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SPATIAL/TEMPORAL MODEL FOR SURVIVABILITY OF PEA LEAFMINER (Liriomyza huidobrensis) IN WARM CLIMATES: A CASE STUDY IN SOUTH FLORIDA, USA

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ABSTRACT

Due to a recently-developed resistance to broad spectrum pesticides, the highly invasive pea leafminer, Liriomyza huidobrensis, has become a polyphagous pest of vegetable and flower crops in many parts of the world, including most Latin American countries. Although L. huidobrensis is acclimated to cooler climates, the possibility exists that seasonal populations could survive and thus pose a risk during the cool seasons in warm-climate regions. This paper reports on a pilot project conducted in South Florida, USA, to test the possibility that L. huidobrensis can survive during cool season months in warm climates. Temporal and spatial analysis of temperature data from South Florida indicate that climatic conditions in the region are consistent with temperature requirements for seasonal development of L. huidobrensis. Favorable climatic conditions, combined with the existence of a major concentration of crop and nursery land uses in the vicinity of the Miami International Airport, a major entry point for potentially infested produce and cut flowers, present a risk of establishment of seasonal populations of L. huidobrensis. This pilot study demonstrates that the potential exists for L. huidobrensis to establish seasonal populations in warmer climates or to survive transport to cooler regions. This potential should raise quarantine concerns even for many parts of the world where year-round populations of L. huidobrensis probably do not pose a threat.

Keywords: pea leafminer, Liriomyza huidobrensis

INTRODUCTION

The pea leafminer, Liriomyza huidobrensis, is a highly invasive pest of many vegetable and flower crops in both greenhouses and open fields. Leafminers inflict damage to leaves through punctures made by females to feed and lay eggs, and by mining in the leaf mesophyll by larvae (Weintraub and Horowitz, 19957). Unlike L. trifolii and L. sativae larvae, which feed on the upper mesophyll, L. huidobrensis, feed in the lower mesophyll, which is more damaging to leaf photosynthesis (Heinz and Chaney, 1995). This can result in a severe yield reduction. Common crop and ornamental host plants of L. huidobrensis include lettuce, potato, celery, sweet and garden pea, broccoli, cauliflower, tomato, pepper, chrysanthemum, and carnation (Steck, 1996).

L. huidobrensis is indigenous to cooler, mostly highland areas of South America but recently has invaded many other countries. Known occurrences include South America (Argentina, Brazil, Chile including Juan Fernandez Island, Colombia, Peru, Venezuela), Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama), the Caribbean (Dominican Republic, Guadeloupe), North America (Ontario, Canada), Europe (Belgium, Netherlands, UK), Africa (Kenya, South Africa), the Middle East (Israel), and East Asia (China, Indonesia, Sri Lanka, Taiwan) (de Clerq and Casteels 1992; Bartlett, 1993; Weintraub and Horowitz, 1995; Steck, 1996; Shiao and Wu, 2000; Scheffer and Lewis, 2001; Scheffer et al. 2001). Flies previously described as L. huidobrensis from the western US have recently been recognized as a separate, yet closely related species, Liriomyza langei (Scheffer, 2000; Scheffer and Lewis 2001), thus increasing quarantine concerns for the true L. huidobrensis in the US.

Due to recently developed resistance to pesticides applied in the 1970's against other pest species of potato (Chavez and Raman, 1987; Mason and Johnson, 1988), L. huidobrensis has become an important pest of various food crops and horticultural plants worldwide. In Peru, potato losses due to L. huidobrensis of more than 30% have been reported (Chavez and Raman, 1987). L. huidobrensis has caused complete crop losses in parts of Western Europe following its introduction (Bartlett 1993). Vegetable losses as high as 60-70% have been reported in Indonesia (Rauf et al., 2000).

The recent change in pest status of L. huidobrensis raises concerns about its potential survivability in warmer climates. Although L. huidobrensis is acclimated to cooler temperatures, the possibility exists that it could survive on infested plants or produce and spread or be transported during the cooler seasons of warm-climate regions. In this paper we report on a case study conducted in South Florida, USA, to test the possibility that seasonal conditions in a warm-climate region might be favorable to support L. huidobrensis.

