



Forewarning Models for *Alternaria* blight in mustard crop*

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Agriculture is the most important sector in India which accounts for 25% of the gross domestic product (GDP). There is considerable loss (30-40%) in the yield of the crop due to the infestation of various pests and diseases. Such losses can be reduced to a considerable extent if their occurrence is known in advance so that timely remedial measures may be taken. A disease/pest can only progress if the conditions provided by the host plants and weather conditions are favourable and if some inoculum is present. Weather conditions are responsible for infestation of pests and diseases in the crop. It is therefore, usual to make prediction only after certain biological and meteorological conditions favourable to the disease/pest have been fulfilled. Thus there is a need to develop forewarning systems which can provide advance information for outbreak of pests/diseases attack on the basis of weather parameters so that protection measures can be implemented before the actual onset of the damage. Most of the earlier workers have utilised regression models (both linear and non-linear) for pests/diseases forewarning (Agrawal *et al.* 2004, Chattopadhyay *et al.* 2005a, 2005b; Desai *et al.* 2004 and Dhar *et al.* 2007].

In this study data have been taken from Mission Mode Project under National Agricultural Technology Project, entitled “Development of weather based forewarning system for crop pests and diseases” at CRIDA, Hyderabad. Models were developed for forecasting different aspects relating to diseases for *Alternaria* blight (AB) in mustard crop. In mustard, field trials were sown on 10 dates at weekly intervals (01, 08, 15, 22, 29 October, 05, 12, 19, 26 November and 03 December) at each of the locations, viz. Bharatpur, Dholi and Behrampur for *Alternaria* blight laid out in 2001–02 to 2005–06, 1999–2000 to 2003–04 and 2000–01 to 2003–04 for Bharatpur, Behrampur and Dholi respectively. Observations for percent disease severity were recorded every week until harvesting of crop and hence crop age at first

appearance of diseases, crop age at peak severity of disease and maximum severity of diseases were obtained. Data for different dates of sowing were taken together for model development. Weekly data on weather parameters starting from week of sowing up to six weeks of crop were considered for forewarning various characters such as crop age at first appearance of disease, crop age at peak severity of disease and maximum severity of diseases in two varieties (Varuna and Rohini – Bharatpur, Varuna and Binoy – Behrampur and Varuna and Pusabold – Dholi) for different locations for *Alternaria* blight on leaf and pod portion of plant.

The extent of weather influence on crop pests/diseases depends not only on the magnitude but also on the distribution pattern of weather variables over the crop season which, as such, calls for the necessity of dividing the whole crop season into fine intervals. This will increase number of variables in the model and in turn a large number of model parameters will have to be evaluated from the data. This will require a long series of data for precise estimation of parameters which may not be available in practice. Thus, a technique based on relatively smaller number of manageable variables and at the same time taking care of entire weather distribution, weather indices were obtained which were used as predictors for models development. Weather variables on maximum temperature, minimum temperature, morning relative humidity and evening relative humidity (MAXT, MINT, RHI and RHII) for the period from 2001–02 to 2005–06, 1999–2000 to 2003–04 and 2000–01 to 2003–04 for Bharatpur, Behrampur and Dholi respectively were considered for model development for *Alternaria* blight.

Models were developed for forewarning crop age at first appearance of *Alternaria* blight (Y_1), crop age at peak severity of *Alternaria* blight (Y_2) and maximum severity of *Alternaria* blight (Y_3) for different locations. The extent of weather influence on aphid development depends not only on the total magnitude but also on the distribution of weather variables over small time intervals. But use of data in small time intervals will increase the number of variables in the model and in turn a large number of model parameters will

*Short note

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have to be evaluated from the data. This will require a long series of data for precise estimation of the parameters which may not be available in practice. Thus, a technique based on relatively smaller number of model parameters and at the same time taking care of entire weather distribution may solve the problem. The simplest way to solve the problem is to take weighted accumulation of weather variables, giving weights according to their importance in different time periods. In this study, two approaches were tried using weekly weather data. In the first approach, unfavourable/favourable/highly favourable ranges of weather variables were obtained

based on experience of experts. This information was utilized to decide the weights (subjective) depending on values of the weather variables in different weeks pertaining to these ranges. However, the results of this approach were not found to be satisfactory. The other approach was based on objective weights where correlation coefficients between variable to forecast and weather variables were taken as the indicators of relative importance in respective weeks. In this approach, for each weather variable two indices were developed, one as simple total value of weather variables and the other one as weighted total, weights being correlation coefficients

