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Effect of Abiotic Factors on the Incidence of Rust Disease in *Acorus calamus* L. under Terai Zone of West Bengal, India

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A B S T R A C T

Acorus calamus L. an aromatic rhizomatous herb plant has a long history as a medicine which is often used as stimulant, mild tonic, carminative, diaphoretic, expectorant, hypertensive, sedative and also used in the treatment of arthritis, neuralgia, diarrhea, dyspepsia, hair loss and other disorder. Among the several constraints in productivity of this medicinal plant, abiotic stress relating to disease is the major one. The rust disease caused by *Uromyces* spp is one of the important disease causing huge losses of the plant and is greatly influenced by the abiotic factors. It has been observed from the present study that the rust of *A. calamus* began to appear during March in the field and its intensity increased gradually up to September. Significant positive correlation was found between maximum temperature, minimum temperature, maximum relative humidity, rainfall and disease intensity during 2015. The multiple regression equation also reveals that the weather factor all together accounted for more than 99.1 % variation in diseases severity.

Introduction

Medicinal plants have been used for ameliorating the sufferings of mankind since the dawn of civilization. After food, medicines are the second most essential requisite for mankind. Medicinal plants are the important source of the secondary metabolities (glycosides, coumarins, flavonoids, steroids, etc.) and potential source of raw drugs. The updated information confirms that out of 20,000 medicinal plants of the world, India Contributes about 15% i.e., 3000 – 3500 in numbers and 90% of these plants are used as prophylactic, curative and suppressive drugs in the Indian system of medicine (Roy & Pandey, 2005).Commercial cultivation of a large number of medicinal plants has been taken up in recent years in developing countries. The extensive cultivation of these plants has increased the pathological problems. *Acorus calamus* L. among the medicinal plant is an important aromatic rhizomatous herb plant and has a long history as a medicine. It is distributed throughout the tropics and subtropics, especially in India and Sri Lanka. It is found in marshy tracts of Kashmir and Sirmoor, in Manipur and Naga Hills, wild or cultivated, ascending the Himalayas up to 1800 min Sikkim. It is regularly cultivated in Koratagere taluk in Karnataka. The plant is grown in clayey loams and light alluvial soil of river bank. It is now found widely on the margin of pounds and rivers in most English countries (Anonymous, 2004). The plant parts used in most of the experimental studies are the leaves, roots (rhizomes) and stem of the plant. However, in Traditional systems of medicine mostly the rhizomes are used (Balakumbahan, 2010). Its uses have been reported as stimulant, mild tonic, carminative, diaphoretic, expectorant, hypertensive, sedative and also used in the treatment of arthritis, neuralgia, diarrheam dyspepsia, hair loss and other disorder (Lavrenov and Lavrenova, 1999). Amongst different abiotic and biotic factors, disease problem relating to fungal pathogens are found to damage the plants as a whole or partly and thereby causing considerable loss in biomass. Among the fungal pathogens of *A. calamus*, rust disease causing organism *Uromyces* (Link) Unger, is the most important one. This genus of rust fungi was proposed by Unger (1833) and has more than 1562 taxonomic names within this genus worldwide. It is also considered as the second largest genus of rust fungi next to *Puccinia* and contains more than 600 reported species (Cummins and Hiratsuka, 2003). Both uredinia and telia in *A calamus* are formed on either surface of leaf. These are about 1mm in diameter, circular to oval, dull reddish brown in colour. The sori are either scattered on the leaf blade or are arranged in small cluster, surrounded by a yellow hallow. Sometimes the pastules are arranged in row, bounded by veins and veinlets. Severe disease infestation results in drying of the leaf from tip downward. Apart from this medicinal plant *Uromyces* has a wide range of host including families like Asteraceae, Euphorbiaceae, Fabaceae, Liliaceae, Poaceae, and Loranthaceae (Vidal-Russell and Nickrent 2008). The pathogen gets transmitted through air-borne inoculum to cause the disease and reduced the yield up to 30.-35 % (Schwartz *et al.,* 2004). Due to yield loss by this disease, this medical plant lost its popularity, hence commercial as well as large scale cultivation has becoming a headache and threats for the farmers and farming community. Due to scarcity of data regarding pathogenic response on this medicinal plant under different climatic condition the present study was conducted to find out rational relationship between diseases development and weather condition so as to manage the crop in proper time in order to achieve economic gain.

