Journal of Agrometeorology 15 (1) : 75- 78 (June 2013)

Climate change and shifts in etiology of anthracnose disease of grapevines in India

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ABSTRACT

An analysis of the temperature trends of two geographically and climatologically distinct grape growing locations of India viz. Solapur and Ludhiana, shows that there is a perceptible increase in temperature, especially the minimum (Tmin) temperatures. This increase may have created conditions favourable for *C. gloeosporioides*, which can grow at comparatively higher temperatures, to replace *E. ampelina* as the dominant pathogen of anthracnose. Regression analysis of weather and disease data also indicated that Tmin was significantly contributing to disease development. Further the number of occasions on which the temperature remained above 35^{0}C showed increasing trend at both Ludhiana and Solapur which could have affected survival of *E. ampelina* during non-active summer season.

Keywords: Elsinoe ampelina, Colletotrichum *species, monsoon, climate change, temperature*

Anthracnose is common disease of grapevines which occurs during warm and wet weather. It infects the tender shoots and may cause complete necrosis thus burning-out the whole shoots. Worldwide, it is reported to be caused by *Elsinoe ampelina* (de Bary) Shear, a fungus, which has its anamorphic stage in *Sphaceloma ampelinum* (de Bary) (syn. *Gloeosporium ampelophagum* (Pass.) Sacc. (Cheema *et al*., 1978; Deokate *et al*., 2002).

Recently, Sawant *et al*. (2012) characterized three hundred and eighty two isolates of anthracnose pathogen from geographically diverse locations of India and found that all isolates belonged to the genus *Colletotrichum*. Earlier, too, the association of *C. gloeosporioides* and *Colletotrichum acutatum* with anthracnose disease of grapes in western India was shown by Chowdappa *et al*. (2009) and that of *C. gloeosporioides* with some of the late season anthracnose infections in north India by Kumar *et al.,* (1994). *C. gloeosporioides* is known to infect berries near maturity causing ripe rot disease of grape, but it is not a recognized pathogen on foliage. Thus, it appears that there has been a gradual shift in the population structure of the causal agents of grapevine anthracnose in India in the last few decades from *E. ampelina* to different *Colletotrichum* species, especially those of the *C. gloeosporioides* species complex. The first observed change was recorded in 1990s (Kumar *et al.,* 1994) and by 2010 there appears to be a complete shift in the pathogen (Sawant *et al*., 2012).

The reasons for this shift in the population structure are intriguing. There are few similarities in both these fungal pathogens. The teleomorph stage of *C. gloeosporioides* is placed in *Glomerella cingulata* (Stonem.) Spauld. & Schrenk and both *E. ampelina* and *G. cingulata* belong to the Phyllum Ascomycota. Both fungi reproduce asexually by producing conidia that are responsible for disease spread. Both fungi require tissue wetness for conidial production and for subsequent infection. However, *in vitro* studies on effect of different temperatures on mycelial growth of these fungi showed that they differ in the temperature sensitivities. Though both *G. ampelophagum* (*E. ampelina*) and *C. gloeosporioides* showed maximum growth at 29-30^{0}C; but at higher temperatures of 34-35^{0}C the growth of *G. ampelophagum* was inhibited by 69%, while the growth of *C. gloeosporioides* was inhibited by only 49% (Kore and Gurme, 1978; Sawant *et al*. unpublished data).

In this article we have tried to analyze whether the shift in the etiology could be a consequence of climate change. As per the classic disease triangle concept, any change in the environment may affect the host and / or the pathogen and force a shift in the host-pathogen relationship. Thus the climate changes which have been occurring since beginning of the last century have become a cause of concern regarding the possible major effects on pathogens and diseases (Garrett *et al.,* 2009; Pande and Sharma, 2011).

Table 1 : Absolute change in temperature at two locations in India

Location	Period	Annual			Monsoon	
		Tmax	Tmin	Hmax	Tmax	Tmin
Solapur	1975-2009	+0.51	-0.08	1.05	+0.55	+0.54
Ludhiana	1977-2008	+0.40	+1.70	-0.42	-0.90	+1.54

Table 2 : Results of Mann-Kendall rank statistics and t-test

Location	Period	Mann-Kendall rank statistics			t value calculated		
		*T*max	*T*min	*H*max	*T*max	*T*min	*H*max
Solapur	Annual	0.170	0.008	0.236*	1.95	0.00	2.04
	Monsoon	0.152	0.241*	-	1.30	0.92	-
Ludhiana	Annual	0.087	0.559**	- 0.121	1.16	6.40**	0.60
	Monsoon	- 0.194	0.621**	-	2.09*	7.26**	-

* significant at P=0.05, ** significant at P=0.01(two tailed)

MATERIALS AND METHODS

The monthly weather data of Solapur (1975 to 2009) and Ludhiana (1977 to 2008) was obtained from India Meteorological Department (IMD), Pune. From the monthly temperature data, maximum (Tmax) and minimum (Tmin) values were computed for all the years and also for the monsoon season (June to September) as defined by IMD in each corresponding year. The rainfall and relative humidity (RH) data were similarly computed and linear regression equations were generated. The significance of the trend line was tested by 't' test and Mann-Kendall rank statistics (ô) on SPSS software. The magnitude of the trend was derived from the slope (value of 'm') of the regression line. The absolute change over the years under consideration was calculated by multiplying the slope value of the trend line by the number of years (Dhorde *et. al.,* 2009). Further, the highest maximum temperature per year for both the locations and the number of occasions when the temperatures remained above 35^{0}C and above 40^{0}C were also computed.

