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Prediction of Bhendi Powdery Mildew Epidemics by First order Auto Regression Model

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ABSTRACT

Bhendi (*Abelmoschus esculentus* (L.) Moench) is globally important annual vegetable belongs to family malvaceae, it is most broadly distributed vegetable all over the world. Plant diseases are one of the major constraints in crop production with drastic losses in the quality and quantity of the produce. Powdery mildew of bhendi caused by *Erysiphe cichoracearum* DC. has become a major limiting factor affecting the economic production in North Karnataka. Epidemiological studies are important to understand the magnitude of inoculum load, development and progress of the disease, the perpetuation and dissemination of the pathogen. Epidemiological research knowledge plays an important role in the creation of prediction and forecasting models for disease progression in terms of disease incidence and environmental factors. Present studies were undertaken to develop prediction model for bhendi powdery mildew disease. Based on the observed PDI, the auto regressive model for *rabi,* 2019-20 was of the form Y = 7.90 + 0.86 X, with autoregression co-efficient as R = 0.91, whereas the autoregressive model for *rabi* 2020-21 was of the form Y = 7.579 + 0.849 X,with autoregression co-efficient as R = 0.902 where Y = Predicted PDI and X= observed PDI. This obtained first order auto regressive model would be more appropriate for the prediction and explaining epidemics of bhendi powdery mildew well in advance based on the previous week observed data.

Keywords Bhendi, Powdery mildew, *Erysiphe cichoracearum,* Auto regressive model, Epidemics.

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INTRODUCTION

Bhendi (*Abelmoschus esculentus* (L.) Moench) is globally important annual vegetable belongs to family malvaceae, it is most broadly distributed vegetable all over the world. In the world it is cultivated in tropical, sub-tropical and warm temperate regions. It is grown over an area of 534 thousand hectares with a production of 6,371 thousand metric tonnes in India

(Anon 2020). In Karnataka it is cultivated over an area of 10.91 thousand hectares with a production of 98.91 thousand metric tonnes. West Bengal has the largest area of 77.55 thousand ha followed by Gujarat (75.27 thousand ha). Gujarat ranks first in production (921.72 thousand metric tonnes) followed by West Bengal 914.86 thousand metric tonnes (Anon 2019). Many factors responsible for yield loss of the crop, one of them are the diseases which are the major constraints for low yield of bhendi (Sastry and Singh 1974). A number of fungal, bacterial and viral diseases have been reported in India. Among the fungal diseases affecting bhendi crop, powdery mildew caused by *Erysiphe cichoracearum* DC. is the most important disease causing considerable yield losses.

The disease initiates as white minute powdery patches first on the upper surface of leaf and lower older leaves and then spreads to younger ones. Grayish white powdery coating is visible on severely affected leaves. Leaves finally show necrosis resulting in withering, drying and defoliation (Sidappa *et al.* 2013). Powdery mildew affects plants at all the growth stages and may result yield losses up to 17 to 86.6% (Sridhar and Sinha 1989).

Epidemiological studies are important to understand the magnitude of inoculum load, development and progress of the disease, the perpetuation and dissemination of the pathogen. Epidemiological research knowledge plays an important role in the creation of prediction and forecasting models for disease progression in terms of disease incidence and environmental factors. The study on powdery mildew development in relation to environmental factors would also help us to quantify the correlation and the variability among the different independent variables on the dependent variable and further helps in developing suitable auto-regression model.

MATERIALS AND METHODS

Phytoepidemiology has attracted people with different professional back ground, which deals with dynamics of plant pathogens infecting the host population. In the last few years, there has been a considerable advancement in epidemiology and disease forecasting. In the light of the above, present studies were undertaken to develop prediction model for bhendi powdery mildew disease.

Highly susceptible variety Arka anamika was selected and raised with recommended package of practices for crop establishment except for the management of powdery mildew disease. Development of powdery mildew disease was studied in relation to previous disease intensity by using first order auto regression model.