Table 1 Models to forecast different character of *Alternaria* blight in mustard crop along with coefficient of determination and MAPE in different varieties

Location	Variety	Character	Model	R ²	MAPE
Bharatpur	Rohini (on Leaf)	Y ₁	81.16 – 1.38 Z ₂₀ + 0.06 Z ₁₂₁ + 0.001 Z ₃₄₁	0.75	8.9
		Y ₂	2.95 + 0.75 Z ₁₁	0.82	26.2
		Y ₃	7.59 + 0.006 Z ₂₃₁	0.40	196.3
	Rohini (on Pod)	Y ₁	11.42 + 0.0012 Z ₃₄₀ + 0.026 Z ₂₃₁	0.29	24.7
		Y ₂	87.10 – 00.01 Z ₂₄₀ + 0.01 Z ₂₃₁ + 0.08 Z ₂₄₁	0.40	17.6
		Y ₃	26.94 + 0.06 Z ₃₁ + 0.001 Z ₂₄₁	0.63	229.6
	Varuna (on Leaf)	Y ₁	60.65 + 0.002 Z ₃₄₀ + 0.01 Z ₁₂₁ + 0.006 Z ₃₄₁	0.78	14.7
		Y ₂	7.82 + 0.54 Z ₁₁ + 0.005 Z ₂₃₁	0.83	22.3
		Y ₃	– 4.68 + 0.34 Z ₁₁	0.58	150.1
	Varuna (on Leaf)	Y ₁	36.11 + 0.08 Z ₃₁	0.60	14.2
		Y ₂	– 222.95 + 4.43 Z ₂₀ – 0.14 Z ₁₂₀ + 3.61 Z ₁₁ + 2.38 Z ₃₁	0.63	5.4
		Y ₃	68.41 – 0.02 Z ₁₃₀ + 0.66 Z ₂₁ + 0.04 Z ₁₃₁	0.71	132.6
Dholi	Pusa Bold (on Leaf)	Y ₁	28.79 – 0.01 Z ₂₄₀ + 0.04 Z ₁₂₁ + 0.002 Z ₁₃₁	0.96	10.4
		Y ₂	24.29 – 0.001 Z ₁₄₀ + 0.01Z ₁₃₁	0.72	7.0
		Y ₃	– 87.90 + 17.56 Z ₂₀ + 31.64 Z ₂₁ + 2.32 Z ₃₁	0.52	48.5
	Pusa Bold (on Pod)	Y ₁	68.95 + 0.39 Z ₄₁ + 0.01 Z ₁₂₁ + 0.007 Z ₁₃₁	0.83	6.9
		Y ₂	81.10 – 0.003 Z ₂₄₀ + 0.01 Z ₁₂₁ + 0.005 Z ₁₄₁	0.87	3.3
		Y ₃	144.65 + 1.87 Z ₃₁ + 0.33 Z ₄₁ + 0.01 Z ₁₃₁	0.77	91.8
	Varuna (on Pod)	Y ₁	72.89 – 2.11 Z ₂₁ + 3.35 Z ₄₁ + 0.07 Z ₁₂₁ – 0.02 Z ₃₄₁	0.93	8.4
		Y ₂	– 17.86 – 0.05 Z ₂₄₀ + 0.01Z ₁₃₁ – 0.007Z ₂₃₁ + 0.10 Z ₂₄₁	0.84	9.3
		Y ₃	– 59.10 + 1.72 Z ₃₁ + 0.015 Z ₁₂₁	0.55	51.9
	Varuna (on Pod)	Y ₁	– 206.31 + 0.61 Z ₃₀ + 0.02 Z ₁₂₁ + 0.005 Z ₃₄₁	0.79	3.9
		Y ₂	106.97 -0.03 Z ₂₃₀ + 0.029 Z ₁₂₁ + 0.03 Z ₂₃₁	0.87	3.0
		Y ₃	121.89 + 0.02 Z ₁₃₀ + 0.045 Z ₁₃₁ – 0.01 Z ₁₄₁	0.87	88.9
Behrampur	Binoy (on Leaf)	Y ₁	57.38 – 0.025 Z ₁₄₁ + 0.03 Z ₂₄₁	0.54	12.4
		Y ₂	92.84 + 5.17 Z ₂₁ + 3.94 Z ₃₁ – 0.11 Z ₁₂₁	0.61	9.7
		Y ₃	– 93.70 + 4.91 Z ₁₀ + 0.06 Z ₂₃₀ + 0.31 Z ₁₂₁	0.62	61.0
	Binoy (on Pod)	Y ₁	– 99.41 + 0.021 Z ₁₃₁	0.62	12.6
		Y ₂	93.91 – 0.04 Z ₂₄₀ + 0.09 Z ₂₄₁ – 0.004 Z ₃₄₁	0.61	2.9
		Y ₃	170.01 + 0.01 Z ₁₃₁ + 0.005 Z ₂₃₁	0.50	182.7
	Varuna (on Leaf)	Y ₁	59.21 + 0.56 Z ₃₀ + 5.67 Z ₃₁ + 0.03 Z ₁₂₁	0.57	22.3
		Y ₂	213.53 – 0.01 Z ₁₃₀ – 0.003 Z ₁₄₀ + 0.09 Z ₁₂₁	0.67	9.7
		Y ₃	125.08 + 9.19 Z ₁₀ + 27.51 Z ₁₁	0.46	61.9
	Varuna (on Pod)	Y ₁	188.16 + 1.55 Z ₃₁ + 1.15 Z ₄₁ + 0.03 Z ₁₂₁	0.56	23.3
		Y ₂	148.25 + 1.66 Z ₃₁ + 0.02 Z ₁₂₁	0.60	7.4
		Y ₃	– 31.168 – 0.007 Z ₂₄₀ + 0.01 Z ₃₄₁	0.53	68.1

