

## Weather based forewarning model for *Alternaria* leaf spot of safflower (*Carthamus tinctorius* L.) in scarcity zone of Maharashtra

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### ABSTRACT

An experiment was carried out in post rainy (*rabi*) seasons of 2006-07 to 2010-11 for studying the effect of environmental factors and crop phenology on *Alternaria* leaf spot disease development in safflower under three different sowing conditions viz., early, normal and late at Zonal Agricultural Research Station, Solapur in Maharashtra, India. The studies revealed that subnormal temperature coupled with above normal humidity and rainfall contributed significantly for the disease incidence and its spread under different sowing situations. Safflower plants were susceptible to *Alternaria carthami* at all growing stages, but susceptibility increased as the plants matured. Further, the percent disease index (PDI) has progressed at linear rate throughout the plant growth and it was negatively correlated with maximum temperature under late sown condition, while it was positively correlated with rainfall, minimum temperature, relative humidity (morning and evening) in addition to age of crop. By employing step down linear regression models, the incidence of *Alternaria* leaf spot on safflower can be predicted to an extent of 97.6%, 95.3% and 92.2% accuracy under early, normal and late sowing conditions, respectively while with non-linear models the prediction rate for the leaf spot under above sowing situations was improved to 99.8%, 99.6% and 99.4%, respectively.

**Keywords :** *Alternaria carthami*, *Carthamus tinctorius* L., linear and non-linear regression models, safflower

The leafspot disease caused by *Alternaria carthami* Chowdhary is a major destructive disease of safflower (*Carthamus tinctorius* L.) grown in India. The disease is endemic in most of the safflower growing areas of Maharashtra which infects the leaves, stem, head, seed etc. and causes severe seed yield loss and also deterioration in the quality of the seed. Under severe infections, disease has been reported to cause 50 per cent loss in seed yield (Indi *et al.*, 1986). Weather conditions play a predominant role in determining the course and severity of epidemics. Along with the weather factors, crop factors viz., age of the crop also contributes for the disease incidence and spread significantly (Ojiambo *et al.*, 1999). Hence, an attempt was made to study the role of different weather parameters viz., rainfall, relative humidity and temperature along with the crop factor i.e. age of the crop on infection and development of *Alternaria* leaf spot of safflower and secondly to develop forewarning model for predicting disease incidence in advance.

### MATERIALS AND METHODS

The effect of weather factors like temperature (maximum and minimum), relative humidity (morning and evening in per cent), rainfall (mm) along with one crop factor i.e. age of the crop, on the incidence and development of leafspot disease were studied at the Zonal Agricultural Research Station, Solapur of Maharashtra, India. The weekly meteorological observations recorded by automatic weather station (AWS-KEPL) at Zonal Agricultural Research Station, Solapur were used for this experiment. The field experiment was conducted for five consecutive years from 2006-07 to 2010-11 in post rainy (*rabi*) seasons on medium black soil with three sowing dates. The cultivar Phule Kusuma was sown in three plots measuring 500 m<sup>2</sup> each at 15 to 20 days interval i.e. second fortnight of August (early), second fortnight of September (normal) and first/second fortnight of October (late). The crop was fertilized at the rate of 50 kg N and

**Table 1:** Effect of weather and crop factors on PDI of *Alternaria* leaf spot of safflower during 2006-07 to 2010-11 (post rainy/*rabi* season)