Materials and Methods

Location of Study

The present study was conducted in the Terai zone which is situated between $25^0 57'$N and 27^0N latitude and $88^0 25'$E and $89^0 54'$E longitude in the northern region of West Bengal during 2015. The total geographical area of the zone is 1025 sq. km, which occupies 13.5% of the state area. Generally subtropical humid climate prevails in this zone comprising of prolonged rainy season. The rainy season starts from 1st week of May and continues up to last week of September having intermittent, drizzling and occasional heavy rainfall. The average rainfall of this zone varies between 2100 to 3300 mm and the maximum rainfall, i.e., about 80%, is received from south-west monsoon during the rainy months of June to September. The temperature range of this area varies from minimum of 7-8ºC to maximum of 24-33.2ºC. The average relative humidity of the area at 8.30 A.M. is 58% and 87% in March and July respectively. The relative humidity at afternoon at 5.30 P.M. is 48% and 84% in March and November respectively. The area as a whole is humid and warm except having a short winter spell from December to February. This climatic situation makes the agro-ecological condition more complex and dynamic which in turn is conducive for occurrence of a large number disease and pests in medicinal plants.

Effect of weather parameters on percent disease intensity of rust of *A. calamus*

To study the effect of weather parameters on the development rust disease of *Acalamus*, incidence of disease was recorded along with the records of maximum and minimum relative humidity and maximum and minimum temperature and rainfall. Percent disease index was calculated with the following formula

$$\text{PDI} = \frac{\sum \text{ of total rating}}{\text{Total plants observed} \times 9} \times 100$$

The PDI values were transformed, by arc sign transformation, and analyzed statistically by using "INDOSTAT" software.

Results and Discussion

The result presented in Table 1 indicated that the rust of *A. calamus* began to appear during March in the field and its intensity increased gradually up to September (Fig. 1). On leaves it was maximum during August – September 2015. Perusal of the data on Table 1 indicated that maximum temperature above 30^0C, minimum temperature above 15ºC, maximum relative humidity 90% and rainfall favours the rapid development of the disease (Fig. 2). The rapid occurrence of the disease was observed during June- September.

The probable cause of disease occurrence of Uromyces in the specified period might be attributed to the favourable condition of spore formation as urediospore germination is favoured under 15-24ºC which is frequently observed after the fresh showers of rain during these months in spite of sporadic high temperature spells. Lesser disease incidence was observed during the summer months (April to May) as the higher temperature restricts the disease developments. Similar reports were observed by Singh, 2000 where the disease development in bean (caused *Uromyces* phaseoli typical Arth.) ceases beyond 34ºC. Apart from the temperature, high relative humidity in the specified months (June to September) might be responsible for increase in the disease development. This statement was also in agreement with the observations of Singh (2000).

In initial stage of disease development, apparent infection rate was increased rapidly due to the availability of more plant tissues for infection of rust pathogen and afterwards it declined as the healthy plant tissues gradually decreases with the progression of infection between two successive periods of observation.

Rapid disease development during favorable period in various host and *Uromyces* spp reported by several workers (Agrawal *et al.*, 1976; Hamdany-AI and Abed, 1985; Srivastava and Gupta, 1990 and Pereira *et al.*, 2003).

Significant positive correlation was established between maximum temperature, minimum temperature, maximum relative humidity, rainfall and disease intensity during 2015 (Table 2 and Fig. 2 to 6). The multiple regression equation reveals that the weather factor all together accounted for more than 99.1 % variation in diseases severity during 2015. Of this minimum temperature accounted for more than 87% variation in disease intensity and have significant effect in prediction of disease intensity. However, fitting full model regression to the data, gives the value of r^2 =0.991 and adjusted r^2=0.98. From the ANOVA table we see that the mean square due to regression is highly significant. The final full model regression is mentioned below.

