Pest Management Grants Final Report

Contract No. 98-0272

Forecasting Potato Late Blight at Tulelake

Principal Investigator: Ariena H. C. Bruggen, Professor, Department of Plant Pathology, University of California, Davis, 95616 ph (530)752-0300 fax (530)752-5674

March 20, 2000

Prepared for California Department of Pesticide Regulation

Acknowledgments

I thank Keqiang Cao and Harry Carlson for their cooperation.

This report was submitted in fulfillment of Contract No. 98-0272, "Forecasting Potato Late Blight at Tulelake" by Ariena H. C. Bruggen, Professor, Department of Plant Pathology, University of California, Davis, under the partial sponsorship of the California Department of Pesticide Regulation. Work was completed March 15, 2000.

Table of Contents

Abstract

Late blight is a new and serious disease of potatoes in the Tulelake area of California. In 1999, the disease was absent from the area and analysis of decision support systems could not be made. However, the relationship of four irrigation treatments to late blight-conducive environments within the canopy was studied. The irrigation regimes (all overhead sprinklers) were: (A) 11 hours in the day (8:00-19:00); (B) 11 hours at night (19:00-6:00); (C) 5 hours in the day (14:00-19:00), and (D) 5 hours at night (1:00-6:00). Irrigations were made every 3-5 days during the growing season based on calculated evapotranspiration rates. The irrigation regime of 5 hours of overhead irrigation during the day resulted in the least favorable environment for late blight. The treatment of 11 hours of irrigation during the night resulted in an environment more conducive to the disease.

Summary. In 1999, late blight was absent from the Tulelake area and the efficacy of various models to predict late blight could not be made. However, the canopy environments created by various irrigation regimes and their effect on conditions conducive for late blight was studied. The four different overhead-irrigation regimes were: (A) 11 hours in the day (8:00-19:00); (B) 11

hours at night (19:00-6:00); (C) 5 hours in the day (14:00-19:00), and (D) 5 hours at night (1:00-6:00). Irrigations were made every 3-5 days during the growing season based on calculated evapotranspiration. The irrigation regime of 5 hours of overhead irrigation during the day resulted in the least favorable environment for late blight. The treatment of 11 hours of irrigation during the night resulted in an environment conducive to the disease. Because inoculum was absent in 1999, no conclusions can be drawn on the ability of Blitecast or other models to predict late blight epidemics.

Introduction. Late blight (caused by *Phytophthora infestans*) was not observed on potatoes in the Tulelake area until recently. The initial inoculum for late blight epidemics originate from cull potatoes or volunteer potato plants, other potato fields, or oospores in plant debris or in soil. It is assumed that the most important source of inoculum is probably sporangia from a source in the immediate environment. Sporangia can survive only for a few hours or days after release (depending on weather conditions), and their long-distance dispersal (for example from Mexico) is not certain.

Until the occurrence of metalaxyl-insensitive strains of *P. infestans*, late blight was effectively controlled by the systemic and curative fungicide metalaxyl. There are several newer systemic fungicides (Tattoo, Acrobat, and Curzate), but these are not as effective as metalaxyl, and need to be applied several times per season. A section 18 was obtained for the use of Tattoo C, which has both protective ad curative actions. Other systemic fungicides for late blight control (Curzate and Acrobat) could possibly be registered in the future. However, resistance has already been observed to some of these fungicides in Europe. It is therefore important to use these fungicides judiciously and only when weather conditions are conducive for infection. To optimize fungicide applications, a forecasting system is required to predict periods of infection.

Several forecast models, e.g., BLITECAST, developed at Penn State, WISDOM Integrated Pest Management System from the University of Wisconsin, Dacom Automatisation based on regional weather forecasts and geographic information systems (GIS), and the PLANT-Plus system, modified from a lettuce downy mildew model, are available for late blight management. The purpose of this study was to compare the accuracy of the various models in predicting late blight occurrence in different environments created by various irrigation regimes.

Materials and Methods. In a field experiment at the Intermountain Research and Extension Station, comparison of forecasting systems was combined with four irrigation treatments. The overhead irrigation treatments were: (A) 11 hours in the day (8:00-19:00); (B) 11 hours at night (19:00-6:00); (C) 5 hours in the day (14:00-19:00), and (D) 5 hours at night (1:00-6:00). Irrigations were made every 3-5 days during the growing season based on calculated evapotranspiration rates. Four fungicide-spraying schedules (with chlorothalonil) were based on a modified Downy Mildew Model, PhytoPRE+2000, and Blitecast. An untreated control was included for comparison.

Treatments were arranged in a split-plot design with irrigation treatments as the main plots and spray treatments in subplots. Plots were randomized in four blocks (64 plots in total). Individual plot size was 42X42 feet. Each irrigation treatment was buffered from neighboring irrigation treatments by 60 feet. The entire trial area encompassed approximately 9 acres. Severity of late blight in each plot was monitored daily.