MW	ADG	PDI	Rate of Increase	Rainfall (mm)	T <sub>max</sub> (°C)	T <sub>min</sub> (°C)	RH-I (%)	RH-II (%)	Crop age
Early sowing									
36	0.27	3.0	3.0	67.9	31.5	22.1	90	65	20
37	0.34	3.8	3.8	44.8	31.7	22.3	91	63	25
38	1.39	15.4	11.6	41.2	31.3	22.3	90	69	31
39	2.42	26.9	11.4	30.3	32.2	22.3	89	59	33
40	3.30	36.6	9.7	48.6	31.8	21.6	88	59	35
41	4.30	47.7	11.1	2.7	33.1	20.6	81	44	39
42	5.31	59.0	11.3	5.4	33.5	20.0	79	43	46
43	6.12	68.0	9.0	0.1	33.1	17.9	74	35	54
44	6.50	72.3	4.2	1.4	32.3	17.5	74	43	62
45	7.12	79.2	6.9	23.7	31.8	18.3	79	46	67
46	7.37	81.9	2.8	5.9	31.4	18.1	79	44	76
47	7.80	86.7	4.8	4.7	31.0	17.0	76	45	83
48	7.96	88.5	1.8	0.3	31.2	15.9	73	42	89
49	8.00	88.9	0.4	0.4	31.1	15.2	76	39	92
50	8.04	89.4	0.4	2.5	30.7	15.2	81	43	95
51	8.16	90.7	1.3	0.0	31.0	13.4	77	39	100
52	8.16	90.7	0.0	0.1	31.2	13.7	75	38	105
Normal sowing									
40	0.38	4.2	4.2	48.6	31.8	21.6	88	59	20
41	0.70	7.8	3.6	2.7	33.1	20.6	81	44	26
42	1.17	13.0	5.2	5.4	33.5	20.0	79	43	31
43	1.76	19.5	6.6	0.1	33.1	17.9	71	35	39
44	2.31	25.7	6.2	1.4	32.3	17.5	74	43	45
45	3.53	39.2	13.6	23.7	31.8	18.3	79	46	52
46	4.22	46.8	7.6	5.9	31.4	18.1	79	44	59
47	4.89	54.3	7.5	4.7	31.0	17.0	76	45	65
48	5.51	61.2	6.9	0.3	31.2	15.9	73	42	74
49	5.65	62.8	1.6	0.4	31.1	15.2	76	39	79
50	5.95	66.1	3.3	2.5	30.7	15.2	75	43	87
51	6.15	68.3	2.2	0.0	31.2	13.4	65	39	94
52	6.23	69.2	0.9	0.1	31.2	13.7	75	38	100
1	6.27	69.6	0.4	0.0	30.3	13.8	72	42	107
2	6.31	70.1	0.4	6.4	30.2	14.2	76	39	113
Late sowing									
43	0.09	1.0	1.0	0.1	33.1	17.9	71	35	20
44	0.33	3.6	3.6	1.4	32.3	17.5	74	43	23
45	1.22	13.6	10.0	23.7	31.8	18.3	79	46	28
46	1.89	21.0	7.4	5.9	31.4	18.1	79	44	34
47	2.30	25.6	4.6	4.7	31.0	17.0	76	45	43
48	3.11	34.6	9.0	0.3	31.2	15.9	73	42	49
49	3.65	40.6	6.0	0.4	31.1	15.2	76	39	54
50	4.01	44.6	4.0	2.5	30.7	15.2	81	43	63
51	4.03	44.8	0.2	0.0	31.2	13.4	77	39	69
52	4.19	46.6	1.8	0.1	31.2	13.7	75	38	78
1	4.23	47.0	0.4	0.0	30.1	13.8	77	42	84
2	4.25	47.2	0.2	6.4	30.2	14.2	76	39	93
3	4.25	47.2	0.0	0.0	31.4	13.9	71	34	99
4	4.25	47.2	0.0	0.0	32.8	13.6	68	29	104
5	4.31	47.9	0.7	0.0	33.4	15.9	63	33	115

**Table 2:** Correlation (r) and Regression coefficient (R<sup>2</sup>) for *Alternaria* leaf spot of safflower (2006-07 to 2010-11)

