Examining Micro-Climate Effects in Field Crop Production

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Introduction:
The development of disease within a crop is dependent upon the properties of the host, the pathogen, and the environment. All three factors are necessary for the survival, development, and spread of disease. Many crops are susceptible to specific pathogens, often for extended periods of their life cycle, providing a suitable host for disease organisms to attack. The ability of a pathogen to survive in the soil for many years or to disperse over great distances suggests that the pathogen can quickly develop should conditions be conducive. Wind-borne migration of spores can rapidly spread the disease to larger areas or to adjacent fields. Assuming the disease is present and the host is susceptible, disease forecasting and management is often a function of environment more so than any other factor. All pathogens have range of temperature and moisture conditions whereby optimum growth and development may occur. These conditions will vary spatially both from field to field and within a field. As such, the spatial extent of disease pressure will also vary considerably. While crop management and disease prevention are often dealt with at the field scale and disease risk forecasts are generally issued for a large area intended to represent regional risk, the actual pressure is greatly impacted by microclimates. Understanding the factors that create these microclimates are is important in realizing the implications they have on crop production.

The 2006 growing season was hotter and drier than normal, suggesting that disease pressure would be low. Regional disease forecast models agreed, showing no appreciable threat of disease outbreak. Unexpectedly, numerous instances of disease infections seriously limited the yield potential of various crops. Since environments that are conducive for the development and spread of disease most often occur at the micro-scale, the monitoring of ambient edge-of-field weather failed to detect the conditions that are conducive for the development of disease. Factors such as irrigation, shelterbelt-effect, and topography tended to create microclimates that can cause a potential infection that may go undetected and potentially untreated.

Microclimates Caused by Irrigation:
Due to the low rainfall and high crop water demand in 2006, more frequent irrigation was required, causing increased relative humidity, lower temperatures, and longer periods of dew and leaf wetness within the canopy. Particularly in the region surrounding the center of the irrigation pivot, the modification of the microclimate tended to provide the appropriate temperature and humidity and the free moisture needed for the development of late blight in potatoes. While the rate of water flow is less from the irrigation nozzles nearer to the center of the field, the short distance of travel of these sections as compared to those towards the outside of the field will ensure that the canopy remains wet for sustained periods of time. On a quarter section of land, a pivot will travel 40 times the distance at the edge of the field compared with the distance traveled 10 m from the pivot center during the same time period. The fact that increased incidence of late blight causes decreased tuber yield, as well as quality and storage concerns has prompted many producers to avoid planting potatoes within 30 m of the pivot center.

Microclimates Caused by Shelterbelts and Windbreaks:
Structures that reduce the flow of wind over a field have many advantages such as soil erosion control and snow catching. The reduction in wind velocity due to a shelterbelt will also decrease the rate of crop evapotranspiration. While areas near shelterbelts have the potential of producing higher yields when moisture is limiting, they may also create regions of excess moisture. Particularly under irrigation that is applied uniformly over a field, areas that transpire less moisture will remain wetter than areas that require

more water. Figure 1 shows the estimated reduction in wind speed resulting from a permeable windbreak. The area adjacent to the shelter, extending approximately five times the height of the shelter will experience a 50% reduction in wind speed. The resulting influence would reduce the rate of daily potential evapotranspiration (PET) to about 84% of that expected further from the windbreak (Figure 2). This could result in up to a 2.0 mm day^{-1} savings in water near the shelter. Over the span of a month, this could amount to over 60 mm of additional moisture. Under non-irrigated conditions during a dry season, this would be favorable; however under conditions of excess moisture or heavy irrigation, these areas are most prone to the development and spread of disease.

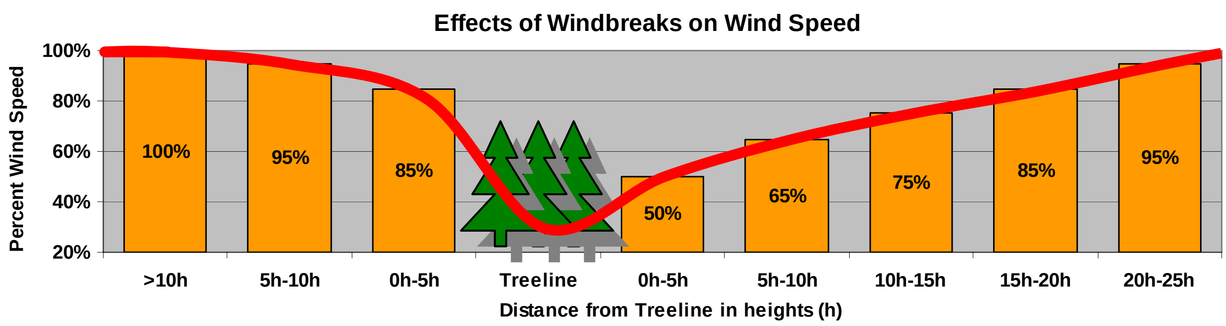

Figure 1: Estimated reduction in wind speed on the windward and leeward side of a permeable windbreak. Based on van Eimern et al. 1964.

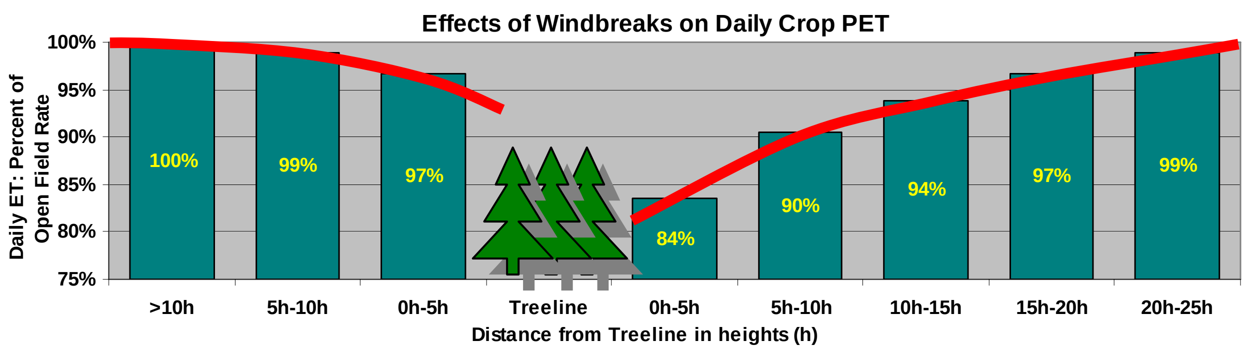

Figure 2: Estimated reduction in daily potential evapotranspiration (PET) on the windward and leeward side of a permeable windbreak. Based on van Eimern et al. 1964.

Conclusion:

Most management practices tend to be based on average field conditions. Unfortunately, general field conditions or those measured outside of the field do not represent the microclimates within which crop diseases tend to develop and spread. The higher than anticipated disease pressure in 2006 demonstrated the importance of considering microclimatological influences in disease scouting and forecasting. Due the effects of the microclimates caused by irrigation, windbreaks and topography, it is imperative that producers and agronomists alike explore management practices that mitigate the risk of creating environments that encourage disease development.

References

van Eimern, J., Karschon, R., Razumova, L.A., and Robertson, G.W. 1964. Windbreaks and shelterbelts. World Meteorol. Organ. Technical Note No. 59. 188 pp.