Four sets of sensors connected to two Dataloggers (CR10) were installed in the four irrigation treatments. Canopy temperature, relative humidity, precipitation (including irrigation time and amount), leaf wetness and above –canopy solar radiation wind speed and wind direction were measured hourly. The recorded data were transferred everyday in the morning from the field in TuleLake to the computer in UC Davis through two cellular phones.

Five-day weather forecasts were obtained daily from DayWeather Inc. through emails. The data included maximum and minimum temperatures, relative humidities, possibility and type of rain, wind direction, wind speed and cloud cover for each three hours in the future five days. Forecast values were first imported into a computer spreadsheet program and interpolated linearly to generate hourly values of all variables.

Results: No late blight was observed in the Klamath Basin (including Tulelake) in 1999. Because there were no differences in cultivation operations, including potato variety, weather conditions might have influenced potential epidemics. Absence of inoculum was unlikely, but initial inoculum might have been killed. Therefore, weather conditions in 1998 and 1999 were compared. Daily comparisons of maximum and minimum temperatures, relative humidity, solar radiation, precipitation, wind speed, and leaf wetness duration in July and August in 1998 and 1999 were compared (Table 1 and Figs. 2 to 7). There were only minor differences in maximum daily temperature, relative humidity, solar radiation, and wind speed. However, in 1999, there was a period of high maximum temperatures in the beginning of the season, which could have killed initial inoculum. In addition, there were lower minimum temperatures throughout the season, less precipitation, and shorter leaf wetness durations in 1999. These factors might have played a role in preventing epidemic development of potato late blight that year.

Although there was no disease in 1999, we compared microclimate conditions and disease prediction for the various irrigation regimens. From July 2 to August 28, there were ten irrigation events in all treatments. Except for one irrigation event with a technical problem, microclimate data during the other nine irrigation events were arranged and compared with data on the day before each irrigation. Figs. 8 to 15 show the temperature and relative humidity changes for all irrigation regimes.

Although there was no disease in 1999, chemical treatments were made according to the forecasting systems, assuming that inoculum was ubiquitous. Irrigation regimes A and B received 7 fungicide applications and irrigation regimes C and D 6 applications following the modified Downy Mildew Model (Fig. 16).

Discussion: Weather conditions in the Tulelake region were favorable for late blight development in 1997, 1998 and apparently in 1999. In 1999, the lack of inoculum was probably responsible for the absence of disease even when conditions became favorable towards the end of the season. Initial infections might have been killed by high temperatures in the beginning of the season.

The irrigation experiment demonstrated that different irrigation regimes could result in significant changes in temperature, relative humidity, and leaf wetness durations. These changes could make dramatic differences in late blight infection events. Long irrigations during the day resulted in the most conducive condition, while shorter irrigation periods during the day or night likely would slow disease development. However, further work is needed.

The Modified Downy Mildew Model was the most conservative model, and predicted frequent infection events, if inoculum had been available. Thus, this model recommended several fungicide applications which were unnecessary due to the lack of inoculum.

Summary and Conclusions. Weather conditions in 1999 were apparently conducive to disease development although high daytime temperatures may have been a factor in the absence of initial inoculum. Comparing the different irrigation regimes, regime A (11 hours of overhead irrigation in the daytime) seemed to be the most favorable regime for late blight development. This regime resulted in conditions most conducive for late blight infections. Shorter irrigation durations may have the potential to reduce late blight development. Irrigation regime C, 5 hours of overhead irrigation, resulted in the least favorable environment for late blight.

Although unnecessary fungicide applications were made in 1999, the modified Downy Mildew Model seemed most promising in predicting conditions conducive for infection. This forecasting system was the most sensitive model in its ability to detect differences among irrigation regimes. However, it was not suitable in predicting when initial fungicide sprays should be made. In general, fungicide applications should be initiated only after the first observation of late blight in the area, assuming an intensive scouting effort is in place thoroughout the region.

BIBLIOGRAPHY

Cao, K. Q., Fried, P. M., Ruckstuhl, M. and Foffer, H. R., 1996a. Ereignisorientierte Krautfaculeprognose mit PhytoPRE+2000. Agraforschung 3(7):325-328.

Cao, K. Q., Ruckstuhl, M. and Foffer, H. R. 1996b. Crucial weather conditions for *Phytophthora infestans*: A reliable tool for improved control of potato late blight. First Workshop of An European Network for Development of An Integrated Control Strategy of Potato Late Blight. Lelystad, The Netherlands. Special PAV-report 1. pp85-90.

Fry, W. E., and Fohner, G. R. 1985. Construction of predictive models: 1. Forecasting disease development. pp. 161-178 in: Gilligan, C. A. (ed.). Mathematical Modeling of Crop Disease, Adv. Plant Pathol. Vol. 3. Academic Press, London.

