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Studies of weather effect on frog-eye spot disease in Bidi tobacco using logistics regression

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ABSTRACT

The frog-eye spot (FES) disease caused by *Cercospor anicotianae* Ell. and Eve. is a major problem in both nursery as well as in the main field of bidi tobacco growing environments. Eight years data (2008-2015) on occurrence of disease and weather parameters were used for logistics regression analysis. The results indicated that sunshine hours (BSS) and minimum temperature (Tmin) were positive and highly significant, whereas maximum temperature (T_{max}) and rainfall (R) were found negative and highly significant.Further results of odd ratio indicated that every increase in 1 unit in BSS and Tmin, the risk of FES increases 1.7 and 1.4 times, respectively, whereas increase in 1 unit in Tmax and rainfall, the risk of FES decreases at rate of 0.6 and 1.0 times, respectively.

The frog-eye spot disease caused by *Cercospor anicotianae* Ell. and Eve. is a major problem in both nursery as well as in the main field of bidi tobacco growing environments. Losses due to this disease have been estimated to the tune of 21 per cent in bidi tobacco (*Nicotiana tabacum*) field under normal monsoon conditions of Gujarat (Patel *et al*., 2001). Nicotine, reducing sugars and chloride contents are very important to assess the quality parameters of bidi tobacco. Frog-eye disease infected plants were less in nicotine content (46.7%) and reducing sugars (24.3%) compared to healthy leaves in nursery (Patel *et al*.,2001).

Humid and warm weather during August-September is highly congenial for development of the disease. Favorable temperature for its development ranges from 18 to 27°C. It can survive on plant debris and other host plants including weeds. *C. nicotianae* attacks all life stages of the tobacco plant and even harvested leaves during curing.Hence, it was desirable to study the incidence and severity of disease in relation to agro-meteorological parameters.

MATERIALS AND METHODS

The field experiment was carried out at Bidi Tabocco Research Station, AAU, Anand from 2008 to 2015. Two hundred fifty square meter area in field of bidi tobacco cv. Anand-119 was earmarked and kept unprotected for this study. Weekly observations of frog-eye spot disease using 0-5 scale were recorded starting from transplanting to end of the crop season.For recording the observations, three block in field were made and observations of 10 randomly selected plants from each block were recorded at weekly interval. Data on weather parameters such as bright sunshine hours (BSS), rainfall (R), rainy days (RD), Maximum and minimum temperature (Tmax, Tmin), relative humidity morning and evening (RH1, RH2), vapor pressure morning and evening (VP1, VP2) and total rainfall (TOTR)were obtained from Agro-meteorological observatory, AAU, Anand.

Logistic equation was derived to identify indicator variables responsible for disease initiation. Binary logistic regression was used to create a dichotomous model that would predict either the presence (= 1) or absence (= 0) of frog-eye spot disease.Logistic regression is a nonlinear regression method that is well suited to probability forecasting, i.e. situations where the prediction is a probability rather than a measurable physical quantity. Logistic regression was chosen due to the fact that logistic regression does not assume that multivariate observations are distributed normally (Johnson,1998).The logistic regression formulas are stated in terms of the probability (P) of occurrence of disease and can be written as

$$ln\left(\frac{p}{1-p}\right) = \beta_0 + \sum_{i=1}^{m} \beta_i X_i$$

The 'ln' symbol refers to a natural logarithm and β_0 and β_i are parameters and X_i is explanatory variables, in this case any weather parameters. The probability of occurrence

Table 1: The estimated coefficients of weather parameters from logistic regression model

Parameter	DF	Estimate	Standard error	Wald Chi-square	Pr > Chi Sq
Intercept	1	9.228	2.0456	20.4	<.0001
BSS	1	0.527	0.1560	11.4	0.0007
Tmax	1	-0.532	0.1152	21.4	<.0001
Tmin	1	0.328	0.0797	16.9	<.0001
TOTR	1	-0.004	0.0007	17.3	<.0001

of disease 'P' can be computed theoretically and the expected probability (P) of disease for a given value of X_i is

$$P = \frac{\exp\left(\beta_0 + \sum_{i=1}^{m} \beta_i X_i\right)}{1 + \exp\left(\beta_0 + \sum_{i=1}^{m} \beta_i X_i\right)}$$

$$Z = \left(\beta_0 + \sum_{i=1}^{m} \beta_i X_i\right)$$

where Z is a linear function of the predictor variables.

