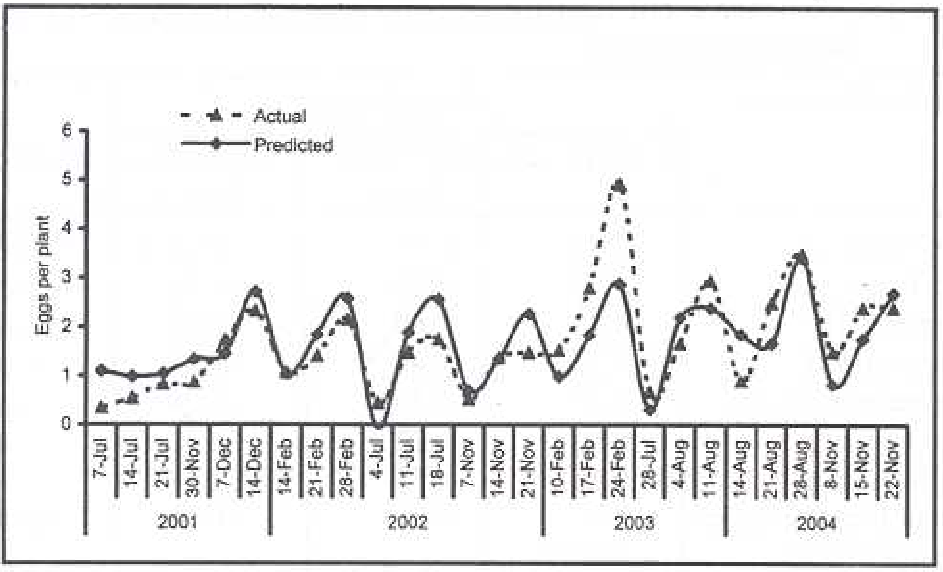

Fig 1: Actual and predicted shootfly eggs during 2001-04

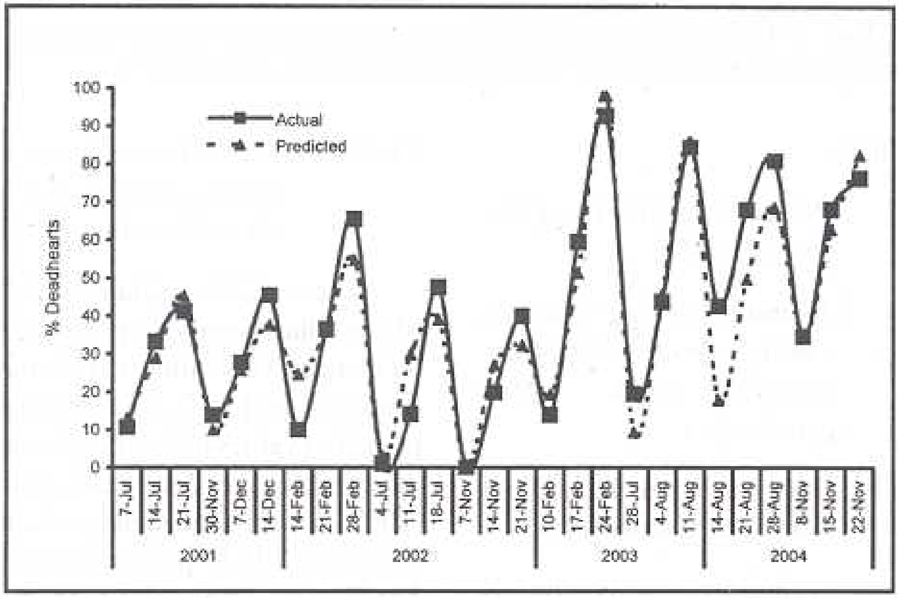

Fig 2 : Actual and predicted deadhearts due to Shootfly during 2001-04

Table 1: Correlation coefficients for shoot fly eggs and dead hearts vs. weekly weather and plant age

Weather Parameter	Short fly eggs			Deadhearts
	Current week	One week before	Two weeks before	
Max. temp	0.28	0.13	-0.25 *	0.40
Min. temp	-0.22	-0.28	-0.38	0.43
Morning RH	0.18	-0.09	0.26	0.35
Afternoon RH	-0.35	-0.47 *	-0.39	0.31
Number of rainy day	-0.25	-0.30	-0.29	-
Total rainfall	0.00	-0.22	-0.31	-0.04
Sunshine hours	0.45	0.53 *	0.34	-
Vapour pressure deficit	0.07	0.15	-0.18	0.48 *
Age of the Plant	0.56 *			-
Egg count	0.92 **			0.81 **
Growing degree days	0.50			-

* significant at 5%; ** Significant at 1%

Note: All weather variables are daily cumulative values from the date of sowing and egg counts are weekly cumulatives starting from two weeks after germination.