between variable to forecast and weather variables in respective weeks. The first index represents the total amount of different weather variables received by the crop during the period under consideration while the other one takes care of distribution of weather variables with special reference to its importance in different weeks in relation to the variable to forecast. Similarly, for joint effects of weather variables, weather indices were developed as weighted accumulations of product of weather variables (taken 2 at a time), weights being correlation coefficients between variable to forecast and product of weather variables considered in respective weeks. The form of the model was [Agrawal *et al.* 1986 and Agrawal and Mehta 2007].

$$Y = a_0 + \sum_{i=1}^p \sum_{j=0}^p a_{ij} Z_{ij} + \sum_{i \neq 0}^p \sum_{j=0}^1 b_{ii'j} Z_{ii'j} + e$$

where

$$Z_{ij} = \sum_{w=n_1}^{n_2} r_{iw}^j X_{iw}$$

$$Z_{ii'j} = \sum_{w=n_1}^{n_2} r_{ii'w}^j X_{iw} X_{i'w}$$

Y, variable to forecast; X_{iw} , value of i th weather variable in w th week; r_{iw} , correlation coefficient between Y and i th weather variable in w th week; $r_{ii'w}$, correlation coefficient between and product of X_i and $X_{i'}$ in w th week; p , number of weather variables used; n_1 , initial week for which weather data were included in the model; n_2 , final week for which weather data were included in the model; e , error term.

Stepwise regression technique was used for selecting important variables to be included in the model. The forecasting performance of various models were judged by Mean Absolute Percentage Error (MAPE).

$$MAPE = \frac{1}{n} \sum \left| \frac{(Y_t - F_t)}{Y_t} \right| \times 100$$

where Y_t is actual observation F_t is the forecast form models and n is the total number of tested data.

Models along with coefficients of determination (R^2) and Mean Absolute Percentage Error (MAPE) is given in Table 1 which indicate that the models fitted well because the coefficients of determination are highly significant in most of the cases. MAPE are in the affordable range. The MAPE is high for maximum severity this may be due to sampling fluctuations. Forecasts from the models were very close to the observed values in subsequent years. Therefore these models, based on weekly weather data starting from week of sowing up to six weeks of crop growth, can be used

for reliable forewarning of *Alternaria* blight.

SUMMARY

The reliable forewarnings through this approach are possible well in advance. In general, the models fitted well with all the coefficients of determination are highly significant. Forecasts from the models were very close to the observed values in subsequent years. Therefore these models, based on weekly weather data starting from week of sowing up to six weeks of crop growth, can be used for reliable forewarning of *Alternaria* blight. Therefore, reliable forewarning for crop age at first appearance of disease, crop age at peak severity of disease and maximum severity of diseases in different two varieties of mustard crop for *Alternaria* blight are possible well in advance.

