10.3 POSSIBLE GEOGRAPHIC SOURCE AREAS AND OVER-WINTERING HOSTS OF *MYZUS PERSICAE* MIGRANTS IN THE RED RIVER VALLEY

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1. INTRODUCTION

The Red River Valley of Minnesota and North Dakota produces 80,000 ha of potato; ranking this region as the second largest area of production in the United States (National Potato Council 2001). Seed potato production is an important component of this industry. During the mid-1980's, this region produced ~30,000 ha of seed potatoes with an on farm value of $60-70 million. Since the mid-1980's, potato viruses have been epidemic. Seed lot rejections due to excess *Potato Leaf-roll Virus* (PLRV) and *Potato Virus Y* (PVY) have approached 50% some years. Faced with these recurring losses, seed potato production in the Red River Valley had declined to 12,100 ha by 2001 (MDA 2001, NDSSD 2001).

Green peach aphid, *Myzus persicae* (Sulzer), is thought to be the only PLRV vector of consequence in the Red River Valley (Radcliffe et al. 2002). This aphid has also been implicated as being a key vector of PVY in the Valley. *Myzus persicae* does not overwinter outdoors in the northern Midwest. Populations are reestablished each spring in the Red River Valley with the arrival of migrant alatae borne on low-level jet streams. The life cycle of *M. persicae* is typical of a heteroecious, holocyclic aphid (van Emden et al. 1969). It overwinters either as eggs on peach, *Prunus persica* Miller, and closely related *Prunus* spp. or, if winter temperatures permit, can maintain continuous parthenogenetic reproduction on a wide range of secondary hosts. However, the geographic source and overwintering hosts of these *M. persicae* immigrants remains uncertain. Since green peach aphid is a weak flier, its flight in the air is passive, meaning that its transit can be treated as an air parcel in various migration models. During migration aphids can be lifted by convection currents to high altitude. We propose that the geographic source of *M. persicae* immigrants can be identified using meteorological models to calculate the trajectory route of an air parcel.

Laboratory research showed that extensive pre-freeze mortality occurred in *M. persicae* at –8°C (Bale et al. 1988). McLeod (1987) demonstrated that *M. persicae* collected from overwintered spinach had significant mortality when exposed to -17°C for several hours. He also found that overwintering *M. persicae* populations on spinach in Arkansas crashed after exposure to an extreme minimum temperature (ETmin) of -21°C (McLeod 1987). David Voegtlin reported that *M. persicae* overwintered outdoors on secondary host plants in southern Illinois in 2000 (ETmin = -14°C), but no overwintering population was found in 2001 (ETmin = -21°C) (personal communication). Our approach has been to identify geographic areas in which *M. persicae* overwintering might occur, and to use meteorological information to plot back trajectories of spring wind events that could have transported migrants to the Red River Valley.

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2. MATERIALS AND METHODS

A Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT) developed by the NOAA Air Resources Laboratory was used to backtrack the origin of wind events reaching the Red River Valley. We do not know whether the migrant *M. persicae* transported to the Red River Valley by spring wind events originate primarily from populations that overwinter on the primary host or from populations that reproduce parthenogentically throughout the winter on secondary hosts. Presumably, extreme minimum winter temperatures would not be limiting for the survival of *M. persicae* eggs on its primary host, but we would expect that the success of parthenogenetically overwintering populations would be delimited by an extreme minimum temperature threshold.

2.1 *Wind Event*

Achieved weather maps of wind vectors at 1500 m above ground level (AGL) at 2-3 h intervals April through June, 1992 to 1994 and 1998 to 2002 were accessed from the National Climatic Data Center (NCDC 2002). Data from 1992 to 1994 used the Nested Grid Model (NGM) from the Regional Analysis and Forecast System developed by NCEP using a 10 level, 180 km grid, and 2 h interval. (ARL 2002). Data from 1998 to 2002 used the Eta Data Assimilation System (EDAS) developed by the Weather Service's National Centers for Environmental Prediction (NCEP). EDAS is an intermittent assimilation system that has a 38 level, 48 km grid, and 3 h interval based on high frequency observations (ARL 2002). NGM and EDAS data from April through June were used for trajectory analysis.

2.3 *Trajectory Analysis*

The HYSPLIT model developed by NOAA was designed to aid in understanding the transport and dispersion of atmospheric pollutants (Draxler 1999, Heffter 2002). HYSPLIT Version 4 is a complete system that calculates trajectories, dispersion and deposition simulations by either puff or particle approaches (Draxler 1997). NGM data was used to calculate trajectories from 1992 to 1994, and EDAS data was used to calculate trajectories from 1998 to 2002. The model calculated both source-oriented (forward-in-time) and receptor-oriented (backward-in-time) trajectories. The trajectories were terminated 48 h backward. This cutoff point was chosen for both atmospheric and biological reasons. Accuracy of atmospheric calculation declines with increasing time because of the complexity of air motion, and survival of *M. persicae* after more than 48 h airborne is doubtful. For the purpose of our analysis we selected 500 m as the altitude of interest. Airborne *M. persicae* are commonly captured 300 m to 1200 m above ground level, with highest concentration at the lower levels (Taylor 1965). Also, 500 m is considered to be the lower limit of the boundary layer where air moves freely (Dingle 1996, Isard and Gage 2001).

2.4 *Data*

Primary Host. Peach acreage in each county in the United States was used to plot the distribution of primary host (USDA National Agricultural Statistics Service 1997). Data was imported into the ArcView® 3.1 database, and plotted by spatial analysis software.

