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Epidemiology of leaf spot and flower blight of marigold caused by *Alternaria tenuissima* under the South Gujarat condition

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Abstract
Marigold (*Tagetes* spp.) is one of the most popular traditional flower crops grown commercially in different parts of India. It is also an important commercial crop grown in the South Gujarat. In the present study, field experiment was conducted on epidemiological studies during *Kharif* 2020 and 2021 at Floriculture Research Farm, Navsari Agricultural University, Navsari, Gujarat, India, on variety Punjab Gainda-1 of marigold under natural conditions. Effect of different weather parameters on percent disease intensity of leaf spot and flower blight incidence of marigold caused due to *Alternaria tenuissima* were studied using simple correlation technique and regression coefficient to study the development of disease. The maximum percent disease intensity of leaf spot and flower blight incidence were recorded when maximum temperature was in the range of 29.8 °C to 32.3 °C, minimum temperature in the range of 23.2 °C to 24.3 °C, rainfall in the range of 67 mm to 148 mm, evening relative humidity in the range of 81.2% to 85.1% and bright sunshine hours of 2.9 hrs/day to 4.5 hrs/day, as they were most favourable conditions for the rapid development of leaf spot and flower blight of marigold. Correlation matrix revealed that the percent disease intensity and flower blight incidence had highly significant positive correlation with maximum temperature and bright sunshine hours. By working out the stepwise regression it was noticed that at least 90.5 percent variation in percent disease intensity of leaf spot was due to function of weather parameters *viz*., rainfall and minimum temperature and for flower blight incidence 74.3 percent variation was due to bright sunshine hours. This forecasting models can be used as an aid for farmers by forewarning them prior to disease development and hence managing the disease more efficiently.

Keywords: Leaf spot and flower blight, forecasting, correlation, regression

Introduction
Marigold (*Tagetes* spp.) is one of the most popular traditional flower crops grown commercially in different parts of India and Gujarat. Portuguese introduced the flower in India during the 16th century, since then it has been acclimatized in different parts of the country. The marigold belongs to the family Asteraceae and genus *Tagetes*, native to Central and South America especially, Mexico. They are cultivated as annuals mainly during *kharif* and also during summer and winter. The two mains popularly grown species of marigold are *Tagetes erecta* Linn. (African marigold) and *Tagetes patula* Linn. (French marigold). The area under marigold is increasing but overall yield with regard to flower and seed production is decreasing. The reason behind this is the foliar pathogen *Alternaria tenuissima*, which causes leaf spot and flower blight of marigold causing severe damage to the crop.
Epidemiological studies of the pathogen are required for effective management strategies of the disease affecting marigold crop. Epidemiological study is helpful to know the time of occurrence and intensity of a particular disease. It reveals the association between various climatic factors and progress of the disease. The *Alternaria* blight has been recorded in summer, winter and rainy season, however, it is more severe during rainy season as it provides favorable climatic conditions for pathogen such as optimum temperature and high relative humidity.
Hence, present investigation was carried out with the aim to study the effect of various weather parameters on the leaf spot and flower blight of marigold.

Materials and methods
Prevalence of favorable weather conditions and availability of susceptible host play an important role in the process of disease development.

The field trials on epidemiological studies were conducted during *Kharif* 2020 and 2021 at Floriculture Research Farm, Navsari Agricultural University, Navsari on marigold variety Punjab Gainda-1. Seed sowing was done during mid-June in the nursery and transplanting of seedlings was done during mid-July into the field measuring 20 × 20 m. The plant spacing maintained between marigold plants was 60 × 40 cm. After the initiation of the disease, weekly observations of leaf spot severity and flower blight incidence were taken from 5 randomly selected one sq. m. area. Observations were taken from five plants from each one sq. m. area, so total 25 plants were taken for disease development from the time of initiation of the disease at weekly intervals.

The leaf spot intensity and flower blight incidence were recorded from the initiation of the disease at weekly intervals up to final harvest of crop using standard scale. Meteorological parameters (maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, total rainfall, total number of rainy days and wind velocity) were obtained from the Department of Meteorology, N. M. College of Agriculture, Navsari Agricultural University, Navsari and thereafter the correlation between the disease incidence and individual meteorological parameters was worked out. The leaves were assessed using 0-5 scale evolved by Hotchkiss and Baxter (1983) [1] (Table 1).

