

Comparative Epidemiology of Potato Late Blight: Management Implications Contrasting Highland Tropics and Temperate Climates

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Abstract

Data from Ithaca (NE USA), and Toluca (Central Mexico, 2640 masl), is used to emphasize some of the differences in the epidemiology of late blight in temperate and highland-tropical climates. The Ithaca region has a humid continental type of climate. Annual precipitation ranges between 700-1100 mm. During the growing season, the total precipitation usually ranges from 400-500 mm. The Toluca Valley is characterized by monthly average temperatures in the range of 12-17 °C and a yearly rainfall around 800-900 mm. Most of the precipitation occurs during the growing season. Epidemics of late blight in the Toluca Valley begin shortly after the rain season starts. In contrast, in the Ithaca region late blight epidemics are unpredictable in their regularity or their onset. Average monthly temperatures are higher while total monthly precipitation is lower in the Ithaca area than in the Toluca area during the peak of the growing season. The combined effects of differences in climate make epidemics develop less fast in Toluca than in Ithaca. Use of cultivars with high levels of field resistance such as Rosita and Norteña in combination with a properly adapted fungicide forecasting system like SimCast show promise for use in the Toluca Valley and possible in other areas of the highland tropics. Susceptible cultivars such as Alpha are best managed with weekly or 5-day calendar spray applications.

Resumen

Grünwald, N. J., Romero Montes, G. and Fry, W. E. 2002. Epidemiología Comparativa del Tizón Tardío de la Papa. Implicaciones de Manejo Contrastando Climas del Trópico Alto y Climas Templados. pp. 133–138 en: Fernández-Northcote E. N. (ed), Memorias del taller internacional Complementando la resistencia al tizón (*Phytophthora infestans*) en los Andes, Febrero 13–16, 2001, Cochabamba, Bolivia, GILB, Taller Latinoamérica 1. Centro Internacional de la Papa, Lima, Perú.

Datos de Ithaca (NE USA) y Toluca (México Central, 2640 msnm), se utilizaron para enfatizar algunas de las diferencias en la epidemiología del tizón tardío entre climas templados y de trópico alto. La región de Ithaca tiene un clima de tipo continental húmedo. La precipitación anual varía entre 700-1100 mm. Durante el período del cultivo, la precipitación generalmente varía entre 400-500 mm. El valle de Toluca se caracteriza por temperaturas promedio mensuales en el rango de 12-17 °C y una precipitación anual de 800-900 mm que ocurre mayormente durante el período de cultivo. La epidemia de tizón tardío en el valle de Toluca empieza poco después de que empiezan las lluvias. En contraste, en la región de Ithaca las epidemias de tizón tardío son impredecibles tanto en su regularidad como en su inicio. Las temperaturas promedio mensuales son más altas mientras que la precipitación total mensual es más baja en el área de Ithaca que en la de Toluca durante el pico del desarrollo del cultivo. El efecto combinado de las diferencias en clima hace que las epidemias desarrollen más rápido en Ithaca que en Toluca. El uso de cultivares con altos niveles de resistencia de campo tales como Rosita y Norteña en combinación con un sistema de predicción adaptado apropiadamente tal como el SimCast se muestra promisorio para su uso en el valle de Toluca y posiblemente en otras áreas de los trópicos altos. Cultivares susceptibles como Alpha se manejan mejor con aplicaciones calendario semanales o de cada cinco días.

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Introduction

Late blight of potato (*Solanum tuberosum* L.) is caused by the oomycete *Phytophthora infestans* (Mont.) de Bary. It is considered to be one of the most serious pest problems affecting the potato crop. Late blight is of particular importance in the highland tropics of the developing countries where it causes yield losses estimated to add up to US\$ 2,750 million each year. Even more money is spent on purchasing fungicides to manage late blight.

Our current understanding of the epidemiology of late blight is based mostly on studies conducted in regions with temperate climates (Bruhn, 1979; Bruhn and Fry, 1981; Crosier, 1934; Melhus, 1915). Most of the knowledge used to manage late blight in the highland tropics is thus knowledge derived from studies conducted in temperate climates. There is a clear need to reevaluate research knowledge for the highland tropics.

There are obvious differences between highland tropical and temperate climates and these will be discussed focusing on our observations from the area of Ithaca, New York, and Toluca in central Mexico (Table 1). The potato growing areas of the highland tropics are often found at high altitudes ranging from 2,000 to about 3,500 masl (meters above sea level). The high altitudes result in relatively low average temperatures during the potato-growing season, which result in slower epidemic progress. Other differences between the highland tropics and temperate climates are found for inoculum availability and day-length.

Table 1. Obvious differences in the potato-late blight host-pathosystems of Freeville, NY, and Toluca, Mexico.