The weather data on maximum (Tmax) and minimum (Tmin) temperature, relative hmidity (RH), rainfall and leaf-wetness was recorded on Metos automatic weather station at the research farm of the Centre. Disease incidence was recorded on 10 leaves per plant following a 0-5 rating scale where, 0=no infection; 1=1-10% leaf area infected; 2=11-25% leaf area infected; 3=26-50% leaf area infected; 4=51-75% leaf area infected; 5=76-100% leaf area infected. The percent disease index (PDI) was calculated. Three replications of one plant each were maintained. The data was run on SAS system ('Local', W32_7PRO) using stepwise linear regression model.

RESULTS AND DISCUSSION

An analysis of the temperature data from Solapur and Ludhiana indicates perceptible warming trend of the climate over the period. In Solapur, the annual Tmax increased by 0.51^{0}C over the last thirty five years, though there was negligible change in Tmin (-0.08^{0}C) (Table 1). However, during the monsoon season both the Tmax and the Tmin showed an increase by more than 0.5^{0}C. In Ludhiana, there was significantly higher increase in annual temperature as compared to Solapur. The annual Tmax and Tmin increased by 0.4^{0}C and 1.7^{0}C, respectively (Table 1). The monsoon Tmax showed a decrease of 0.9^{0}C but Tmin increased by 1.54^{0}C.

Anthracnose is primarily a disease of monsoon season as leaf wetness is essential for infections to occur. We observed a significant (Mann-Kendall rank statistics) increasing trend in Tmin during the monsoon for both the locations (Table 2). Similar significant increasing trend in the monsoon Tmin for Pune, another grape growing location, over the last century (1901-2000) was reported by Gadgil and Dhorde (2005). We found that the warming trend has continued further in the last decade, too, as the monsoon Tmin increased substantially by 1.40 and the annual Tmin increased by 0.36^0C (data not presented). These warming trends during the monsoon season could have had a significant impact on the shift in the pathogen populations on grapevines which occurred in the last few decades.

Stepwise regression analysis of two years weather and disease data indicated that the parameters which significantly (P=0.05) contributing to PDI were minimum temperature (12.39%) and leaf wetness (6.72%). This indicates the importance of monsoon Tmin, as compared to monsoon Tmax, on disease development.

Climate change is also implicated in similar phenomenons occurring in many countries in the last few decades. In Europe, the higher temperature favouring *Fusarium graminearum* has now replaced *F. culmorum,* which was the predominant species of the late 1980s / early 1990s as pathogen of head blight of wheat (Waalwijk *et al*., 2009). In India, A2 mating type of *Phytophthora infestans* has emerged over the last 15 years and has resulted in increased frequency of potato late blight epidemics (Annon, 2011).

Apart from warming climate, extreme changes in temperature i.e. more frequent higher temperature may also impact plant diseases by affecting the infection process as well as the over-summering of the pathogens. Analysis of the highest maximum (*H*max) temperatures showed that the range was same at both the locations, ranging between 41.6 to 46^0C in Solapur and 41.2 to 46.2^0C in Ludhiana. However, there was an increasing trend at Solapur and a decreasing trend at Ludhiana (Table 2). Further, the number of occasions on which the temperature remained above 35^0C showed increasing trend at both Ludhiana and Solapur.

Chowdappa *et al.* (2009) isolated *C. acutatum* apart from *C. gloeosporioides*, while Sawant *et al*. (2012) found *C. capsici* and other unidentified *Colletotrichum* species, but did not get *C. acutatum.* The yearly fluctuations in temperature (or rainfall) may be responsible for the sporadic occurrence of species of *Colletotrichum* on grapevines in some years but not in others. Thus, the effect of long term climate changes and seasonal extremities on pathogen and grapevine behavior needs the attention of both pathologists and horticulturists.

CONCLUSION

A shift in the etiology of grape anthracnose in India was noticed at the end of the last century and by 2010 it appears that *Elsinoe ampelina*, the known pathogen, has gradually been replaced by *Colletotrichum* species mainly those belonging to *C. gloeosporioides* sensu lato. Increase in the minimum (Tmin) temperatures which would have created conditions more favorable for *C. gloeosporioides* than *E. ampelina* as the former can grow and infect at higher temperatures.

Regression analysis of weather and disease data indicated that Tmin was significantly contributing to disease development.

ACKNOWLEDGEMENTS

The authors would like to thank the Indian Council of Agricultural Research (ICAR) for part financial support under the Outreach Program on "Diagnosis and Management of Leaf Spot Diseases of Field and Horticultural Crops"; India Meteorological Department, Pune; for providing the meteorological data and Dr. Amit Dhorde, Asst. Proff., Dept. of Geography, University of Pune for help in statistical analysis.

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Received : June 2012 ; Accepted : March 2013