Parameter	Correlation coefficient (r)			Regression coefficient					
	Early	Normal	Late	Linear			Non-linear		
				Early	Normal	Late	Early	Normal	Late
Constant (Y)				-4.941	404.077	-72.362	-514.620	1569.773	279.200
T <sub>max</sub>	0.717**	0.375	-0.123	-	-10.707	-	-	-78.451	-
T <sub>min</sub>	0.726**	0.557*	0.641*	8.058	-	-1.463	-12.467	-	3.734
RH-I	0.404	0.218	0.454	-1.342	-0.570	1.321	14.731	-10.661	-9.331
RH-II	0.362	0.284	0.703**	-1.323	-	-	0.345	-	-
Rainfall	0.285	0.294	0.588*	0.173	-0.268	-0.277	0.019	-0.177	-0.280
Crop age	0.935**	0.961**	0.886**	1.387	0.371	0.499	2.943	2.462	2.018
R <sup>2</sup>				0.976	0.953	0.922	0.998	0.996	0.994

Table value of r at 5 % (\*) = 0.532 at 1 % (\*\*) = 0.661

25 kg P<sub>2</sub>O<sub>5</sub> per hectare as a basal dose. Recommended agronomic practices like spacing, weeding, hoeing, irrigations were followed as per the crop requirement. Crop was protected against aphid by spraying Dimethoate 30 EC @ 0.05%, twice during the crop growth. Twenty plants each from early, normal and late sown crop were tagged and scored for the *Alternaria* leaf spot disease at four days intervals using 0-9 scale (DOR, 2010).

The observations were made on disease severity starting from 20 DAS and till the end of the crop. The rate of increase of disease was calculated based on the average disease gradient (ADG) and percent disease index (PDI) was calculated (Mayee and Datar, 1986). Observations on maximum and minimum temperatures (T<sub>max</sub> and T<sub>min</sub>, respectively), relative humidity at morning and evening (RH-I and RH-II, respectively) and rainfall were recorded weekly from sowing to maturity. The averages of the meteorological week (MW) wise weather parameters over the period of experimentation were used in the correlation of the average disease intensity with different weather parameters along with the age of the crop. The data was again subjected to step down regression equations by eliminating the non-significant factors and including only significant factors and linear and non-linear regression equations were developed for disease prediction.