Hadders,]an. 1996. Experience with a late blight DSS(PLANT-Plus) in starch potato area of the Netherlands in 1995 and 1996. Presentation EU.NET. DACOM Automatisering b.v.

Harrison, J. G. 1992. Effects of the aerial environment on late blight of potato foliage - A review. Plant Pathology 41:384-416.

Harrison, J. G., and Lowe, R. 1989. Effects of humidity and air speed on sporulation of *Phytophthora infestans* on potato leaves. Plant Pathology 38:585-591.

Krause, R. A., Massie, L. B., and Hyre, R. A. 1975. Blitecast: A computer forecast of potato late blight. Plant Disease Reporter 59:95-98.

Raposo, R., Wilks, D.S., and Fry, W. E. 1993. Evaluation of potato late blight forecasts modified to include weather forecasts: A simulation analysis. Phytopathology 83:103-108.

Royer, M. H., Russo, J. M., and Kelley, J.G.W. 1989. Plant disease prediction using a mesoscale weather forecasting technique. Plant Disease 73:618-624.

Sherm, H., and van Bruggen, A. H. C. 1993. Sensitivity of simulated dew duration to meteorological variations in different climatic regions of California. Agric. and Forest Meteorology, 66:229-245.

Wilks, D. S., and Shen, K. W. 1991. Threshold relative humidity duration forecasts for plant disease prediction. J. Appl. Meteorol. 30:463-477.

APPENDICES

Table 1. Comparison of weather conditions in July and August 1998 and 1999 (daily averages)

Factors	1998	1999
Maximum temperature (C)	28.88	27.81
Minimum temperature (C)	8.73	5.83
Relative humidity (%)	67	72
Precipitation (mm)	1.17	0.65
Days with precipitation	45	27
Solar radiation (micromoles/m^2s)	628	618
Wind speed (mph)	18.9	19.4
Leaf wetness duration (hrs/day)	13.74	9.41

Table 2. Fulfillment of weather conditions conducive for disease development according to different forecasting systems in 1998 and 1999.

Decision support systems	1998	1999				
		Irrig.	A	B	C	D
PhytoPRE+2000 (Day)	5		8	6	0	4
Downy Mildew Model (Day)	32		44	15	28	31
Blitecast (Severity value)	1		24	1	0	2

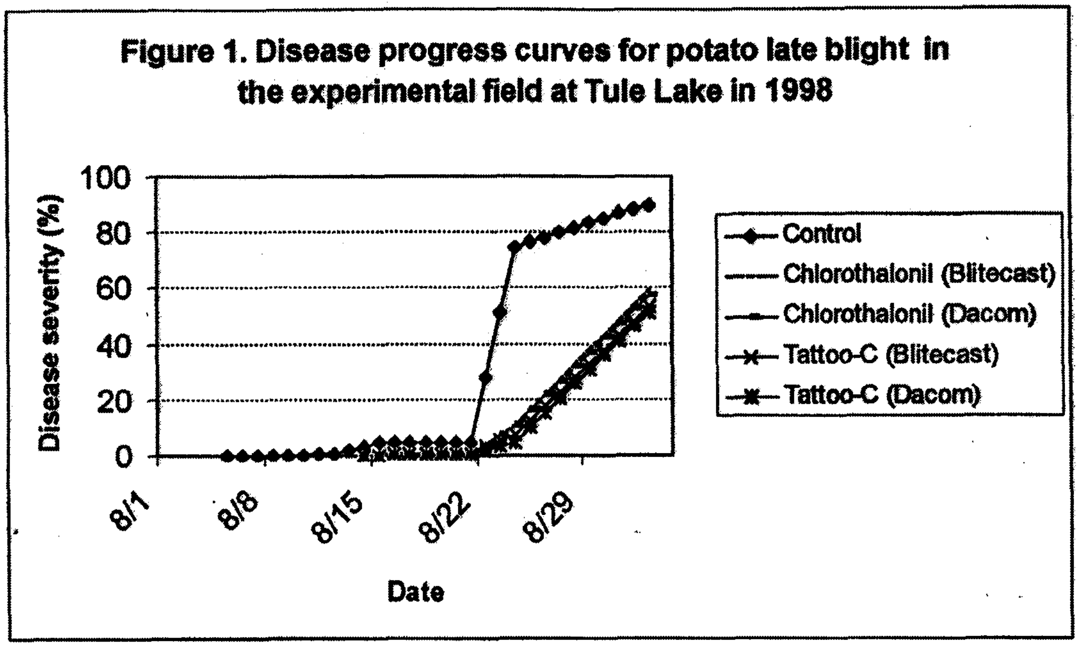


Figure 1. Disease progress curves for potato late blight in the experimental field at Tule Lake in 1998
Disease severity (%)
100
80
60
40
20
0
8/1
8/8
8/15
8/22
8/29
Date
Control
Chlorothalonil (Blitecast)
Chlorothalonil (Dacom)
Tattoo-C (Blitecast)
Tattoo-C (Dacom)