BIOLOGY

Laboratory and greenhouse studies have determined that the egg stage lasts from 1.5 to 4 days, depending on temperature and host plant, the larval feeding stage lasts from 3.6 to 10 days, and the pupal stage lasts 7.9 to 12.6 days (Weintraub and Horowitz, 1995; Lanzoni et al., 2002). Adults are approximately 2 mm long. Females live up to 18 days, and males about 6. Mating begins at about 1 day of age and oviposition rate peaks at 4 to 8 days after emergence (Steck, 1996). L. huidobrensis is acclimated to cooler temperatures. Lanzoni et al. (2002) reported a lower total development threshold of 8.1oC (46.6oF), an upper total threshold of 29.5oC (85.1oF) and an optimum temperature of 25.0oC (77oF) (Table 1). Climatic chamber experiments using L. huidobrensis collected from greenhouse plantings of Gerber in southern Italy showed that development time was inversely proportional to temperature for each stage between 15 and 25oC (trials in 5oC increments) and that at 30oC no adults emerged (Lanzoni et al., 2002) (Table 1).

Table 1. Climatic chamber experimental data for *L. huidobrensis* from Lanzoni et al., 2002.

Temperature °C (°F)	15 (59)	20 (68)	25 (77)	30 (86)
Total Development Time (days)	43.6	22.5	16.1	--
Cummulative Growing Degree Days in °F	540.6	481.5	489.4	--
Percent Mortality	39.1	64.7	60.0	100

PEA LEAFMINER IN FLORIDA

There is only one known confirmed field record of L. huidobrensis in Florida, reported by Poe and Montz (1981) from a field of Gypsophila in Lee Co. The infestation was assumed to have been transported on nursery stock from an infested area of California. The same site was repeatedly resampled, and no further L. huidobrensis were detected (Steck, 1996). A second published report (CABI/EPPO, 1992) stating that L. huidobrensis occurs in glasshouses in Florida was deemed to be an erroneous report based on a misreading of Poe and Montz (1981). We could find no documented field infestations of L. huidobrensis in Florida since 1981 (Steck, 1996).

Steck (1996) speculated that the climate in Florida is not amenable to year-round viability of pea leaf miner populations, but noted that "the range of ambient and glasshouse conditions tolerated by L. huidobrensis has not been established, and it cannot be presumed that it will not establish under any Florida conditions."

Live larvae continue to enter Florida on various hosts imported from infested areas. Larvae-infested produce, especially snow peas and cut flowers, have been intercepted many times at Florida ports of entry (Steck, 1996; Florida Department of Agriculture and Consumer Services, 1998; Michael Shannon, USDA APHIS PPQ, pers. comm. 2005).

Miami International Airport (MIA) is an especially important access point for potential importation of L. huidobrensis. It is by far Florida's largest conduit for air cargo, handling 72 percent of airfreight entering Florida (FDOT Aviation Office). In 2004, MIA handled 82 percent of all air imports between the United States and Latin America and the Caribbean. Although air cargo is the most expensive way to ship goods, it is the only way to transport perishable goods such as flowers, seafood, fruits and vegetables from Latin American countries (Miami Herald, 5/26/05). 85 percent of the 165,000 tons of fresh-cut flowers imported into the United States every year pass through MIA, which handles 32,500 boxes of flowers a day. Major producers include Colombia, Ecuador, Costa Rica, and Mexico (Miami International Airport press release, 5/7/04, accessed on MIA airport website on 6/4/05).

METHODOLOGY

This study is a pilot project that investigated the possibility that climatic conditions in South Florida may be favorable to support seasonal populations of L. huidobrensis. Data from 10 NOAA weather stations in South Florida weather stations for the years 1997-2001 were compiled and used to determine if temperature conditions at any time during the year are consistent with experimentally determined parameters for L. huidobrensis. Station sites were plotted on base maps, which were used to prepare temperature surfaces of monthly maximum temperatures. Using inverse distance weighting, temperature maps were created for each month delineating areas in which the temperature was below or exceeded the experimentally determined (Lanzoni et al., 2001) maximum temperature threshold of approximately 85 degrees F. Based on these maps, the cool season of 1997-1998 (November – April) was chosen for detailed study because large areas of the region had temperatures below the upper threshold (Figs. 1 and 2).

Because insect development rates vary with temperature between upper and lower thresholds, growing degree days (GDD) were calculated for each cool season month and compared with experimentally determined GDD required for total development time of L. huidobrensis. Calculation of GDD is a method for predicting the development rate of an insect with respect to temperature fluctuations. GDD models calculate the number of GDD required for development of each stage of an insect. The number of GDD accumulated each day varies with temperature fluctuations. Daily GDD are calculated by the following formula:

$$(GDD) = (Tmax + Tmin)/2 - Tlow$$

where:

Tmax = the daily maximum temperature

Tmin = the daily minimum temperature

Tlow = the lower temperature threshold for the insect

If the daily maximum and minimum temperatures exceed the insect thresholds they are set equal to the thresholds in the calculation.