Table.1 Effect of weather parameters on percent disease index of rust of *A. calamus*

Month	PDI (%)	Maximum Temperature. (^{0}C)	Minimum Temperature. (^{0}C)	Maximum Relative Humidity (%)	Minimum Relative Humidity (%)	Rainfall (mm)
March	3.50 (10.58)	29.30	15.10	86.50	68.50	79.50
April	9.20 (17.65)	31.20	17.50	91.00	79.50	156.00
May	21.40 (27.55)	30.40	18.60	91.30	80.50	251.50
June	43.20 (41.09)	31.50	22.90	93.00	81.80	832.80
July	67.50 (55.24)	30.90	25.20	95.30	82.00	802.60
August	72.40 (58.30)	32.20	25.20	92.20	81.00	825.00
September	75.00 (60.00)	33.20	24.70	92.30	81.80	86.00
October	59.80 (50.65)	29.20	21.10	91.00	84.30	504.20
November	24.20 (29.46)	27.90	15.60	91.60	82.60	-
December	-	25.80	12.20	88.30	70.30	-

Table.2 Correlation coefficient between weather factors and disease intensity (%) on *A. calamus* leaf

Weather factor	Year (2006)
Maximum Temperature (^{0}C)	0.662*
Minimum Temperature (^{0}C)	0.935**
Maximum Relative Humidity (%)	0.732*
Minimum Relative Humidity (%)	0.700*
Total rainfall (mm)	0.644*

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Fig.1 Percent Disease Index at different month during the year 2015

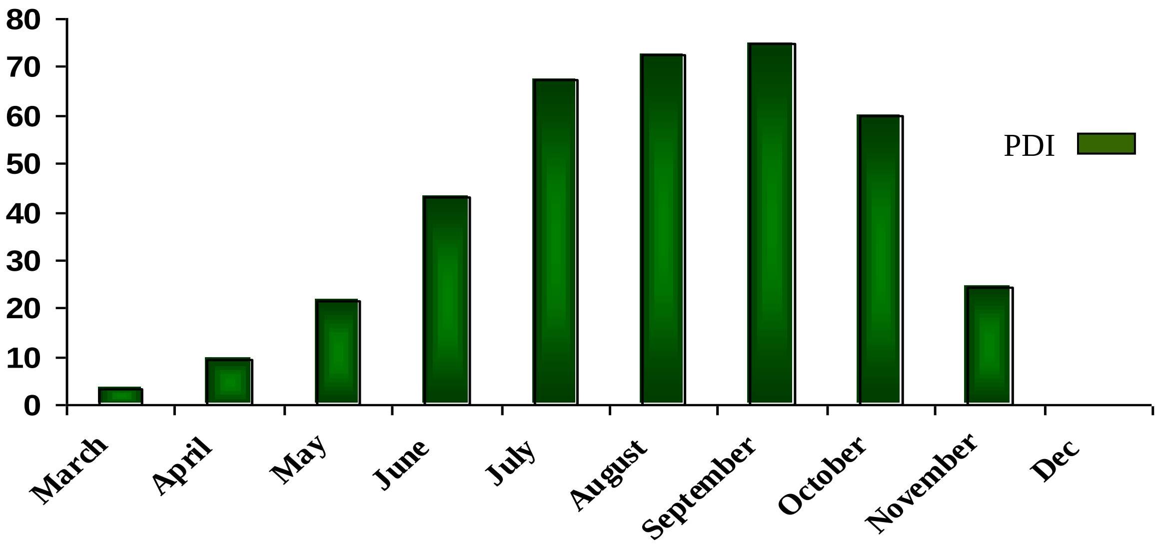

Fig.2-6 Regression between max and minimum temperature, maximum relative humidity, rainfall and disease intensity during 2015