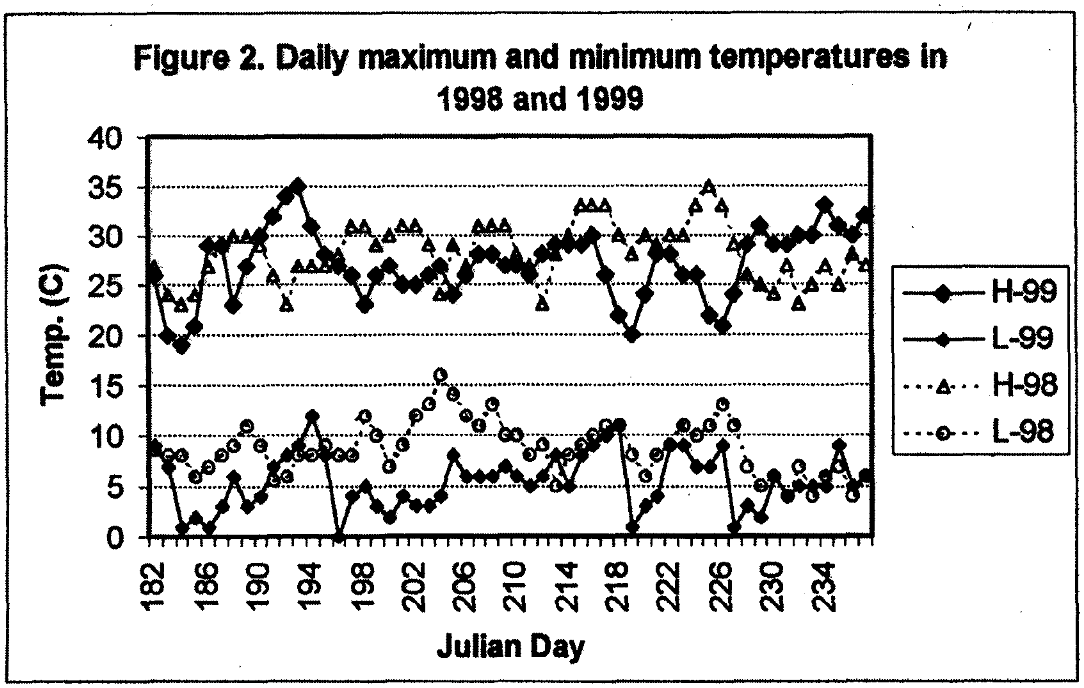


Figure 2. Daily maximum and minimum temperatures in 1998 and 1999
Temp. (C)
40
35
30
25
20
15
10
5
0
182
186
190
194
198
202
206
210
214
218
222
226
230
234
Julian Day
H-99
L-99
H-98
L-98

Figure 3. Daily relative humidities in 1998 and 1999

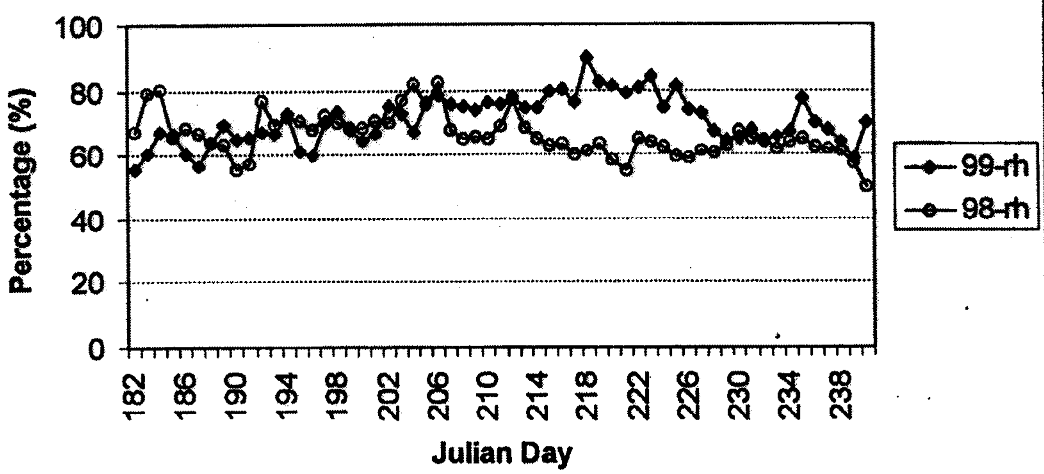
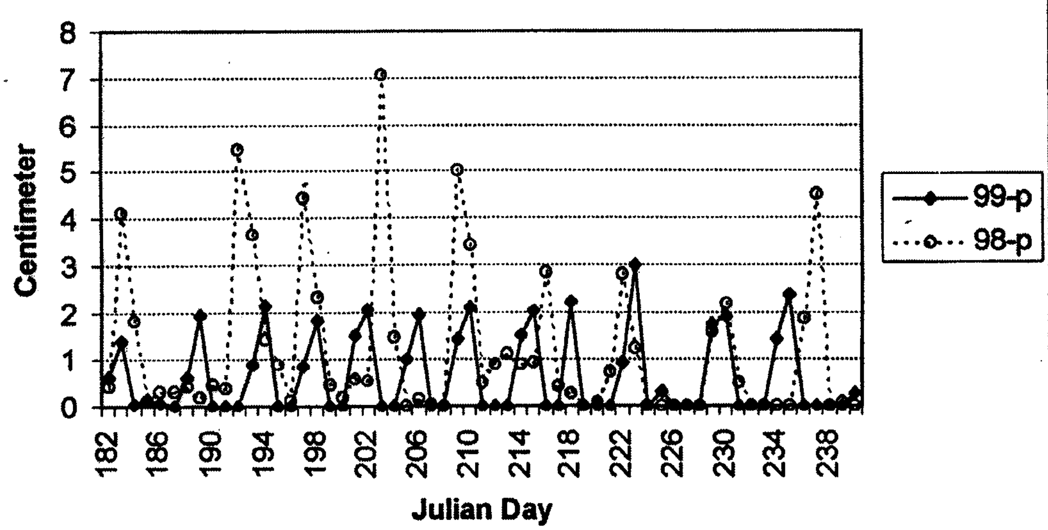