The mathematical form of the logistic regression equation yields 'S-shaped' prediction functions that arestrictly bounded on the unit interval ($0 < p < 1$). The name logistic regression follows from the regression equation being linear on the logistic, or log-odds scale.

In the second step, scale data of frog eye spot disease from tobacco fields were converted on 0 and 1 to enter in the logistic regression procedure of SAS (PROC LOGISTICS) along with the selected weather variables. The stepwise selection method was preferred over other selection procedures available in PROC LOGISTIC to build the models because, in the stepwise selection procedure, the variables have to meet both the entry as well as the retention criteria, which makes it a more stringent selection method.

RESULTS AND DISCUSSION

Scale data on frog-eye spot (FES) converted into 0 and 1(FES_code) and weather parameters were subjected to Logistic regression analysis similar to regression technique with different in the nature of dependent variable.The dependent variable assumes exactly two distinct value (0 or 1) represent status of phenomenon like absent or present of disease. This technique also provide reasonable estimate of probability of occurrence of phenomena. A logistic regression

Table 2: Estimates of odd ratio for weather parameters

Effect	Point estimate	95% Wald confidence limits	
BSS	1.694	1.248	2.300
Tmax	0.587	0.469	0.736
Tmin	1.387	1.187	1.622
TOTR	0.997	0.996	0.998

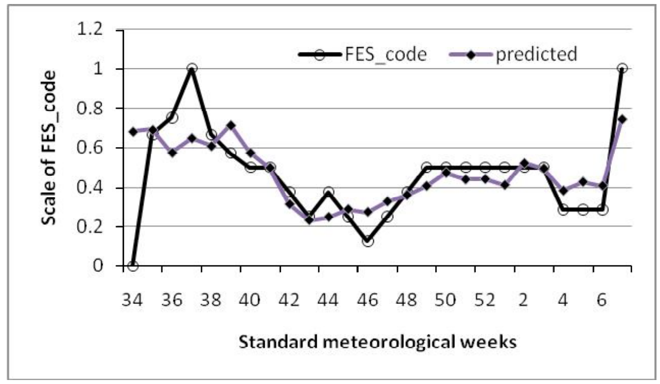

Fig 1: Predicted and observed FES_CODE over standard meteorological weeks

can formerly state as

$Z = \log(Pi/1\text{-}Pi) = a + b_1X_1 + b_2X_2 + \ldots\ldots.. + b_kX_k$

The variable Z is binary variable and takes 1 or 0 for disease (FES) present and absent and Xi are independent variable (weather parameters BSS, R, RD, WS, Tmax, Tmin, RH1, RH2, VP1 and VP2). The value of 'a' and 'bi' were estimated by maximum likelihood method using SAS 9.3 (PROC logistic).

The logistic regression model developed was as under.

$\text{FES\_code}(1,0) = \log(Pi/1 - Pi)$=9.2280 + 0.5272 ** BSS – 0.5321**Tmax + 0.3275 **Tmin – 0.00305** TOTR

The results of logistic regression analysis indicated that weather parameters BSS and Tmin formed positive and highly significant, whereas Tmax and TOTR were found negative and highly significant (Table 1). Thus if BSS and Tmin increase the disease FES also increases and Tmax and TOTR had negative effect on FES indicating that decreasing Tmax and TOTR cause increase in the FES (Harikrishnan and del Rio, 2008).

Further results of odd ratio (Table 2) indicated that every increase in 1 unit in BSS and Tmin, the risk of FES increases 1.7 and 1.4 times, respectively, whereas increase in 1 unit in Tmax and TOTR, the risk of FES decrease at rate of 0.6 and 1.0 times, respectively. The observed and predicted FES during different standard weeks are presented in Fig. 1.A predicted probability curves were produced for BSS, Tmax, Tmin and TOTR using logistic regression for each weather parameters. It was estimated that probability if disease initiation > 0.5 when the BSS was > 8.5 hrs and Tmax was 31^{0}C, Tmin was > 18 ^{0}C and TOTR< 750 mm.

On the basis of overall results it can be concluded that the weather parameters BSS, Tmax, Tmin and TOTR were responsible for FES in tobacco.

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