The accumulated number of GDD required for an insect to complete a developmental stage is calculated by the following equation:

GDD = (Experimental Temperature – Lower Development Threshold) x Development Time in days

Calculated GDD required for total development times for L. huidobrensis are given in Table 1.

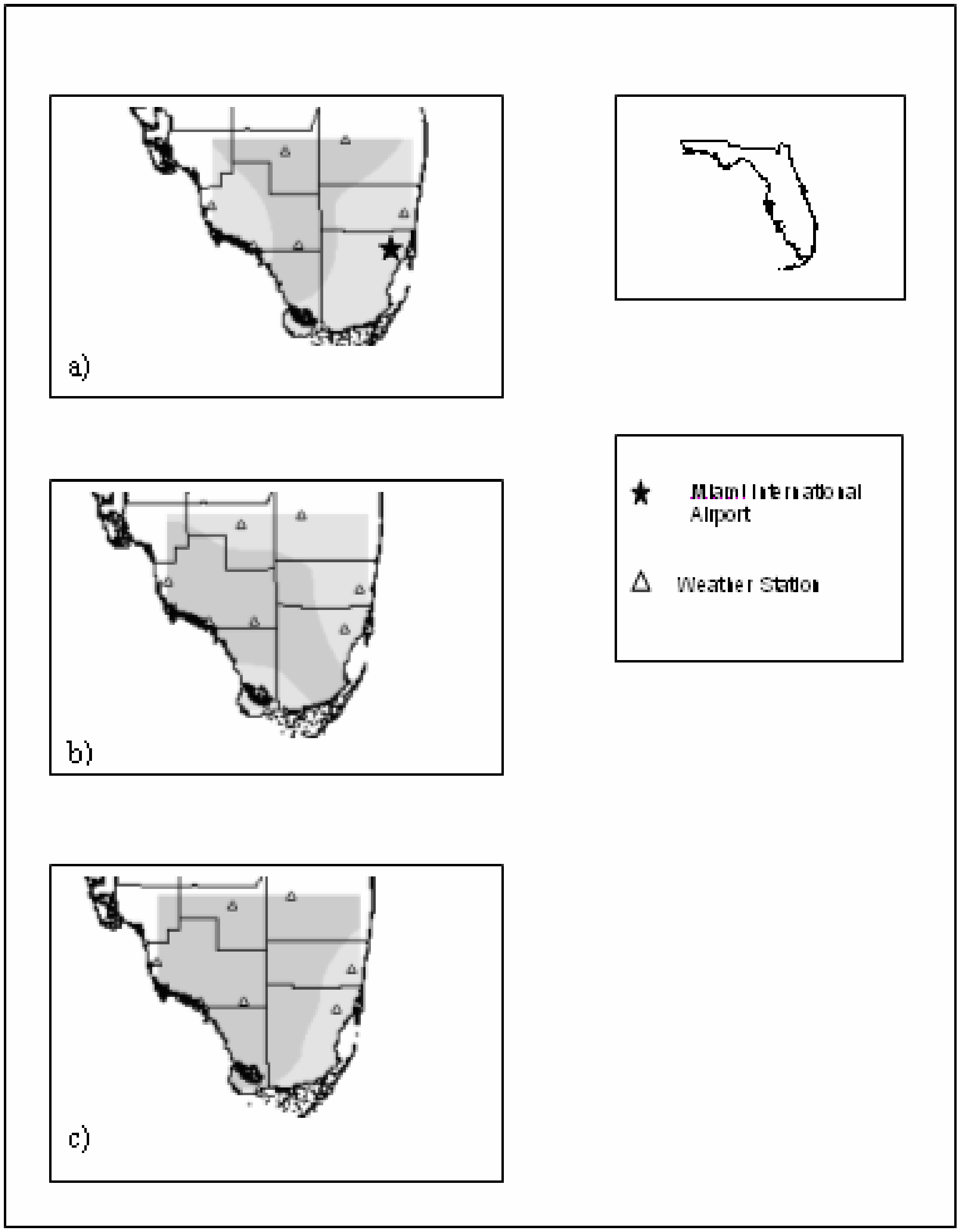

Fig. 1. Maximum monthly temperature surfaces for South Florida for a) January, b) February, and c) March 1998. Darker gray shading represents temperatures equal to or above 85°F, lighter gray shading represents temperatures below 85°F. Monthly temperature data from NOAA Cooperative Observer weather station network.