Figure 4. Daily precipitation in 1998 and 1999



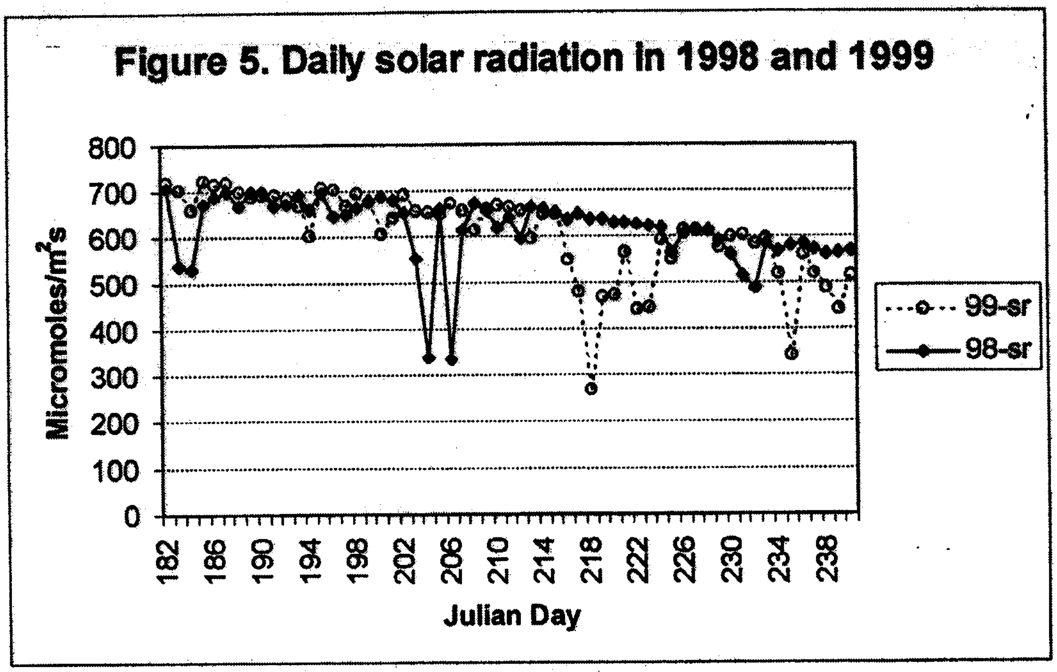


Figure 5. Daily solar radiation in 1998 and 1999
800
700
600
500
400
300
200
100
0
Micromoles/m²s
182
186
190
194
198
202
206
210
214
218
222
226
230
234
238
Julian Day
99-sr
98-sr