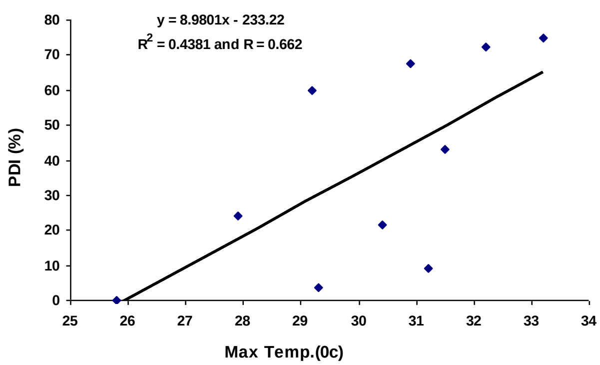

Fig.2

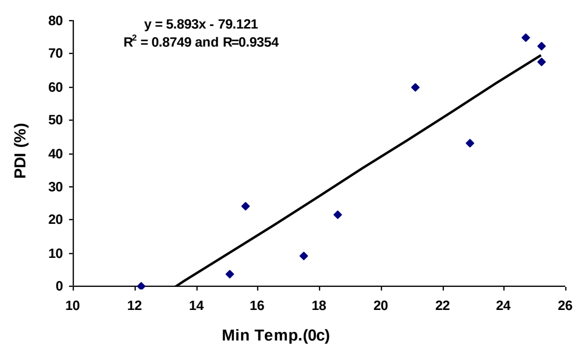

Fig.3

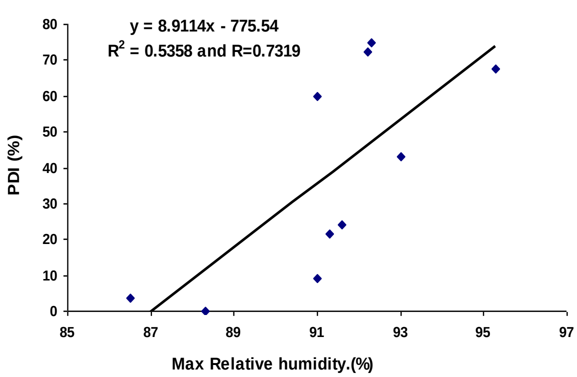

Fig.4

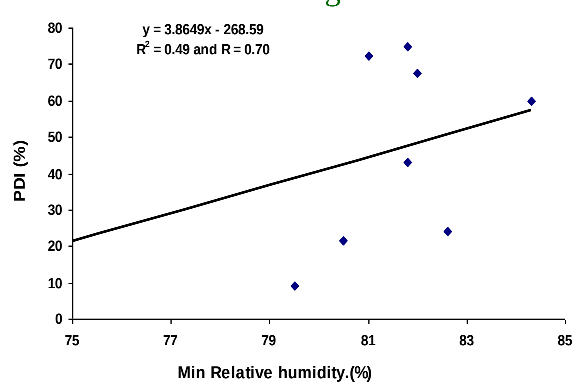

Fig.5

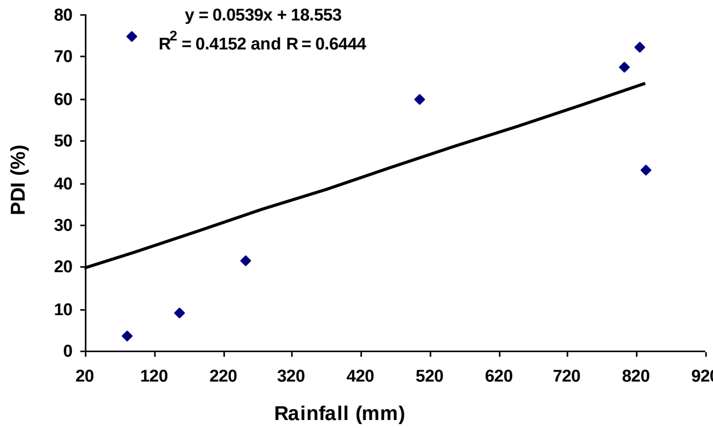

Fig.6

PDI = 322.567-8.803 × (Maximum Temperature) +11.733 × (Minimum Temperature) – 3.461× (Maximum Relative Humidity) +0.941× (Minimum Relative Humidity) -0.03 × (Rain fall)

Using step wise regression, we found the value of r^2 = 0.875 and adjusted r^2 = 0.859 which is a good fit. However individual regression relationship between PDI and weather parameters are recorded in Figures 2-6 where it is clearly seen that the minimum temperature and to some extent relative humidity produced the positive response as indicated by the higher regression coefficient (R^2). This supports further the observation perceived in Table 1. Similar trends of disease development have also been reported by Nirmalakar *et al.*, in 2006 where they mentioned that the disease increased during rainy and winter months and declination their after.

From the present investigation it can be concluded the minimum temperature and relative humidity are the important parameters for considering the disease epidemics under the Terai zone of West Bengal. The months especially June to September are very crucial for the disease development in the medicinal plant (i.e. *Achorus calamus* L.) hence adequate management practices including the adjustment of sowing time, cultural and chemical control are of utmost need to cope up with the disease.

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