	Gamefarm, NY	Toluca, Mexico
Altitude of potato growing areas	150-300 m	2,600-3,500 m
Temperature regime during growing season	Warm	Cool
Day-length	Long	Short
Inoculum pressure at beginning of season	Low	High
Epidemic development	Fast	Slow

Progress of the late blight epidemic is dependent in large part on (i) the level of resistance of the host to the pathogen, (ii) the fungicide management scheme, and (iii) the microclimate. A good disease management program should integrate the effects of host resistance, weather and fungicide management. Forecasting systems such as BLITECAST (MacKenzie, 1981) and calendar spray schedules have been used with success in temperate climates to control Late Blight. This chapter will discuss the importance of resistance, fungicide management and microclimate on management of LB in the highland tropics with insights gained from our experience in working in Toluca, Mexico, and Ithaca, NY. We will try to identify major differences between the two climate zones and outline corresponding implications for disease management.

Comparative climate

Data from regions of Ithaca, NY, and Toluca, Central Mexico, are used to emphasize some of the differences in the climate patterns that might affect the epidemiology of late blight in temperate and highland-tropical climates. The Toluca valley is characterized by monthly average temperatures in the range of 12-17° C and a yearly rainfall around 800-900 mm. The winter is dry and mild followed by a rainy and cool summer. Potatoes (*Solanum tuberosum* L.) are grown during the summer months, which are characterized by cool and wet weather (Grünwald et al., 2000). Most of the precipitation occurs during the growing season. The Toluca Valley offers a tropical highland climate due to the latitude (19°14'N; 99° 34' E) and altitude of the area (2640 masl).

In contrast, the Ithaca region has a humid continental type of climate (Dethier and Pack). Summers are warm and the winters are long and cold. Maximum precipitation occurs in late spring and summer. Annual precipitation ranges between 700-1100 mm. During the growing season, the total precipitation usually ranges from 400-500mm.

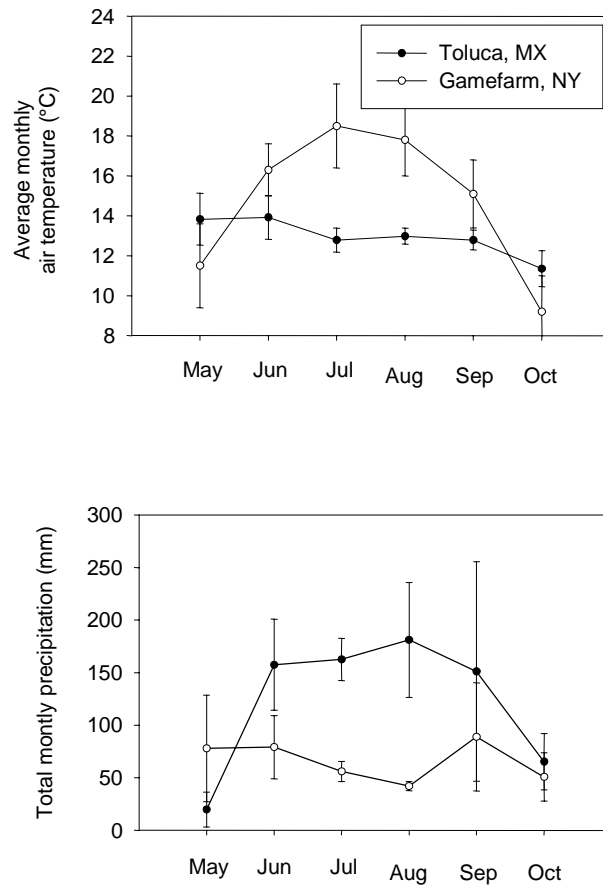


Figure 1. Averages and standard deviations of air temperature (°C) and precipitation (mm) calculated for monthly averages obtained for the years 1998-2000. Data for NY came from the Gamefarm weather station and were obtained through the Northeast Regional Climate Center (Ithaca, NY). Data for Toluca were obtained from an automated weather station located in Metepec as described previously (Grünwald et al., 2000).

Epidemics of Late Blight in the Toluca Valley begin shortly after the rain season starts (Grünwald et al., 2000). Thus, potatoes are grown when conditions are most conducive to late blight. In contrast, in the Ithaca region late blight epidemics are unpredictable in their regularity or their onset. Average monthly temperatures are higher while total monthly precipitation is lower in the Ithaca area than in the Toluca area during the peak of the growing season (Figure 1). While increased precipitation might be expected to increase disease pressure, the lower temperature is more important and epidemic pressure as measured by accumulated blight units actually progress faster in Ithaca than in Toluca (Figure 2). In conclusion, epidemics are slower in Toluca, but disease pressure is constant and predictable. Thus, a combination of resistant cultivars and scheduled fungicide applications seem appropriate as strategies in further slowing the epidemic to minimize yield loss.