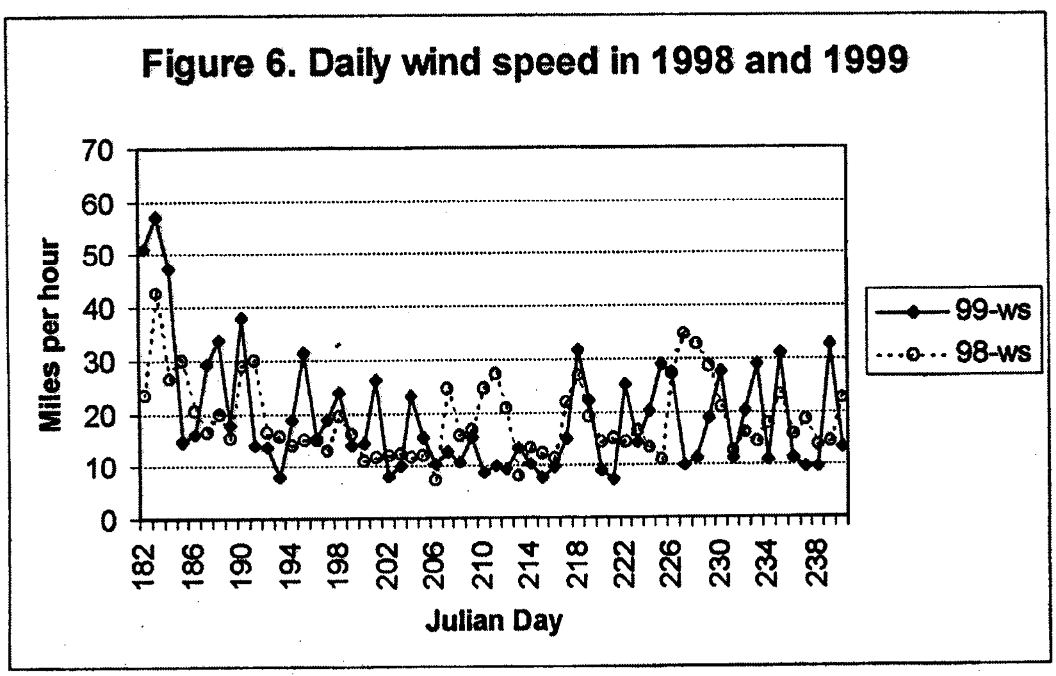


Figure 6. Daily wind speed in 1998 and 1999
70
60
50
40
30
20
10
0
Miles per hour
182
186
190
194
198
202
206
210
214
218
222
226
230
234
238
Julian Day
99-ws
98-ws

Figure 7. Daily leaf wetness duration in 1998 and 1999

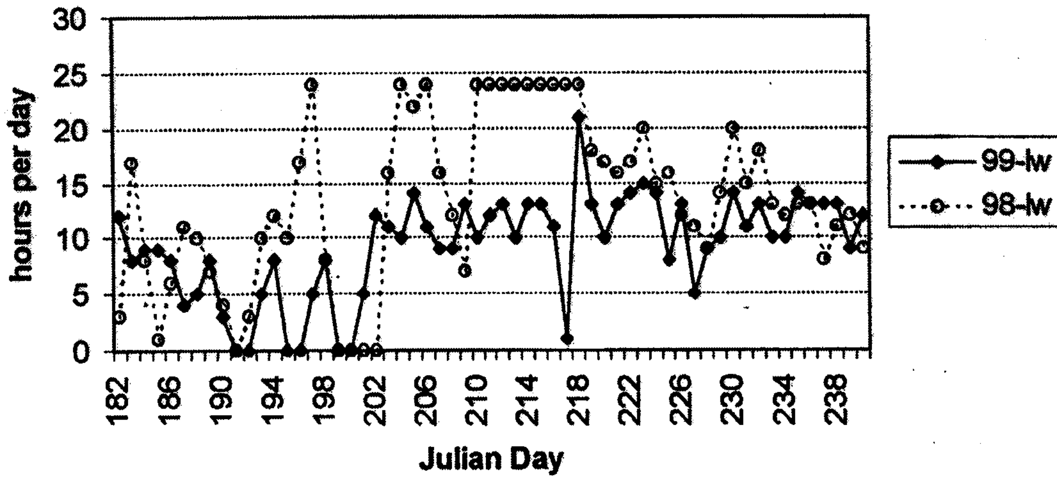


Figure 8. Temperature changes in irrigation regime A compared to the day before irrigation

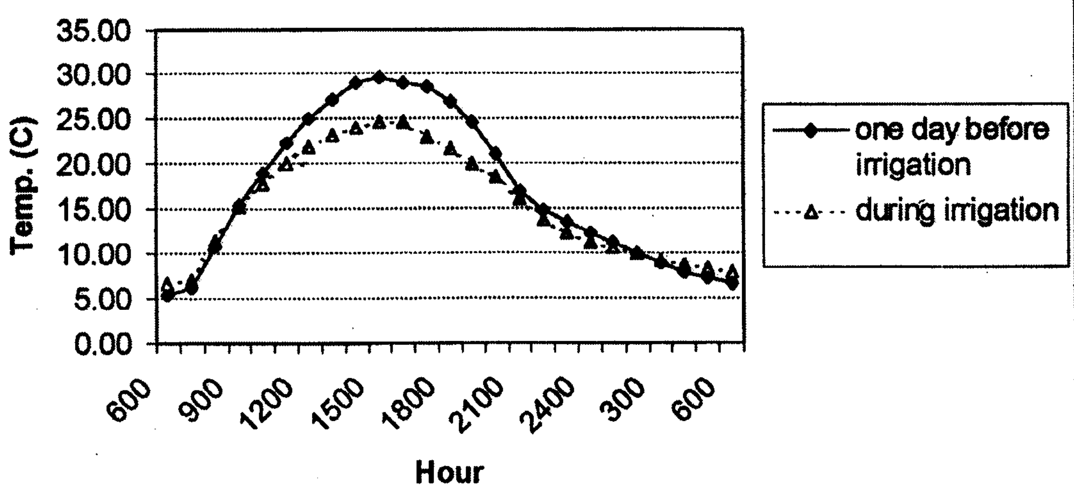


Figure 9. Temperature changes in irrigation regime B compared to the day before irrigation