The powdery mildew disease was recorded on 10 randomly selected plants by following 0-5 scale (Som Prakash and Saharan 1999) at an interval of seven days starting from the first appearance of the disease till maturation of leaves. PDI was calculated by using formula given by Wheeler (1969). Later the disease was predicted using first order auto regression model developed by Nargund (1989), Benagi (1995), Amaresh and Nargund (2002), Aswathanarayana and Nargund (2007).

First order auto regression model:

$Y_{t+1} = aY_t + e_{t+1}$

Y_{t+1} = Predicted PDI at time t+1

Y_t = Observed PDI at time t

t = Time of interval

a = A parameter

e_{t+1} = Error associated with the model at time t+1

The value of "a" was obtained with the help of following formula

$$a = \frac{\sum yt + 1 \times yt}{\sum yt^2}$$

RESULTS AND DISCUSSION

The disease development was predicted using the first order auto regression model as explained in "Materials and Methods". The observed and predicted values of PDI so obtained are presented in Tables 1, 2.

Table 1. Disease progression and apparent rate of infection on bhendi powdery mildew during *rabi* 2019-20. *DAS - Days after sowing . PDI - Percent disease index.

Standard meteoro-logical weeks	Crop age (DAS)	PDI (%)	AUDPC between to consecutive weeks	Apparent rate of infection (r) between two consecutive weeks
42	48	0.00	-	-
43	55	4.56	59.99	-
44	62	12.58	139.37	0.157
45	69	27.24	211.71	0.136
46	76	33.25	250.49	0.041
47	83	38.32	342.44	0.032
48	90	59.52	462.49	0.123
49	97	72.62	528.15	0.084
50	104	78.28	480.34	0.044
51	111	58.96	344.82	-0.131
52	118	39.56	138.46	-0.112

Table 2. Disease progression and apparent rate of infection on bhendi powdery mildew during *rabi* 2020-21. *DAS - Days after sowing. PDI - Percent disease index.

Standard meteoro-logical weeks	Crop age (DAS)	PDI (%)	AUDPC between two Consecutive weeks	Apparent rate of infection (r) between two consecutive weeks
42	48	0.00	-	-
43	55	4.65	52.15	-
44	62	10.25	124.35	0.121
45	69	25.28	201.46	0.155
46	76	32.28	243.67	0.049
47	83	37.34	328.72	0.032
48	90	56.58	448.35	0.112
49	97	71.52	514.5	0.094
50	104	75.48	452.09	0.029
51	111	53.69	312.69	-0.139
52	118	35.65	124.77	-0.105

During *rabi* 2019-20, the observed PDI varied from 4.56 to 78.28 and the difference in PDI was not in regular form. The difference between observed and predicted PDI was maximum at 48th SMW. On par difference between observed and predicted PDI was observed at 44th, 46th and 47th SMW (Fig. 1).

Based on the observed PDI, the auto regressive model for *rabi*, 2019-20 was of the form

$$Y = 7.90 + 0.86\ X,$$

With auto regression co-efficient as R = 0.91
Where Y = Predicted PDI and X= observed PDI

During *rabi* 2020-21, the observed PDI varied from 4.65 to 75.48 and the difference in PDI was not in regular form. The difference between observed and predicted PDI was maximum at 48th SMW. On par difference between observed and predicted PDI was observed at 44th and 47th SMW (Fig. 2).

