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Impact of Weather Parameters on the Incidence of Leaf Blight Disease in Taro (*Colocasia esculenta* (L.) Schott.)

Taro (*Colocasia esculenta* (L.) Schott.) belonging to the Araceace family is grown in developing countries for its nutritious cormels, corms and leaves. Many fungal pathogens affect taro at various stages of crop growth. The most destructive disease is leaf blight of taro, caused by *Phytophthora colocasiae* Raciborski. The early stage of leaf blight is characterized by the formation of small, circular brown to olive-green spots. Later, white, powdery masses of spores are produced on these blights. An extensive survey of major taro growing areas in the states of Orissa, West Bengal, Bihar and Uttar Pradesh in northern and eastern parts of India (Misra, 1996) revealed that a mean yield loss of 25 – 60% occurs due to taro leaf blight every year (Gadre and Joshi, 2003; Misra et al., 2007). It is a major limiting factor for taro production in all taro growing countries causing yield loss of 25-30% (Jackson et al., 1980).

Leaf blight is prevalent in almost all the major taro growing districts of Andhra Pradesh with varying intensities on different varieties causing yield loss of 10-55%. The disease generally starts with the onset of rains and its severity is mainly influenced by weather parameters. But the actual role of individual weather factors on the disease incidence in the context of climate change is not known much. Hence, a study was conducted on the epidemiology to find out the influence of weather factors on the incidence of taro leaf blight.

Field trials were conducted from June to December during 2005-2010 in taro var. Telia, which is susceptible to leaf blight, at Vegetable Research Station, Rajendranagar, Hyderabad, Andhra Pradesh, India. The taro var. Telia was planted during the first fortnight of June during *Kharif* at a spacing of 60 x 45 cm following the recommended agronomic practices every year. A fixed plot survey was conducted and the disease incidence and the weather data during the crop growth period (June to December) during 2005-2010 were recorded. The leaf blight disease incidence was recorded on 0-5 scale suggested by the All India Co-ordinated Research Project on tuber crops, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India. The data on weather parameters such as maximum and minimum temperature, maximum and minimum relative humidity (RH) at 14 h and 8 h respectively, rainfall and rainy days were recorded during the crop growth period at the weather recording station, Agricultural Research Institute, Rajendranagar, Hyderabad. The per cent disease index (PDI) was calculated at 10 days intervals starting from June 2005 to December 2010. Regression and step down analysis was performed as per the method described by Snedecor and Cochran (1967) using the following prediction equation.

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 \dots\dots\dots\dots\dots\dots + b_nx_n$$

Where y = per cent disease index, b_0 = intercept, b_1, b_2 ......b_n = regression coefficient and x_1, x_2 ...... x_n = independent variables. The goodness of fit of multiple regression models was evaluated by the coefficient of determination (R^2).

Disease severity on leaves was recorded using a five point rating scale based on the percentage of leaf area affected by the disease according to Ahuja and Payak (1978) (Table 1).

Table 1. Disease rating scale

Leaf area affected	Grade
No infection	0
Up to 5 %	1
6 – 10 %	2
11 – 20 %	3
21 – 50 %	4
More than 50 %	5

Based on the numerical ratings given above, the PDI was calculated as given below.

$$\text{Per cent disease index (PDI)} = \frac{\text{Sum of numerical ratings}}{\text{Number of leaves examined x Maximum grade}} \text{ x } 100$$

The values of weather parameters and PDI during 2005 to 2010 showed that the leaf blight disease incidence varied from 0 to 32.8% during June to December months, while maximum leaf blight disease incidence of 20.5 to 32.8% was recorded in September and October months in different years. Variation in the weather parameters are maximum temperature between 27.8°C and 37°C, minimum temperature between 13.1°C and 26.2°C, maximum RH between 70 and 92%, minimum RH between 33 and 77%, rainfall between 0 and 506.6 mm and rainy days between 0 and 15 during these years. This shows that the weather conditions were more congenial for the rapid spread of *Phytophthora* leaf blight disease in taro. Moreover, these congenial weather parameters coincided with the initiation and development of new leaves in taro, which increased the leaf blight disease incidence and decreased the yields up to 56% in severe disease incidence conditions.

The mean month wise PDI data of five years presented in Table 2 revealed that the disease index increased gradually from the second fortnight of August with the beginning of monsoon and reached a mean maximum of 24.2% in October during the crop growth period. The disease index gradually declined from the second fortnight of November and the PDI was zero in January during all the years. The disease incidence was mainly influenced by the minimum temperature and maximum RH during the crop growth period. The PDI of taro leaf blight was maximum, when the minimum temperature was 20.3°C ± 2°C, while maximum RH was 87.3%. Similar observations were made by Misra et al. (2008) that under cloudy weather conditions with intermittent rains and temperature around 28°C the disease spread quickly across the entire field. Gadre and Joshi (2003) reported that an increase in sunshine period by 1 h decreased the leaf blight incidence by 0.23%, while an increase in soil temperature at 5 cm depth in the afternoon by 1°C and an increase in crop age by 1 day resulted in 0.18 and 0.02% increases in disease incidence.