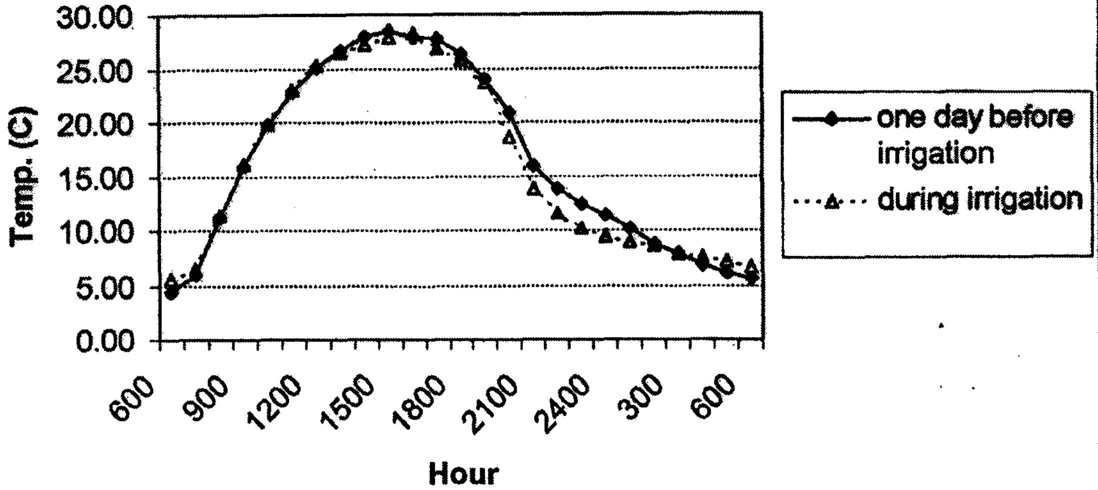
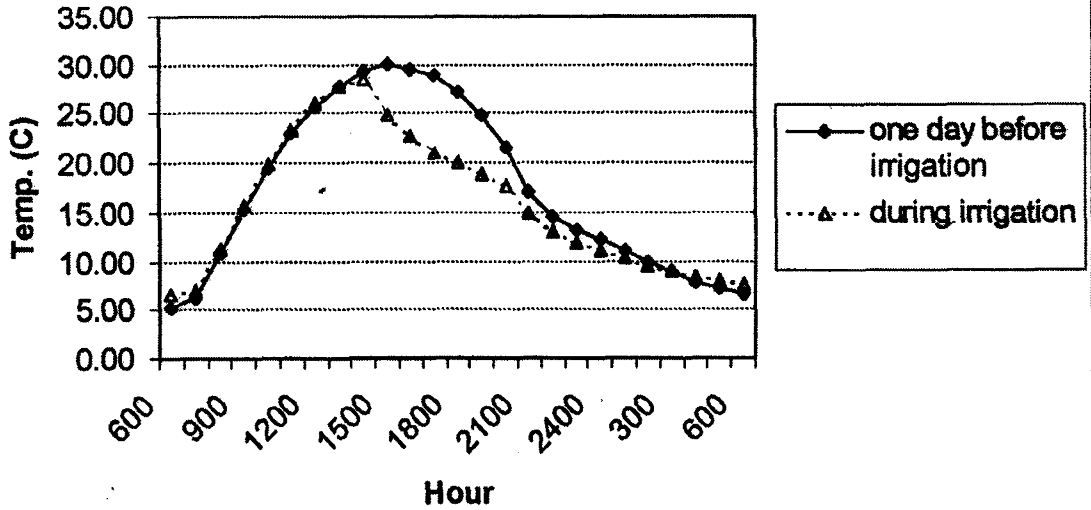


Figure 10. Temperature changes in irrigation regime C compared to the day before irrigation