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CORRIGENDUM

In article entitled “Yield and nutrient uptake of isabgol (*Plantago ovata*) in response to sowing dates and spacing” in *The Indian Journal of Agricultural Sciences* **80**(12): 1102–4 by Sudeep Singh, G S Buttar and Parmjit Singh, on page no. 1102 in the lines 12 and 13 in the second column please read in subplots with 4 replications in place of in subplots with 5 replications and on page 1103 in Table 1 seed yield of row spacing in tonnes/ha in place of q/ha as given below.

In Table 1 Last column of seed yield (tonnes/ha)

Treatment	2006–07	2007–08	Mean
<i>Date of sowing</i>			
15 November	0.74	0.76	0.75
30 November	0.67	0.52	0.59
LSD ($P = 0.05$)	NS	0.10	
<i>Row spacing</i>			
22.5 cm	0.73	0.74	0.73
30 cm	0.68	0.54	0.61
LSD ($P = 0.05$)	0.03	0.18	

CORRIGENDUM

In research article, “Impact of biopesticide formulation on tomato (*Lycopersicon esculentum*): economics and environmental effects” by Sumitra Arora, Ashok K Kanojia, Ashok Kumar, H R Sardana and Susheel Kumar Sarkar, published in December issue of 2012, pp 1075–8, one column of Table 1 should be read as given below. The interpretation of table should be read as given below the table.

Table 1 Assessment of EIQ Field use ratings based on application of pesticides

Stage of application	Pesticides/ biopesticides/ bioagents applied	Field use rating
<i>IPM field data</i>		
<i>Nursery treatment</i>		
Soil	<i>Trichoderma harzianum</i>	
	Neem cake	3.02
Seed treatment	<i>T. harzianum</i>	
	Copper oxychloride	
<i>Main field</i>		
Seedling treatment	Imidacloprid	0.65
	NSKE	0.12
	<i>Trichogramma chilonis</i>	
	HaNPV	
	Emamectin benzoate	0.66
	Ridomyl MZ (metalaxyl+ mancozeb=8 + 64% WP)	35.97
Total environmental impact		40.42
<i>Non-IPM fields</i>		
<i>Nursery treatment</i>		
	captan	15.77
	Mancozeb	19.29

Table Contd.

Table 1 (Concluded)		
Stage of application	Pesticides/ biopesticides/ bioagents applied	Field use rating
<i>Main field/crop</i>		
	Endosulfan	53.97
	Cypermethrin	4.54
	Profenophos	59.53
	Indoxacarb	4.52
	Quinalphos	21.43
	Ridomyl	14.87
	Dithane M-45	38.58
	Methomyl	8.8
Total environmental impact		241.3
<i>Organic fields</i>		
	Neem oil	3.6
<i>ITK treated BPF</i>		
<i>BPF@ 5%</i>		
Nursery treatment	Neem leaves (Azadirachtin)	0.033275
Main field/Crop	Neem leaves (Azadirachtin)	0.06655
<i>BPF @ 10%</i>		
Nursery treatment	Neem leaves (Azadirachtin)	0.1331
Main field/Crop	Neem leaves (Azadirachtin)	0.2662
Total Environmental Impact		0.499
BPF, Biopesticide formulation		
<p>Data analysis for EIQ field use ratings (Table 1) shows that BPF treatment has the least value followed by organic treatments as compared with IPM and non-IPM treatments. Although the EIQ field use rating (FUR) for IPM experiments is far below than values in check/ non-IPM field trials, but incomparable with BPF treated trials. The relative high FUR (~40) in IPM trials is for the use of two applications of Ridomyl MZ, which is mixture of two fungicides (metalaxyl and mancozeb), and high toxicity value of their active ingredients. The FUR value for non-IPM trials are observed to be extremely high (> 240) for inclusion of pesticides with high toxicity values. It is very interesting to observe that endosulfan has lower toxicity as per its EIQ value, in comparison with quinalphos and profenophos, but its FUR is comparable with profenophos and higher than quinalphos. Cypermethrin and indoxacarb insecticides, with two applications each, have comparable higher EIQ values but their FUR values are quite low. On comparing different pesticides within an IPM package, NSKE treatment is observed to be the best followed by imidacloprid and emamectin benzoate. Ridomyl MZ, being mixture of two fungicides (metalaxyl and mancozeb), is observed as the most toxic treatment because of combined EIQ values, giving major contribution in total environmental impact. For non-IPM trials, the safer pesticides observed are cypermethrin, indoxacarb and methomyl as per their FUR values. For organic and BPF treatments, the FUR values are negligible for not inclusion of any synthetic pesticide application. These two treatments therefore strongly favour safety of environment for tomato crop.</p>		