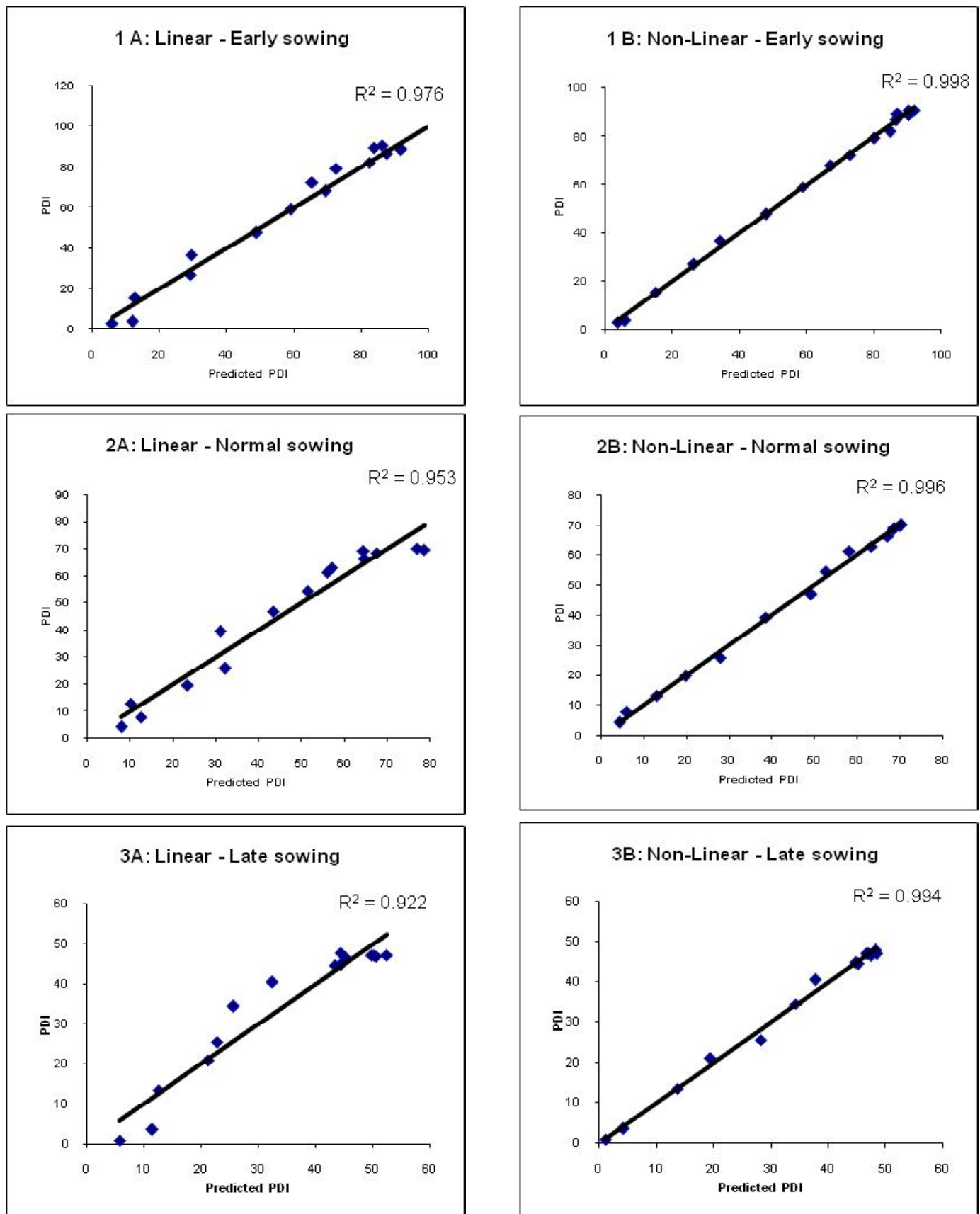
## RESULTS AND DISCUSSION

The experimental data (average of five years *i.e.* from 2006-07 to 2010-11) is presented in Table 1.

### *Correlation between rate of increase of disease with weather parameters and age of the crop*

The rate of disease build up at different stages of crop growth was correlated with weather parameters prevailed during the respective stage and the age of the crop under the three different sowing conditions. The correlation coefficients are presented in Table 2. The results revealed that maximum temperature was positively correlated with the disease development under early and normal sowings with correlation coefficient (r) values of 0.717 and 0.375, respectively. Minimum temperature was significantly positively correlated with the rate of increase of disease under different sowing conditions (r = 0.726, 0.557 and 0.641). The *Alternaria* leaf spot of safflower mainly depends on the weather. Excessive sporulation of the conidia and favourable incubation temperature has resulted in progressive increase of the disease during the study period. Murumkar *et al.*, (2008) reported that *Alternaria* leaf spot of safflower had positive correlation with rainfall, temperature and relative humidity under Solapur conditions. Arun Kumar *et al.*, (2011) reported similar results with *Alternaria* blight of chrysanthemum. Bhaskaran and Kandaswamy, (1980) have reported that prolonged minimum temperature of 20°C is highly congenial for the development of *Alternaria* leaf blight in sunflower.

The age of the crop played a crucial role in the disease development and spread during the crop growth period. As the age of the plant advanced, the percent of



**Fig. 1A to 3B:** Distribution plots depicting the mean predicted PDI to actual PDI values of *Alternaria* leaf spot of safflower under three sowing situations

leaf area showing symptoms linearly increased. Crop age showed a highly significant positive correlation with the PDI under all sowing conditions ( $r = 0.935, 0.961$  and  $0.886$  under early, normal and late sowing conditions, respectively).