Table 1: Disease rating scal

Rating scale	Area of leaf infected (%)	Percent disease intensity
0	0	No visible symptom
1	0-10%	0-10% leaf area infected
2	11-20%	11-20% leaf area infected
3	21-30%	21-30% leaf area infected
4	31-40%	31-40% leaf area infected
5	*p*> 41%	*p*> 41% leaf areas infected

Percent leaf spot intensity (%) was calculated according to Mckinney (1923) [2]

$$\text{PDI (\%)} = \frac{\Sigma \text{ of ratings of infected leaves observed}}{\text{No. of leaves observed} \times \text{Maximum disease grade}} \times 100$$

The data on flower blight incidence was recorded from 25 randomly selected plants of marigold and percent flower blight incidence was calculated by the following formula.

$$\text{Flower Blight incidence(\%)} = \frac{\text{No. of infected flowers}}{\text{Total no. of flowers per plant}} \times 100$$

Results and Discussion

The experimental data on various weather parameters *viz*., maximum and minimum temperature, morning and evening relative humidity, rainfall, wind speed and bright sunshine hours (Average of two years *i.e*., 2020 and 2021) under the South Gujarat conditions was studied weekly and is presented in Table 2.

Progressive Percent Disease Intensity of Leaf Spot and Flower Blight Incidence

Percent disease intensity of leaf spot and flower blight incidence were comparatively more during the year 2021 than 2020. For pooled, the data are presented in Table 2 and Figure 1 and 2. The first leaf spot symptoms were recorded on 35th Standard Meteorological Week (13.60%) on Punjab Gainda-1. Since then, there was linear progress on percent disease intensity of leaf spot (13.60%) from 35th SMW to maximum PDI (70.53%) in 46th SMW. Percent disease intensity of leaf spot reached its periodical peak from 20.67 percent to 30.54 percent from 36th SMW to 37th SMW due to favourable weather conditions as maximum temperature (32.0°C and 32.3°C), minimum temperature (24.3°C and 24°C), morning relative humidity (94.7% and 95.1%), evening relative humidity (83.9% and 83.0%), rainfall (67 mm and 64.5 mm), wind speed (4.6 km/hr and 3.5 km/hr) and bright sunshine hours (3.0 hrs/day and 4.5 hrs/day), respectively. During 39th to 46th SMW, the periodical increase in disease intensity was found minimum that means the disease progress gradually slowed due to unfavourable weather conditions. Hence, the period of 36th to 37th SMW can be considered as window period for increase in percent disease intensity of leaf spots on marigold.

Flower blight incidence was first observed on 37th SMW as 17.04%. Since then, linear progress was noticed in flower blight incidence from 37th SMW (17.04%) to 46th SMW (74.27%). Flower blight incidence reached its periodical peak from 17.04 percent to 30.81 percent during 37th SMW to 38th SMW due to favourable weather conditions as maximum temperature (32.3°C and 32.0°C), minimum temperature (24.0°C and 23.9°C), morning relative humidity (95.1% and 96.0%), evening relative humidity (83.0% and 81.2%), rainfall (64.5 mm and 100.5 mm), wind speed (3.5 km/hr and 3.3 km/hr) and bright sunshine hours (4.5 hrs/day and 3.3 hrs/day), respectively. This period can be considered as peak period for flower blight incidence. From 41st to 46th SMW the progress of flower blight incidence declined due to weather conditions that were not favourable for the disease.

Correlation of Percent Disease Intensity of Leaf Spot and Flower Blight Incidence with Weather Parameters

The coefficient of correlation between leaf spot intensity and flower blight incidence with various meteorological parameters (maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall, wind speed and BSSH were worked out using simple correlation technique.

The correlation matrix was worked out for pooled (Table 3) and it was revealed that percent disease intensity of leaf spot had a highly significant positive correlation with maximum temperature (0.886**) and bright sunshine hours (0.860**). While it had a highly significant negative correlation with minimum temperature (-0.768**), evening relative humidity (-0.810**) and rainfall (-0.911**) and wind speed (-0.698**). Also, it was observed that there was significant negative correlation with morning relative humidity (-0.710) at 0.05 level of significance.

The correlation matrix for flower blight incidence is presented in Table 4. The data indicated that the flower blight incidence had a highly significant positive correlation with maximum temperature (0.850**) and BSSH (0.862**). It had a highly significant negative correlation with minimum temperature (-0.810**), evening relative humidity (-0.826**) and rainfall (-0.846**). While, it had significant negative correlation with morning relative humidity (-0.728*) and windspeed (-0.673*). Maximum temperature, bright sunshine hours and minimum temperature were playing an important key role in the development of leaf spot and flower blight of marigold as

compared to other parameters.

Stepwise Regression of Percent Disease Intensity of Leaf Spot and Flower Blight Incidence with Weather Parameters

The regression coefficient based on stepwise regression analysis for seven independent variables and to identify much critical variable (s) separately towards the percent disease intensity of leaf spot and flower blight incidence is worked out and presented. The result for stepwise regression of percent disease intensity of leaf spot indicated that R value was high (0.95), indicating strong association between percent disease intensity and weather parameter. The R^2 value was found to be high as 90.5 per cent. This clearly indicated that at least 90.5 percent of variation in percent disease intensity of leaf spot was explained by the function of weather parameters *viz*., rainfall and minimum temperature as evident from stepwise regression equation.

$$\hat{Y} = 119.576 + (-0.229)\ X_1 + (-2.876)\ X_2$$

Where
$\hat{Y}$ = Predicted disease incidence,
X_1= Rainfall and
X_2 = Minimum temperature.