Based on the observed PDI, the autoregressive

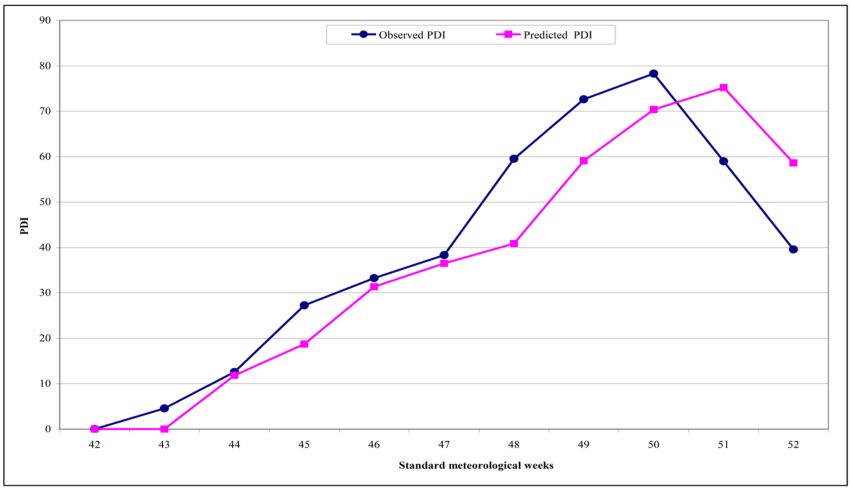

Fig. 1. Observed and predicted PDI of bhendi powdery mildew by first order auto regression model during *rabi* 2019-20.

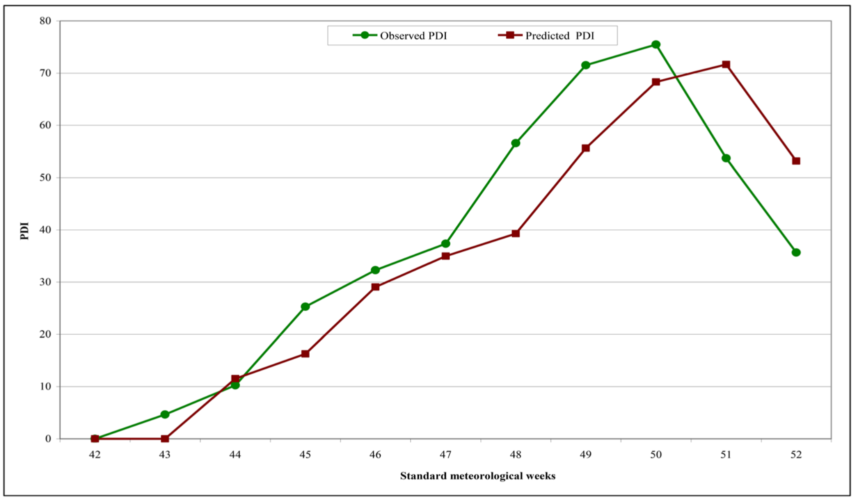

Fig. 2. Observed and predicted PDI of bhendi powdery mildew by first order auto regression model during *rabi* 2020-21.

model for *rabi* 2020-21 was of the form

$$Y = 7.579 + 0.849 X,$$

With auto regression co-efficient as R = 0.902
Where Y = Predicted PDI and X= observed PDI

The first order auto regressive model would be more appropriate for the prediction and explaining epidemics of powdery mildews well in advance based on the previous observed data. Similar observations were made by the workers viz., Amaresh and Nargund (2002) reported that, the predicted sunflower rust disease that varied from 0.00 to 60.93 and 0.00 to 63.41 PDI during 1998 to 1999 and 1999 to 2000, respectively. Aswathanaranyana and Naragund (2007) studied the powdery mildew of grape and predicted the disease development by following the first order auto regression model for the late *Kharif* 2002 and *rabi* 2002-03. They found that the predicted PDI for grape powdery mildew disease varied from 0.00 to 25.79 PDI and 0.00 to 11.38 PDI during late *kharif* 2002 and *rabi* 2002-03 respectively, with correlation co-efficient as 0.926 and 0.978 respectively. Similarly, Basavaraj *et al.* (2018) developed an auto regression model for the prediction of cucumber powdery mildew disease and he observed that, the predicted PDI forcucumber powdery mildew varied from 0.00 to 70.13 PDI and the difference between observed and predicted PDI was maximum at 48th SMW (14.57 PDI). On par difference observed and predicted PDI was observed at 44th and 46th SMW.

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