#### **Disease prediction models**

The data was subjected to step down regression by eliminating the non-significant factors and including only significant factors under all sowing conditions for predicting the incidence of *Alternaria* leafspot of safflower for three different sowing situations using linear and non-linear models (Table 2). Coefficient of determination ( $R^2$ ) improved significantly when non-linear regression models were fitted for predicting the *Alternaria* leafspot incidence. By employing step down linear regression models, the incidence of *Alternaria* leaf spot on safflower can be predicted to an extent of 97.6%, 95.3% and 92.2% accuracy under early, normal and late sowing conditions, respectively. While with non-linear models the prediction rate for the leaf spot under above sowing situations improved to 99.8%, 99.6% and 99.4%, respectively (Fig. 1A to 3B). Vijayalakshmi *et al.*, (2009) reported that non-linear regression models are more precise over linear models for prediction of pests and diseases in groundnut. Moreover, Suresh *et al.*, (2012) also reported that among the regression models, non-linear model found to be the more precise for predicting the incidence of *Alternaria* leaf spot of safflower under southern Telangana zone of Andhra Pradesh. In present study, observed and predicted values from linear and non-linear model of PDI of *Alternaria* leaf spot of safflower are tested with Chi-square test for goodness of fit. As  $\chi^2_{\text{Cal}}$  is less than  $\chi^2_{\text{Tab}}$  for early, normal and late sowing situations for linear and non-linear model, hence the equations are best fit. The high  $R^2$  values under regression models, particularly in non-linear model confirm the validity of the model in estimating the percent disease index.

#### **CONCLUSION**

Forecasting the incidence and spread of leaf spots helps in adopting effective fungicidal spray schedule. The correlation and regression analysis clearly indicated the importance of weather factors and crop age in the prediction of *Alternaria* leaf spot of safflower. Among the regression models, non-linear model found to be the more precise,

compared to linear model, for predicting leafspot incidence and further spread. Hence, these models can be utilized in Agro-Advisories for *Alternaria* leaf spot prediction of safflower after validation.

#### **REFERENCES**

- Arun Kumar, G.S., Kamanna, B.C. and Benagi, V.I. (2011). Effect of environmental factors on leaf blight disease development in chrysanthemum. *Plant Arch.*, 11(2): 575-578.
- Bhaskaran, R. and Kandaswami, T.S. (1980). Epidemiology of leaf spot disease of sunflower. *East Afr. Agric. For. J.*, 43: 5-8.
- DOR. (2010). AICRP on Safflower: Technical programme (2010-11) and guidelines for implementation. Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500030 (India), pp. 40.
- Indi, D.V., Lukade, G.M. and Patil, P.S. (1986). Influence of *Alternaria* leaf spot (*Alternaria carthami* Chowdhary) on growth and yield of Safflower. *Curr. Res. Rep.*, 2(1): 137-139.
- Mayee, C.D. and Datar, V.V. (1986). "Diseases of safflower, Phytopathometry". A technical bulletin published by Marathwada Agric. Univ., Parbhani (M.S.), India, pp. 100-104.
- Murumkar, D.R., Gud, M.A., Indi, D.V., Shinde, S.K. and Kadam, J.R. (2008). Development of leaf spot of safflower (*Alternaria carthami*) in relation to weather parameters. *J. Plant Dis. Sci.*, 3(2): 201-205.
- Ojiambo, P.S., Ayiecho, P.O. and Nyabundi, J.O. (1999). Effect of plant age on sesame infection by *Alternaria* leaf spot. *Afr. Crop Sci. J.*, 7(1): 91-96.
- Suresh, M., Kishore Varma, P., Sudhakar, C., Sameer Kumar, C.V. and Vishuvaradhan Reddy, A. (2012). Weather based fore-warning model for *Alternaria* leaf spot of safflower (*Carthamus tinctorius* L.) in southern Telangana zone of Andhra Pradesh. *J. Oilseeds Res.*, 29(Spl. Issue): 354-359.
- Vijayalakshmi, K., Raji Reddy, D., Varma, N.R.G. and Pranuth, G. (2009). Weather based pest and disease forewarning models in groundnut in the context of climate change. *Proc. Impact of climate change on Agriculture*, pp. 48-50.