Extreme Minimum Temperature. Extreme minimum temperature data from Arkansas, Kansas, Missouri, Louisiana, Oklahoma and Texas, from 1992 to 1994 and 1998 to 2002 were downloaded from National Climate Data Center (2002). Data was introduced into Geographic Information System ArcView® 3.2, and plotted by spatial analysis package. Isotherms of extreme minimum temperatures of -8°C, -14°C, and -21°C were drawn for the six states.

3. RESULTS

Wind vector analysis revealed the occurrence of 28 potential immigration events from 1992 to 1994 and 1998 to 2002. Among these, 27 of the 28 events could be analyzed by the HYSPLIT model. Data was not available for one event in June 1998. Results showed that 26 of these 27 probable transport events originated from the area south of 41°N, east of –103°W and west of Mississippi River, including parts of Arkansas, Kansas, Missouri, Oklahoma, and Texas, suggesting these states as the primary geographic source of *M. persicae* immigrants into the Red River Valley. Results also showed that the source of 19 of 27 events originated in peach production areas. Peach production in this region is most concentrated in eastern Texas, eastern Oklahoma, southern Missouri and northern Arkansas. Five of these 27 events originated from areas within the -8°C ETmin isotherm, 15 were from within the -14°C ETmin isotherm and 20 from within the -21°C ETmin isotherm.

4. SUMMARY

Green peach aphid populations vary greatly from one year to the next in the Red River Valley (Radcliffe et al. 2002). Populations were high in 1998 and 1999, low in 1993 and 2001, and intermediate in 1992, 1994 and 2000 (Radcliffe et al. 2002). Since *M. persicae* does not overwinter in the Red River Valley, populations must be reestablished each spring by migrants transported by low level jet streams from southern overwintering sites. We hypothesize that summer populations of *M. persicae* in the Red River Valley are determined in large extent by the magnitude of migrant influxes and timing of the wind events responsible for their transport. We have yet to establish whether the invading migrants originate primarily from populations overwintering on the primary host or are from populations continuously reproducing on secondary winter hosts. If secondary winter hosts are important in the population dynamics of these southern populations, then extreme minimum winter temperatures may be an important determinant of the geographic source and magnitude of the migrant population invading the Red River Valley the following spring. Other researchers have found that winter temperature, leaf surface wetness, and the total number of frost days are significantly correlated with the rate of *M. persicae* population change (Bale et al. 1988, Harrington and Cheng 1984). Identification of the climatic and host associations that determine overwintering success and relating this information to the occurrence of wind events suitable for transport of migrant aphids north is needed to develop a model to forecast *M. persicae* pressure, the transmission of potato viruses, and to suggest IPM strategies for potato seed growers in the Red River Valley.

5. REFERENCES

Air Research Laboratory, 2002: Archived meteorology. [Available online at http://www.arl.noaa.gov/ss/transport/archives.html.]

Bale, J.S., R. Harrington, and M.S. Clough, 1988: Low temperature mortality of the peach-potato aphid *Myzus persicae*. *Ecol. Entomol.*, **13**, 121-129.

Dingle, H., 1996: Migration, winds and currents. *In*: Dingle, H, *Migration- the biology of life on the move*. Oxford University Press, 95-136.

Draxler, R.R. and G.D. Hess, 1997: Description of the HYSPLIT_4 modeling system. *NOAA Technical Memorandum ERL ARL*-224.

Draxler, R.R., 1999: Hybird single-particle Lagrangian integrated trajectories (HY-SPLIT): Version_4

User's guild. *NOAA Technical Memorandum ERL ARL*-230, 35.

Harrington, R. and X. Cheng, 1984: Winter mortality, development and reproduction in a field population of *Myzus persicae* (Sulzer) (Hemiptera:Aphididae) in England. *Bull. Ent. Res*., **74**, 633-640.

Heffter, J.L., 2002: Running HYSPLIT on the READY Website. [Available online at http://www.arl.noaa-.gov /ready/sec/training.pdf.]

Isard, S.A. and S.H. Gage, 2001: The importance of microscale motion systems and flight aptitude to the ascent of aphids through the surface boundary layer: a research agenda. In Isard, S.A. and S.H. Gage (eds). *Flow of life in the atmosphere*. Michigan State University Press. East Lansing, 127-142.

McLeod, P., 1987: Effect of low temperature on *Myzus persicae* (Homoptera: Aphididae) on overwintering spinach. *Environ. Entomol*., **16**, 796-801.

Minnesota Department of Agriculture, 2001: *Minnesota certified seed potato directory 2001*. 1-20.

National Agricultural Statistics Service, 1997: Census of Agriculture CD-ROM Set. United States Department of Agriculture.

National Climate Data Center, 2002: NNDC climate data online [Available online at http://cdo.ncdc.no-aa.gov/plclimprod/plsql/poemain.poe.]

National Potato Council, 2001: 2000-2001 *Potato Statistical Yearbook*. National Potato Council. Englewood. USA, 95pp.

North Dakota State Seed Department, 2001: 2001 seed potato growers and varieties.

Radcliffe, E.B., D.W. Ragsdale, and R.A. Suranyi, 2002: IPM case studies – potato, In: van Emden, H.F. and R. Harrington (eds). *Aphid as Crop Pests*. CABI Publ., Wallingford, in press.

Taylor, L.R. 1965: Flight behavior and aphid migration. *Proc. North Centeral Branch Entomology Society of America,* **20**, 9-19.

Van Emden, H. F., V. F. Eastop, R.D. Hughes, and M.J. Way. 1969: The ecology of *Myzus persicae*. *Annu. Rev. Entomol.*, **14**, 197-270.