Journal of Agrometeorology 15 (2) : 115-119 (December 2013)

Understanding the relationship between groundnut canopy level weather and observatory weather for leafspot disease prediction*

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ABSTRACT

One of reasons for non-translation of weather based prediction systems for groundnut late leafspot is inability of the models to account for the variability due to prime contributing weather parameters and inadequate data on microclimate of the pathogen in the canopy. The instruments for measuring microclimate are not only expensive but also need timely calibration. Hence, an effort was made to find out relationships between observatory meteorological data and microclimate at canopy level. Field trials were laid out during *kharif* seasons of 2004 and 2006 and wireless sensors were placed in the field near to crop canopy to record weather. During 2004 Tmax, Tmin and RHe were significantly positively correlated ('r'=0.729, 0.943 and 0.680, respectively) whereas RHm was not significant ('r'=0.201). On the other hand, during 2006, both Tmax and RHe were strongly positively correlated ('r'=0.791 and 0.652, respectively) whereas 'r' values of RHm and Tmin were not significant (-0.380 and 0.151, respectively). The relationship between the Tmax of observatory and canopy level showed logistic relationship with a mean deviation of 8.1±1.4 and a range of 5.7 to10.6. Similarly, Tmin of observatory and canopy level showed logistic relationship with a mean deviation of 1.0±1.6 and a range of –2.0 to 4.3. During kharif 2004, RHm and RHe showed an exponential relationship between observatory and canopy level data. However, during *kharif* 2006, the relationships were sinusoidal. These functional relationships for temperatures could be used for developing weather based forewarning systems. Though the apparent infection rate in 2004 (0.0664) was similar to 'r' in 2004 (0.0759), the area under disease progress curve (AUDPC) was relatively less in 2006 as compared to 2004, which signifies the role of weather and other crop husbandry practices including date of sowing. The results are discussed in this paper.

Key words: Late leafspot, Microclimate, Groundnut, apparent infection rate, AUDPC

India is the largest grower and second largest producer of groundnut in the world. The average yields hover around 1000 Kg ha^{-1}, which are much lower than other major groundnut growing countries. Among several constraints diseases also take a considerable toll. Among fungal foliar diseases, leafspots and rust are economically important in India and widely distributed. Yield losses due to leafspots range from 15 to 59 %, but vary from place to place and between seasons. Late leafspot (LLS) is caused by *Phaeoisariopsis personata* and optimum conditions for disease development include ambient temperatures between 25 and 30^0 C prolonged leaf wetness hours, and high relative humidity of >80%.

The disease is an outcome of interaction among host, pathogen, and weather over a period of time. Disease forewarning will help in reducing excessive use of chemical pesticides. By substituting risk-assessment-based spray schedules against calendar-based schedules, growers can reduce spray volumes and thus health and environmental hazards of pesticide use. At times, disease-warning systems may also enhance profitability by reducing input costs (Gleason *et al*. 1994; Sentelhas *et al*. 2007). Many statistical, empirical models and decision systems have been developed for forewarning of groundnut leafspots (Bailey *et al.* 1994; Cu and Phipps, 1993; Rangarao *et al.* 2008; Volatinwo *et al.* 2012). However, most warning systems have not been translated from scientific validation to real-world application (Magarey *et al.*, 2002). Often the variability in disease manifestation due to changes in weather, when susceptible host and virulent pathogen are

* Paper presented in national seminar on "Climate change and Indian Agriculture : Slicing down the Uncertainty" held at CRIDA, Hyderabad during 22-23 January-2013 and reviewed for special issue of the Journal.

present, has not been successfully accounted for. The probable reasons are aberrant variations in weather in monsoon dependent tropical and sub-tropical production systems and consideration of macro-weather parameters of the crop that partially accounts for true environment of the host-pathogen interaction. Collection of accurate crop micro-weather data is often difficult as the instruments developed for this purpose are expensive, need to be calibrated precisely and installed in the crop environment. Since, microclimate at crop canopy is a function of interactions among weather conditions at some height above the canopy with plant and soil. Thus, any surrogate method to estimate microclimate is a welcome step as it would help in capital expenditure as well as deployment of extra manpower for collection of such data. However, very few efforts have been made to establish relationship between observatory data and crop microclimate data in open field conditions. Wang and Boulard (2000) have established relationship between observatory data and crop microclimate under plastic house conditions. Similarly, Brown and Gillespie (1991) developed a mathematical model (MICROSIM) to estimate the microclimate at the top of crops using inputs of weather station data and some knowledge about crop characteristics, such as height, albedo, and leaf area index. They validated model over soybean and maize. Accuracy of the CART/SLD/Wind model identifying hours as wet or dry varied little among the 15 sites, suggesting that this model may be desirable for estimating LWD from site-specific data throughout the Midwestern United States (Kim *et al.*, 2002). A relationship between macro- and micro-weather data would be very useful to overcome such difficulties and refine the disease forewarning systems. Here, findings of such an exercise in groundnut (*Arachis hypogaea* L.) are presented.