Stepwise multiple regression analysis yielded five distinct models (Table 3) for prediction of PDI that were significant ($p < 0.01$) with R^2 values ranging from 0.63 to 0.61. These R^2 values decreased marginally with dropping of each independent parameter used in the step down regression. Among the models, Model - 4 with x_1, x_2 and x_5 and Model-5 with x_1, x_2, x_5 and x_6 were found to be suitable in predicting leaf blight disease and these models caused significant effect on PDI with R^2 adj value of 0.554 and 0.567 respectively.

Table 2. Weather parameters and PDI of leaf blight in taro

Month	Temperature (°C)		RH (%)		Rain fall	Rainy days per	
	Max.	Min.	Max.	Min.	(mm)	month	PDI
January	29.6	13.8	84.2	33.9	20.6	3.0	0.0
February	32.3	16.3	79.7	29.0	87.2	4.0	0.0
March	35.3	19.7	74.0	30.4	203.2	10.0	0.0
April	37.8	23.3	68.5	30.1	171.7	11.0	0.0
May	39.2	26.0	58.5	30.0	167.6	14.0	0.0
June	35.0	25.1	77.0	50.4	480.8	40.0	0.7
July	31.8	24.5	84.2	62.6	845.7	49.0	4.2
August	30.2	23.1	88.1	68.5	1381.5	69.0	17.7
September	30.1	22.6	90.2	68.1	1199.1	68.0	22.3
October	30.6	20.3	87.3	54.9	541.7	32.0	24.2
November	29.1	16.8	87.3	54.1	112.7	11.0	15.8
December	28.7	13.7	86.5	38.5	23.2	3.0	0.2

Values are mean of weather data from 2005 to 2010

Table 3. The multiple regression equation, coefficient of determination, correlation coefficient and factor between PDI and weather factors

Model	Linear regression equation (y=a + bx)	Coefficient of determination (R^2)	Correlation coefficient (R^2 adj)	Factor (F)
1	PDI= $5.429-0.821\ x_1 + 0.373\ x_2 - 0.78\ x_3 - 0.001\ x_4 + 0.54x_5 + 0.09x_6$	0.63	0.517	5.44
2	PDI= $-5.30 - 0.82\ x_1 + 0.37\ x_2 - 0.78x_3 + 0.54x_5 + 0.09\ x_6 - 0.01x_7$	0.63	0.538	6.64
3	PDI= $-39.6 - 0.78\ x_1 + 0.34\ x_2 + 0.67\ x_5 + 0.062\ x_6 - 0.007\ x_7$	0.62	0.543	7.92
4	PDI = $-36.52 - 0.80\ x_1 + 0.35\ x_2 + 0.67\ x_5 + 0.004\ x_6$	0.61	0.554	10.03
5	PDI= $-35.27 - 0.76\ x_1 + 0.32\ x_2 + 0.65\ x_5$	0.61	0.567	13.68

x_1 =Maximum temperature (°C), x_2 = Minimum temperature (°C), x_3 = Maximum RH (%), x_4 = Minimum RH (%), x_5 = Rainfall (mm), x_6 = Rainy days per month

All the weather factors were highly significant and positively influenced the disease incidence as reported by Sitansu Pan Ghosh (1997), whereas maximum temperature had negative coefficient and this variable was negatively correlated with PDI. The other parameters such as minimum temperature, RH, rainfall and number of rainy days showed positive correlation with PDI ($p < 0.01$). However, there was significant correlation among the weather parameters like rainfall with rainy days and relative humidity, as well as with minimum temperature. The findings of Pouono and Tuugasala (1995) supported the present results that the disease incidence was positively related to rainfall.

It can be concluded that the incidence of taro leaf blight increased from August to October and declined gradually from October to January months, with negligible incidence during January to July. The leaf blight disease index was severe during September to November. It was observed that the disease directly affected the vegetative growth of the crop, which in turn decreased cormel yield by 28% and 32% as per the data recorded in 2007 and 2008 respectively. All the weather factors significantly influenced the disease development. However, PDI was positively influenced by the amount of rainfall received, minimum temperature and maximum RH and negatively correlated with maximum temperature in the preceding fortnight. By using the model PDI= $-35.27 - 0.76\ x_1 + 0.32\ x_2 + 0.65\ x_5$, the incidence of *Phytophthora* leaf blight in taro can be predicted. Based on this preventive measures can be recommended to the farmers to manage the disease at low cost during the crop period.

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