Where,

DH% : Per cent deadhearts in the coming week

Cu Egg : Cumulative egg count at weekly interval starting from second week after germination

GDD : Growing degree days (D °C) from date of sowing

Cu RF : Cumulative daily rainfall (mm) from date of sowing

Cu VPD : Cumulative daily vapour pressure deficit (K Pa) from date of sowing

The variables explained 91 per cent of the total variation in the deadheart incidence. Validation of this model is presented in Fig 2. The observed and predicted values of deadhearts are close to each other in all the years from 2001 -2003. With the independent data set of the year 2004, predicted per cent deadhearts, was close to actuals. Venkatesh and Balikai (2002) worked out regression equations for predicting deadhearts due to shoot fly at four weeks after emergence using mean Max T and mean RH 2 with three and one week lead time, respectively.

With the model developed in the present study, both the egg counts and deadhearts can be predicted every week starting from 14 days after the crop emergence. Therefore, early forewarning of the incidence when the pest is at egg stage enables to take-up timely control operations to avoid the damage that follows in the form of deadhearts at later stages. In addition to weather variables, age of the plant, which was found to influence shoot fly incidence, is also considered in the models.

It is known that host plant resistance plays a vital role in determining the extent of damage due to shoot fly. There are several sorghum varieties and hybrids being cultivated with varying levels of resistance to this pest. Since the regression models for predicting shoot fly eggs and deadhearts were developed using observations on one of the most susceptible variety, *DJ 6514*, it is expected that the prediction from these equations indicate the maximum likelihood of shoot fly incidence on sorghum crop in general.

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REFERENCES

Delobel, A.G.L. 1983. Influence of temperature and host plant condition on pre-imaginal development and survival in the sorghum shoot fly *Atherigona soccata*. *Insect Sci. Application*, 4(4): 327-335.

Delobel, A.G.L. and Lubega, M, C. 1984. Rainfall as mortality factor in the sorghum shoot fly, *Atherigona soccata* Rond. (Diptera, Mucidae). *Zeitchrift fur Angewandte Entomologie*, 97(5): 510- 516.

Dubey, R.C. and Yadav, T.S. 1980. Sorghum shoot fly (*Atherigona soccata* Rondani) incidence in relation to temperature and humidity. *Indian J. Entomol*, 42(2): 273- 274.

F.A.O. 2001. *Food and Agricultural Organization Bulletin of Statistics,* 3: 35-36.

Kandalkar, H.G., Men, U.B., Atale, S.B. and Kadam, P.S. 2001. Studies on correlation between sorghum shoot fly, *Atherigona soccata* Rondani infestation and some ecological factors. *J. Entomol. Res.*, 25 (1): 77-79.

Mote, U.N. and Kadam, J.R. 1986. Population dynamics and incidence of sorghum shoot fly in relation to climatic factors. *Current Res. Reporter, Mahatma Phule Agric. Univ.,* 2(1): 81-84.

Naitham, N.R. and Sukhani T.R. 1985. Ovipositional behaviour of shoot fly *Atherigona soccata* Rondani under different soil, plant and weather parameters. *Indian J. Entomol.,* 47(2): 195-200.

Ogwaro, K. 1979. Seasonal activity of the sorghum shoot fly, *Atherigona soccata* (Diptera: Anthomyiidae). *Entomologia Experimentalis et Applicata,* 26(1): 74-79.

Ogwaro, K. and Kokwaro, E. D. 1981. Development and morphology of the immature stages of the sorghum shoot fly, *Atherigona soccata* Rondani. *Insect Sci. Application*, 1 (4): 365-372.

Sukhani, T.R. and Jotwani, M.G. 1980. Comparison of cultural and chemical methods for the control of sorghum shoot fly, *Entomon*, 5(4): 291-294.

Tetens, O. 1930. Uber einige meteorologische Begriffe. *Z. Geophis.,* 6: 297-309.

Venkatesh, H. and Balikai, R. A. 2002. Influence of weather variables on the incidence of sorghum shoot fly in *rabi* season. *J. Agrometeorol.,* 4 (1): 39-44.

Victor, U. S., Das, N. D., Srinivasa Rao, M., Vijayakumar, P. Srivastava, N.N., Vittal, K.P.R. and Ramana Rao, B.V. 2003. Risk management options using weather forecasts in insect pests and diseases management for some dryland crops. *J. Agrometeorol.,* 5(1): 12-24.