MATERIALS AND METHODS

Field trials were laid out during *kharif* 2004 and *kharif* 2006 at ICRISAT and CRIDA Hayatnagar farms, respectively, in isolation blocks. Two plots of 1000 m^2 were sown with cv JL 24. Between two plots, tall-growing maize was raised to restrict movement of spores of late leafspot (LLS) pathogen, *Phaeoisariopsis personata.* One plot was infected with the LLS pathogen while the other was left for natural infection. The crop was raised following standard agronomic practices and no fungicidal sprays were taken up for management of foliar pathogens. In each plot, 100 plants were tagged at random and LLS progress was recorded weekly commencing from 45 days after sowing. The macro-weather data was collected from ICRISAT and Hayatnagar observatories. For collection of micro-weather data, a thermohygrograph was installed in the field at about 18" above ground level. For recording leaf wetness, a leaf wetness sensor (developed at ICRISAT) was installed at a height of 2 ft. and an angle of 45° to the canopy. Daily observations on maximum (Tmax) & minimum (Tmin) temperature (^{0}C), relative humidity morning (RHm) & evening (RHe) and leaf wetness were recorded. The data were analyzed statistically using appropriate design.

RESULTS AND DISCUSSION

The observatory maximum temperature during crop growth period of *kharif* 2004 ranged from 24.2 to 33.0° C with a standard deviation of 1.46° C whereas maximum temperature at canopy was between 31.9 and 41.8° C with a standard deviation of 2.11° C. However, observatory minimum temperature during *kharif* 2004 varied widely and ranged from 8.2 to 23.7° C with a standard deviation of 4.27° C whereas maximum temperature at canopy was between 6.8 and 21.9° C with a standard deviation of 4.61° C. The morning RH of observatory during *kharif* 2004 ranged from 55 to 98% with a standard deviation of 6.9% whereas at canopy it was between 85 and 100% with a standard deviation of 2.9%. The evening RH of observatory during *kharif* 2004 varied widely and ranged from 20-98% with a standard deviation of 16.2% whereas at canopy it was between 18 and 46% with a standard deviation of 9.2%. Similarly, during crop growth period of *kharif* 2006, the observatory maximum temperature ranged from 22.7 to 34.1° C with a standard deviation of 2.43° C whereas maximum temperature at canopy was between 22.4 and 44.2° C with a standard deviation of 5.93°C. However, observatory minimum temperature during *kharif* 2004 varied widely and ranged from 15.1 to 24.7° C with a standard deviation of 2.22° C whereas maximum temperature at canopy was between 20.5 and 34.1°C with a standard deviation of 2.32° C. The morning RH of observatory during crop growth period of *kharif* 2006 ranged from 59 to 98% with a standard deviation of 6.0% whereas at canopy it was between 57 and 100% with a standard deviation of 14.2%. The evening RH of observatory for the same period varied widely and ranged from 30-96% with a standard deviation of 13.7% whereas at canopy it was between 28 and 78% except for 85-100% humidity for 4 days with a standard deviation of 14.9%. The correlation coefficients between meteorological data of observatory and canopy level showed that during 2004 Tmax, Tmin and RHe were significantly positively correlated ('r'=0.729, 0.943 and 0.680, respectively)