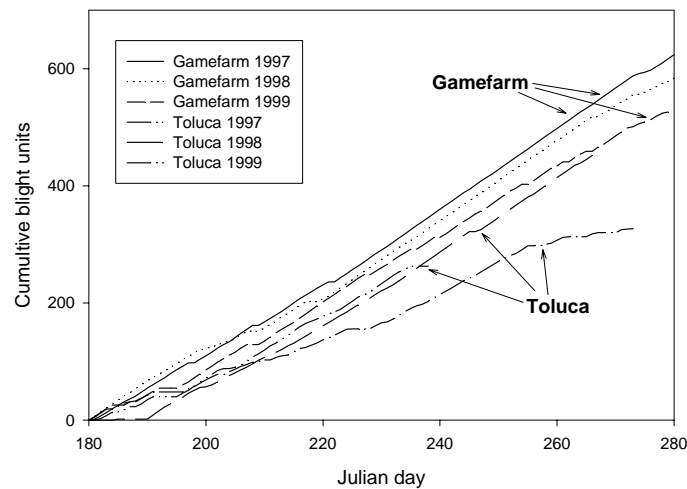


Figure 2. Cumulative blight and fungicide units calculated using historic weather data for 1997-1999 for Gamefarm, NY and Metepec, Mexico. Blight and fungicide units were calculated as defined previously (Fry et al., 1983; Grünwald and Fry, 2000).

Resistance

The Mexican national breeding program has produced several cultivars with high levels of field resistance (Flores-Gutierrez et al., 1996; Grünwald et al., 1999, 2000). These cultivars can be grown without a single fungicide application resulting in about 4% and 20% disease severity for Norteña and Rosita, respectively, while Alpha is completely defoliated (Grünwald et al., 1999) (Figure 3). In 1998 and 99 both cultivars had less than 25% disease at the end of the field season without a single fungicide application. Our results correspond well to informal reports by the National Potato Program (INIFAP). Rosita was released in 1971 (release #: PA-4/71) and Norteña in 1992 (release #: PAP-080592-011). Rosita and Norteña are currently grown on 18% (Rubio - Covarrubias and Flores-Gutierrez, 1997) and approximately 5% (INIFAP National Potato Program, *personal communication*) of the national acreage, respectively. Rosita has been grown commercially for 27 years and its resistance to Late Blight does not seem to break down. Thus, we expect that integration of field resistance with appropriate fungicide management schemes will be important in managing late blight in the highland tropics.

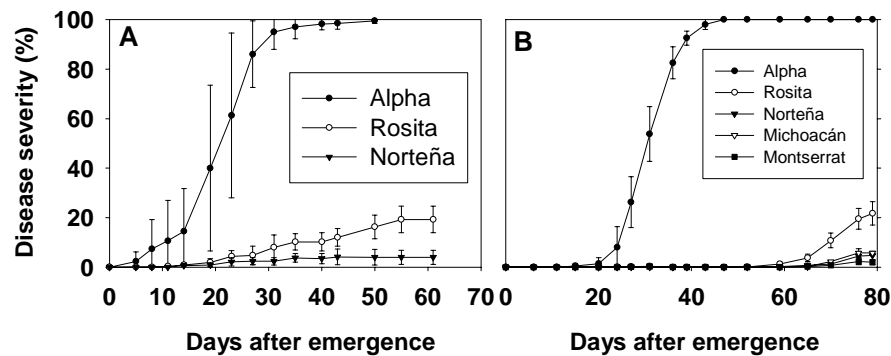


Figure 3. Disease progress curves for late blight on different potato cultivars grown in Toluca in (A) 1998 and (B) 1999, respectively. Cultivar Alpha is a susceptible control. Rosita, Norteña, Montserrat and Michoacán are cultivars released by the Mexican National Potato Program (INIFAP-Programa de Papa).

Fungicide management in Toluca

One possible improvement over scheduling fungicide applications based on calendar sprays would be use of a forecasting system that issues a spray advisory using recent weather history. Of the forecasting systems

tested in Toluca to date, SimCast performed best and as well as a weekly fungicide application (Grünwald and Fry, 1998a, 1998b, 2000; Grünwald et al., 1999, 2000). In all cases, use of SimCast predictions resulted in excellent disease control. With increasing level of resistance (from Alpha, to Rosita and Norteña), the number of fungicide applications declined, even though the growing cycle was longest for Norteña, followed by Rosita and then Alpha (Table 2). In all cases SimCast performed as well or better than a scheduled fungicide application. Compared to the standard grower practice of 15-25 applications (Rubio – Covarrubias and Flores – Gutierrez, 1997), SimCast forecast 8-10 applications in the case of Alpha, 6 in the case of Rosita and 4 in the case of Norteña (Table 2).

Table 2. Number of fungicide applications based on revised SimCast forecasting system contrasted with standard grower practice on cultivar Alpha for the Toluca region in central Mexico.

	No. Fungicide applications
Standard grower practice with cv. Alpha	15-25
SimCast and cv. Alpha	8-10
SimCast and cv. Rosita	6
SimCast and cv. Norteña	4

Outlook

There are obvious differences in climate that affect the development of potato late blight. Most notable are the differences in precipitation and temperature. The combined effects of differences in climate make epidemics develop less fast in Toluca than in Ithaca. Use of varieties with high levels of field resistance such as Rosita and Norteña in combination with a properly adapted fungicide forecasting system like SimCast show promise for use in the Toluca Valley and possibly in other areas of the highland tropics.

Acknowledgements

We thank PICTIPAPA and CEEM for logistical and financial support for these projects. We thank Dr. Enrique Fernández-Northcote of PROINPA and Dr. Graham Thiele of CIP for inviting us to present this work at the workshop.

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