For, flower blight incidence R value was high (0.86), indicating strong association between flower blight incidence and weather parameter. The R^2 value was found to be high as 74.3 per cent. This clearly indicated that at least 74.3 percent of variation in flower blight incidence was explained by the function of weather parameter *viz*., bright sunshine hours as evident from stepwise regression equation.

$$\hat{Y} = -15.870 + 10.345\ X_1$$

Where
$\hat{Y}$ = Predicted disease incidence,
X_1 = Bright sunshine hours.

These conditions were prevailing during 34th to 46th SMW when the crop was in vegetative and reproductive phase. This has caused severe loss and hence can be considered as a constraint in economic production of marigold in the South Gujarat.

The present findings are in accordance with previous work done by Patidar (2000) [3], where he observed that the disease incidence was maximum during September to October, during which the prevailing environmental conditions were temperature ranging from 22-30°C, high rainfall (111.9-132.2 mm) and 92% relative humidity, which favored the rapid disease development.

Uke (2011) [4] performed a field experiment to study the epidemiology of *Alternaria* blight of marigold. It was observed that minimum temperature showed a negative correlation while average relative humidity showed positive correlation with the disease intensity, respectively. The other meteorological parameters *viz*., maximum temperature, total rainfall and number of rainy days did not show any significant correlation with the disease intensity.

Tandel (2021) [5] studied the epidemiology of leaf spot and flower blight of marigold caused by *Alternaria tenuissima*. It was noted that leaf spot severity and flower blight incidence had a highly significant and positive correlation with morning relative humidity, evening relative humidity and rainfall.

Table 2: Progress of percent disease intensity of leaf spot and flower blight incidence in pooled (2020 and 2021)

SMW	Percent disease intensity of leaf spot (%)	Flower Blight Incidence (%)	Temperature Max. (°C)	Temperature Min. (°C)	Morning Relative Humidity (%)	Evening Relative Humidity (%)	Rainfall (mm/week)	Wind Speed (km/hr)	BSSH (hrs/day)
34	0.00	0.00	28.4	23.4	96.9	90.1	216.5	1.8	4.6
35	13.60	0.00	29.8	23.9	94.4	86.7	148.5	3.7	4.4
36	20.67	0.00	32.0	24.3	94.7	83.9	67.0	4.6	3.0
37	30.54	17.04	32.3	24.0	95.1	83.0	64.5	3.5	4.5
38	38.67	30.81	32.0	23.9	96.0	81.2	100.5	3.3	3.3
39	45.20	38.52	30.4	23.2	97.3	85.1	91.5	2.8	2.9
40	50.13	47.78	33.2	22.9	92.9	72.9	0.0	5.6	1.8
41	55.47	57.54	34.6	22.7	93.1	68.5	9.0	6.3	1.8
42	59.87	63.62	34.8	22.2	91.3	79.6	2.5	7.2	2.5
43	63.20	68.11	34.5	19.6	88.7	59.3	0.0	8.7	1.9
44	66.27	71.65	34.9	18.0	75.8	39.6	0.0	9.1	2.9
45	68.40	73.33	34.2	16.9	72.6	41.7	0.0	7.8	2.8
46	70.53	74.27	33.8	17.3	77.4	49.9	0.0	7.9	3.3

Table 3: Correlation matrix between percent disease intensity of leaf spot and weather parameters in pooled (2020 and 2021)

Percent disease intensity of leaf spot (%)	Temperature Max. (°C)	Temperature Min.(°C)	Morning Relative Humidity (%)	Evening Relative Humidity (%)	Rainfall (mm/week)	Wind Speed (km/hr)	BSSH (hrs/day)
Correlation Coefficient	0.886**	-0.768**	-0.710*	-0.810**	-0.911**	-0.698**	0.860**

Note: Critical value at 0.05 = 0.553* and at 0.01 = 0.684**

Table 4: Correlation matrix between flower blight incidence and weather parameters in pooled (2020 and 2021)

Flower Blight Incidence (%)	Temperature Max. (°C)	Temperature Min. (°C)	Morning Relative Humidity (%)	Evening Relative Humidity (%)	Rainfall (mm/week)	Wind Speed (km/hr)	BSSH (hrs/day)
Correlation Coefficient	0.850**	-0.810**	-0.728*	-0.826**	-0.846**	-0.673*	0.862**