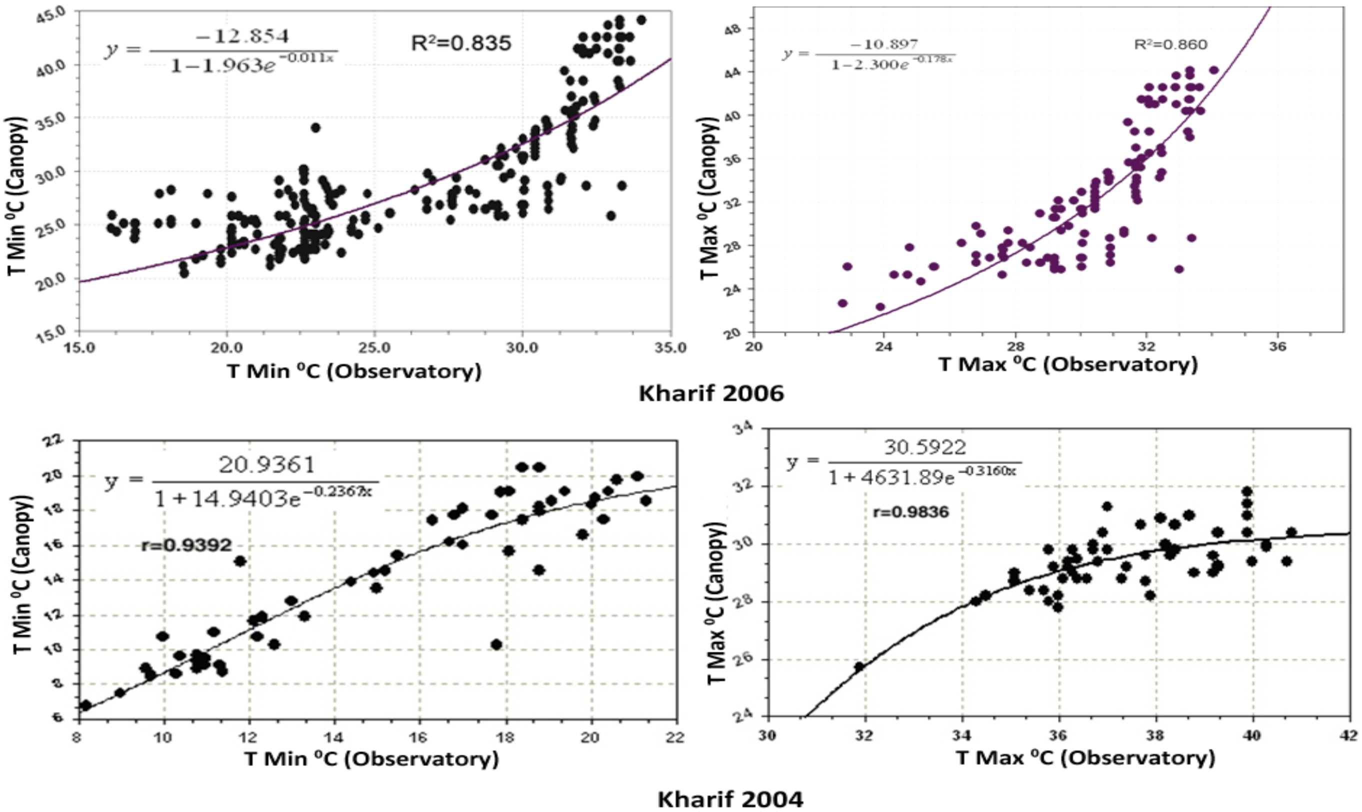

Fig.1: Relationships between observatory and canopy level maximum and minumum temperatures during *kharif* 2004 and *kharif* 2006