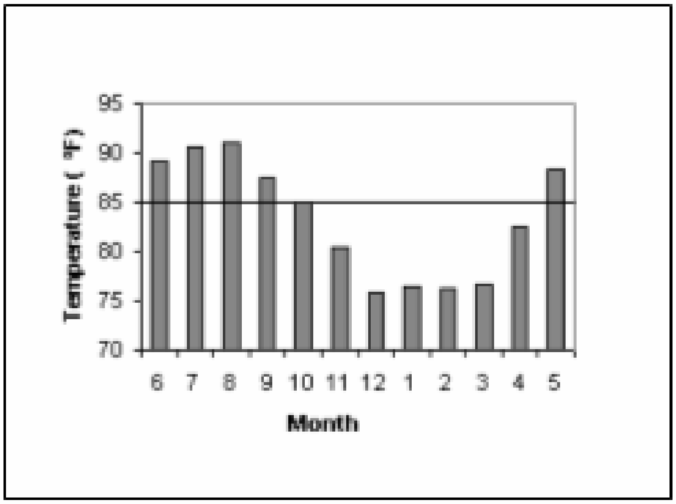

Fig. 2. 1997-1998 average monthly temperatures at Miami International Airport. Data from NOAA Cooperative Observer weather station network. Horizontal line represents the experimental upper threshold for total development of *L. huidobrensis*, as determined by Lanzoni et al., 2002. The months November 1997 through April 1998 were chosen for analysis

RESULTS AND DISCUSSION

Monthly cumulative GDD and monthly average temperatures at the MIA weather station for the November 1997 through April 1998 season are presented in Table 2. Assuming that 480 to 490 GDD are required for total development of pea leafminer (see Table 1), results indicate that GDD requirements were met and exceeded in every month of the cool season. This indicates that, from a climatic perspective, conditions in the region, were favorable to sustain populations of L. huidobrensis. Although this pilot study did not investigate climatic parameters at other weather stations, monthly temperature surface plots suggest that similar temperature conditions tend to prevail along the Atlantic coastal region, with warmer temperatures in the central part of the state (see Fig. 1). A map depicting row crop, field crop and nursery land uses in South Florida (Fig. 3) shows that major areas for these agricultural uses lie along the Atlantic coastal region, with a concentration just south of MIA. Given the potential rapid growth and spread of L. huidobrensis populations (Shiao and Wu, 2000), even populations of L. huidobrensis that only become established seasonally could cause significant crop losses and export restrictions in Florida.

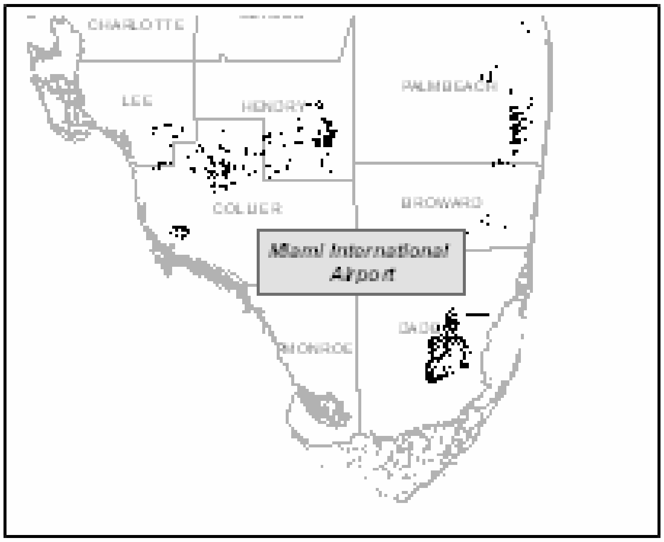

Fig. 3. Map of South Florida region showing locations of Miami International Airport and agricultural land uses (black). 1999 land use data obtained from South Florida Water Management District.