Note: Critical value at 0.05 = 0.553* and at 0.01 = 0.684**

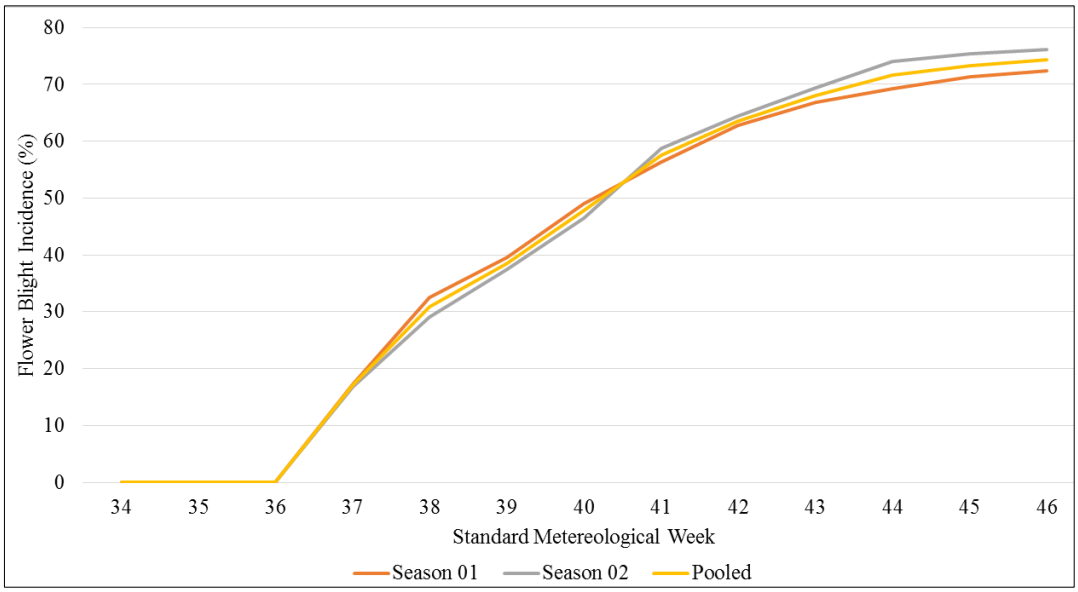

Fig 1: Progress of flower blight incidence observed in 2020, 2021 & pooled during entire crop season

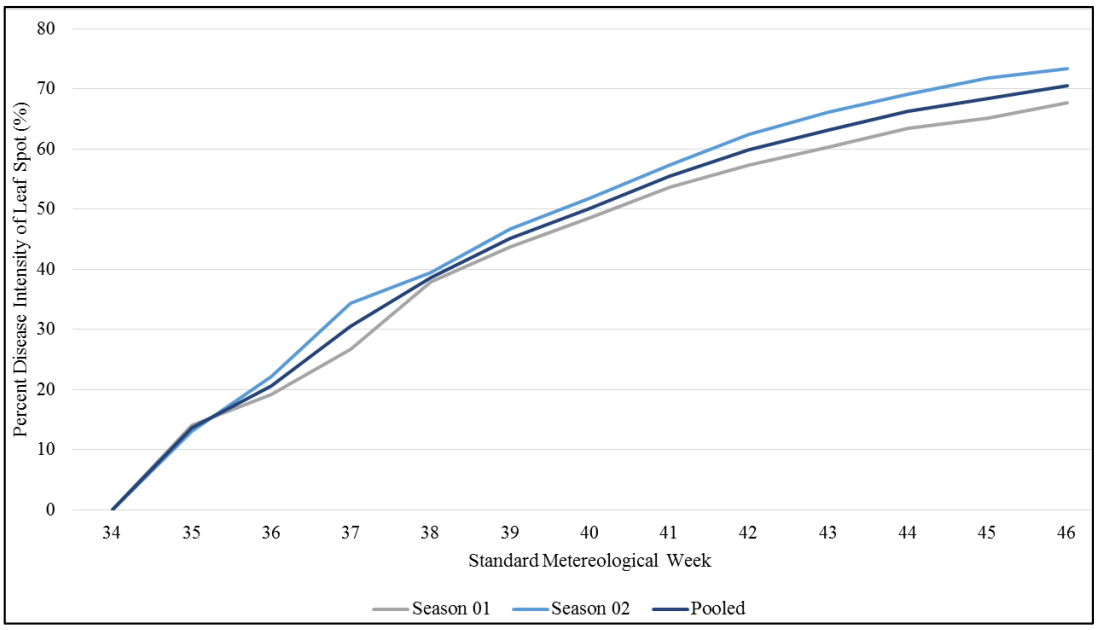

Fig 2: Progress of leaf spot intensity observed in 2020, 2021 & pooled during entire crop season

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