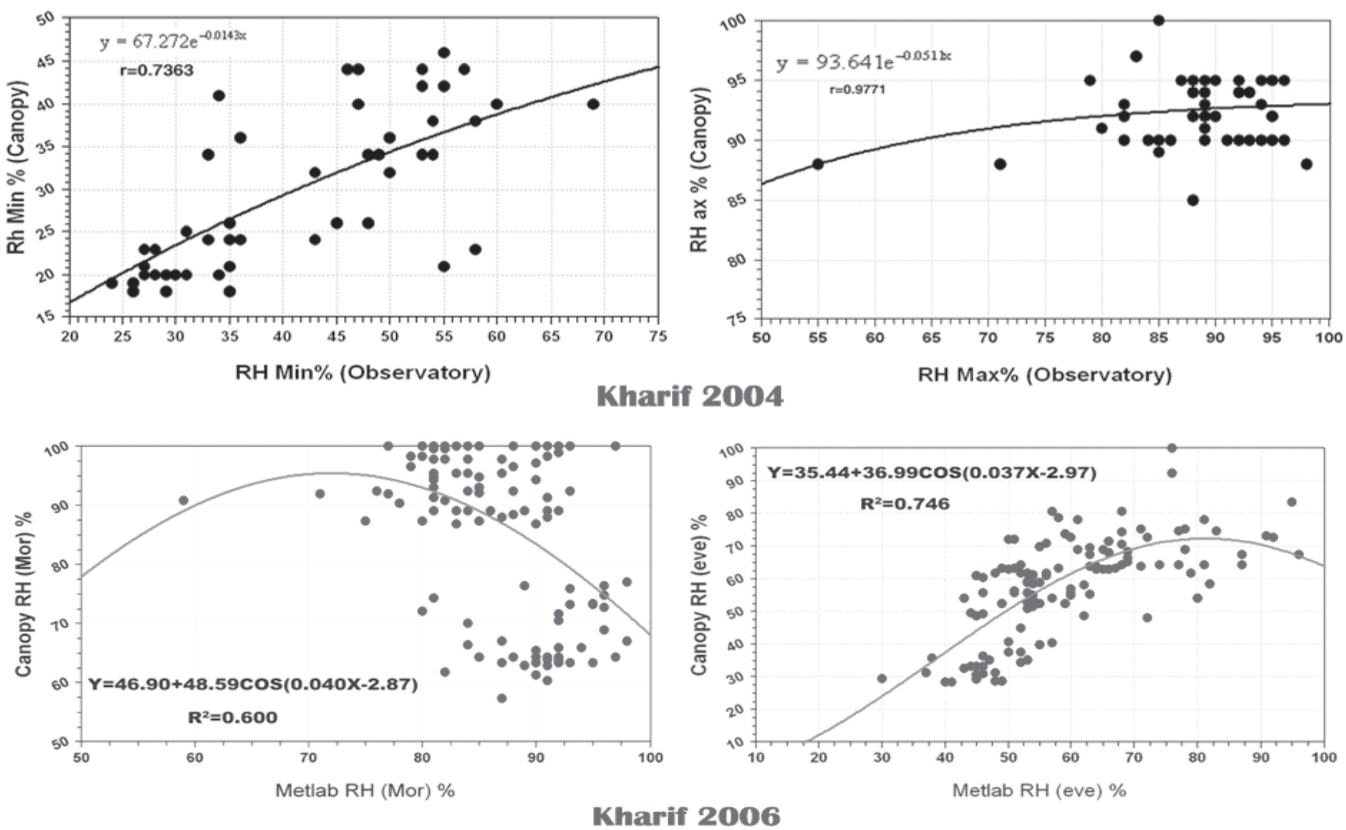

Fig.2: Relationships between observatory and canopy level RHm and RHe during *kharif* 2004 and *kharif* 2006