CONCLUSIONS

Temporal and spatial analysis of temperature data from South Florida indicate that climatic conditions in the region are consistent with temperature requirements for seasonal development of L. huidobrensis. Favorable climatic conditions, combined with the existence of a major concentration of crop and nursery land uses in the vicinity of the Miami International Airport, an important entry point for potentially infested produce and cut flowers, present a risk of establishment of seasonal populations of L. huidobrensis. This pilot study demonstrates that the potential exists for L. huidobrensis to establish seasonal populations in warmer climates or to survive transport to cooler regions. This potential should raise quarantine concerns even for many parts of the world where year-round populations of L. huidobrensis probably do not pose a threat.

LITERATURE CITED

Bartlett, P. W. (1993). Plant quarantine experience of Liriomyza spp. in England and Wales, pp. 23-30, Liriomyza: Conference on leafmining flies in cultivated plants. CIRAD, Montpellier, France.

CABI/EPPO (1992). Data sheets on quarantine pests: Liriomyza huidobrensis, pp. 194-198, Quarantine pests for Europe. CAB International, Wallingford, Oxon, UK.

Chaney, W. E. (1995). The pea leaf miner as a pest of vegetable crops, 4 pp. Monterey Co. Extension Office Crop Notes.

Chavez, G. L. and K. V. Raman (1987). Evaluation of trapping and trap types to reduce damage to potatoes by the Leafminer, Liriomyza huidobrensis (Diptera, Agromyzidae). Insect Sci. Appl. 8: 369-372.

-de Clercq, R., and H. Casteels (1992). Occurrence and host plants of Frankliniella occidentalis and Liriomyza huidobrensis in Belgium. Bulletin OEPP 22: 363-366.

Florida Department of Agriculture and Consumer Services (1998). Triology, v. 37, no. 5., September-October

Heinz, K.M. and W.E. Chaney (1995). Sampling for Liriomyza huidobrensis (Diptera: Agromyzidae) larvae and damage in celery. Environ. Entomol. 24: 204-211.

Lanzoni, A., G. Bazzocchi, G. Burgio, and M. Fiacconi (2002). Comparative Life History of Liriomyza trifolii and Liriomyza huidobrensis (Diptera: Agromyzidae) on Beans: Effect of Temperature on Development. Entomological Society of America, v. 31, 797-803.

Mason G. A. and M. W. Johnson (1988). Tolerance to permethrin and fenvalerate in hymenopterous parasitoids associated with Liriomyza spp. (Diptera: Agromyzidae). Journal of Economic Entomology 81:123-126.

Poe, S. L., and J. K. Montz (1981). Preliminary results of a leafminer species survey, pp. 24-34. In D. J. Schuster [ed.], Proc. IFAS-Industry conference on biology and control of Liriomyza leafminers.

Rauf, A., M. B. Shepard, and M. W. Johnson (2000). Leafminers in vegetables, ornamental plants and weeds in Indonesia: surveys of host crops, species composition and parasitoids. International Journal of Pest Management, 46, 257-266.

Scheffer, S. J. (2000). Molecular evidence of cryptic species within the Liriomyza huidobrensis (Diptera: Agromyzidae). Journal of Economic Entomology 93: 1146-1151.

Scheffer, S. J., and M. L. Lewis (2001). Two nuclear genes confirm mitochondrial evidence of cryptic species within Liriomyza huidobrensis (Diptera: Agromyzidae). Annals of the Entomological Society of America 94: 648-653.

Scheffer, S. J., A. Wijesekara, D. Visser, and R. H. Hallett (2001). Polymerase chain reaction-restriction fragment-length polymorphism method to distinguish Liriomyza huidobrensis from L. langei (Diptera: Agromyzidae) applied to three recent leafminer invasions. Journal of Economic Entomology 94: 1177-1182.

Shiao, S. F., and W. J. Wu (2000). Liriomyza huidobrensis (Blanchard), a newly invaded insect of economic importance to Taiwan (Diptera: Agromyzidae). Plant Protection Bulletin (Taichung) 42: 249-254. In: Spencer, K. A. 1990. Host specialization in the world Agromyzidae (Diptera). Kluwer Academic Publishers, Dordrecht, The Netherlands.

Steck, G. J. (1996). Pea leafminer, Liriomyza huidobrensis (Diptera: Agromyzidae). Florida Department of Agriculture and Consumer Services, Entomology Circular No. 378, 1996. http://doacs.state.fl.us/~pi/enpp/ento/peamin4.htm

Weintraub, P. G., and A. R. Horowitz (1995). The newest leafminer pest in Israel, Liriomyza huidobrensis. Phytoparasitica 23: 177-184.