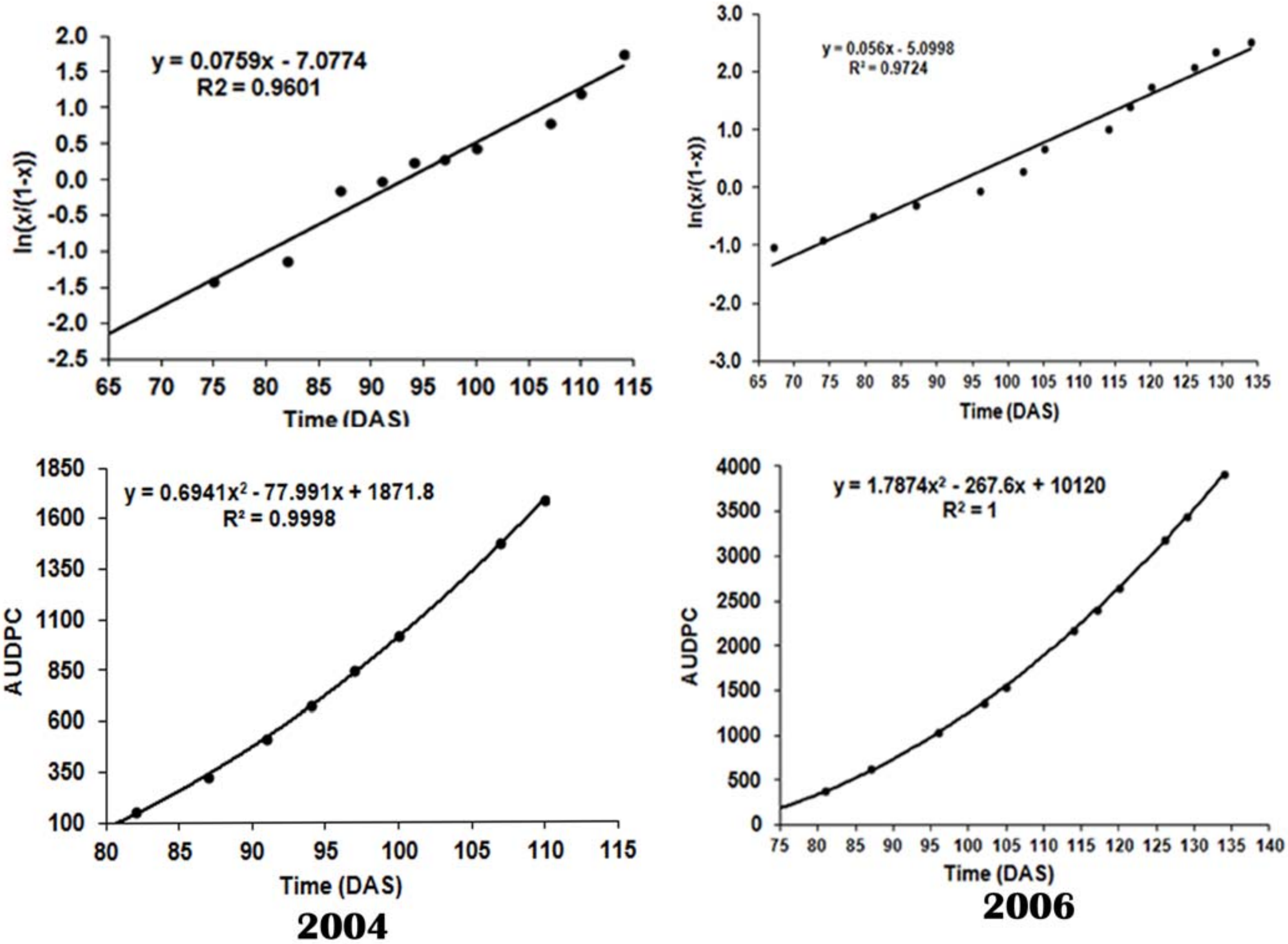

Fig. 3: Comparison of progress of late leafspot in 2004 and 2006

whereas RHm was not significant (‘r’=0.201). On the other hand, during 2006, both Tmax and RHe were strongly positively correlated (‘r’=0.791 and 0.652, respectively) whereas ‘r’ values of RHm and Tmin were not significant (-0.380 and 0.151, respectively).

The relationship between the Tmax of observatory and canopy level showed logistic relationship (Fig 1) with a mean deviation of 8.1±1.4 and a range of 5.7 to10.6. Similarly, Tmin of observatory and canopy level showed logistic relationship with a mean deviation of 1.0±1.6 and a range of –2.0 to 4.3 (Fig.1).

Similar attempts were made to establish relationships for RHm and RHe between observatory and canopy level data. During *kharif* 2004, RHm and RHe showed an exponential relationship between observatory and canopy level data. However, during *kharif* 2006, the relationships were sinusoidal (Fig.2). Thus, it is possible that direct weather data may not be useful for RH but it may have to be transformed to obtain meaningful relationships.

Weather based prediction systems developed for groundnut foliar pathogens have often failed as they could not ccount for the variability due to prime weather parameters that are essential in the crop canopy for disease development. However, it is not always possible to record microclimate in the crop canopy. The present efforts to simulate microclimate conditions of the crop will help in using of observatory data which is far more easily available as compared to microclimate data to develop and validate disease prediction models. Similar efforts have been made Boulard (2000). The disease parameters viz. apparent infection rate (‘r’), percent disease index (PDI) and area under disease progress curve (AUDPC) were compared for both seasons (Fig.3).

Though the ‘r’ in 2004 (0.0664) was similar to ‘r’ in 2006 (0.0759), the AUDPC was relatively less in 2005 as compared to 2004, which indirectly signifies the role of other factors including date of sowing.

The relationships between meteorological data of observatory and canopy level could be used for comparing the disease development patterns with weather and thus refine the disease prediction models to suit to different crop growing regions and seasons.

CONCLUSIONS

From the field trials, it was evident that relationships could be established between metereological data of observatory and canopy level which could be used for understanding disease dynamics in crops. Such relationships will help in developing precise disease prediction models suitable for different agro-ecological regions as crop cultivation conditions for a diverse country like India are different across regions and over seasons.

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