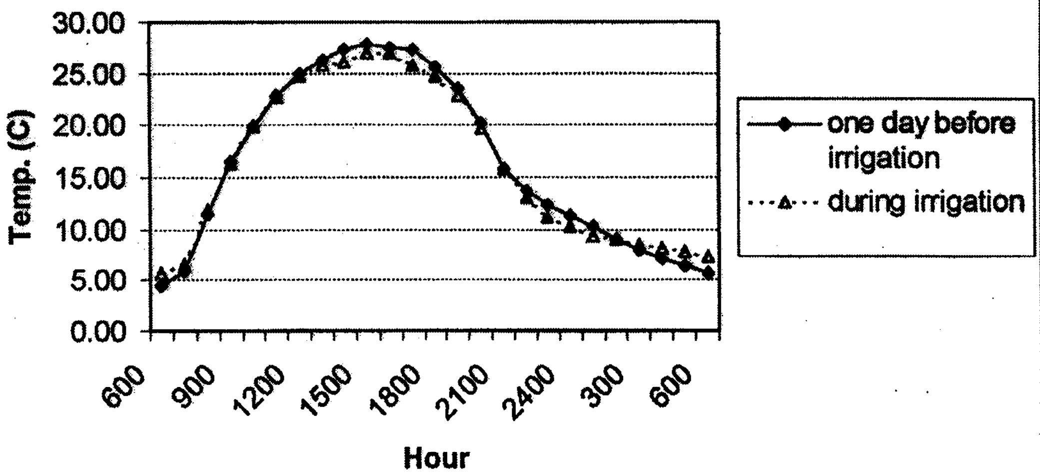


Figure 11. Temperature changes in irrigation regime D compared to the day before irrigation

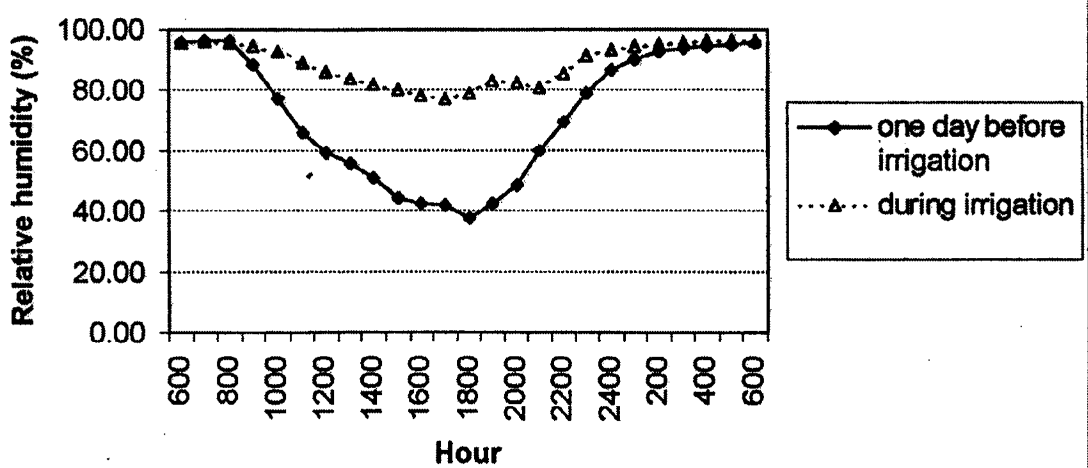


Figure 12. Relative humidity changes in irrigation regime A compared to the day before irrigation

Figure 13. Relative humidity changes in irrigation regime B compared to the day before irrigation

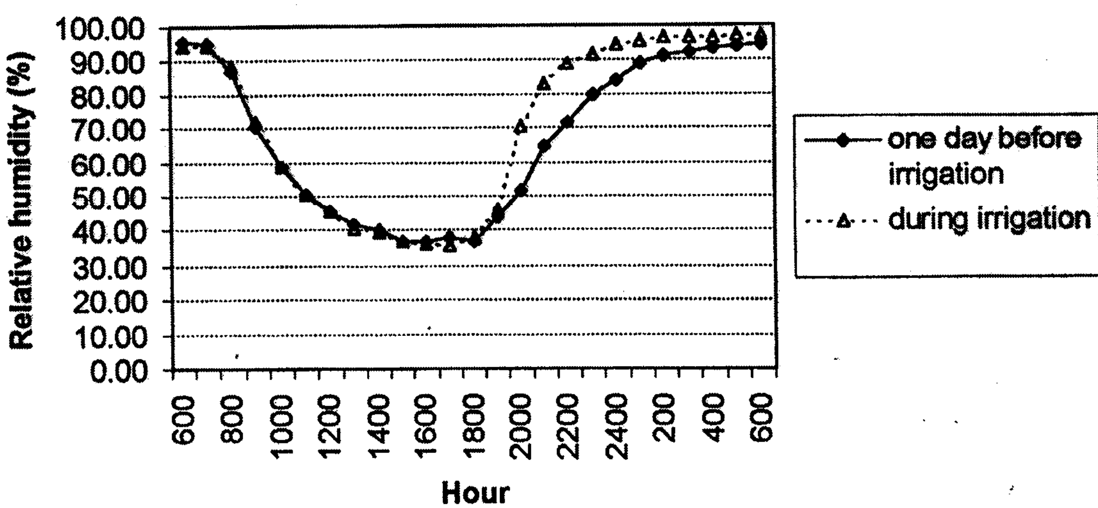


Figure 14. Relative humidity changes in irrigation regime C compared to the day before irrigation

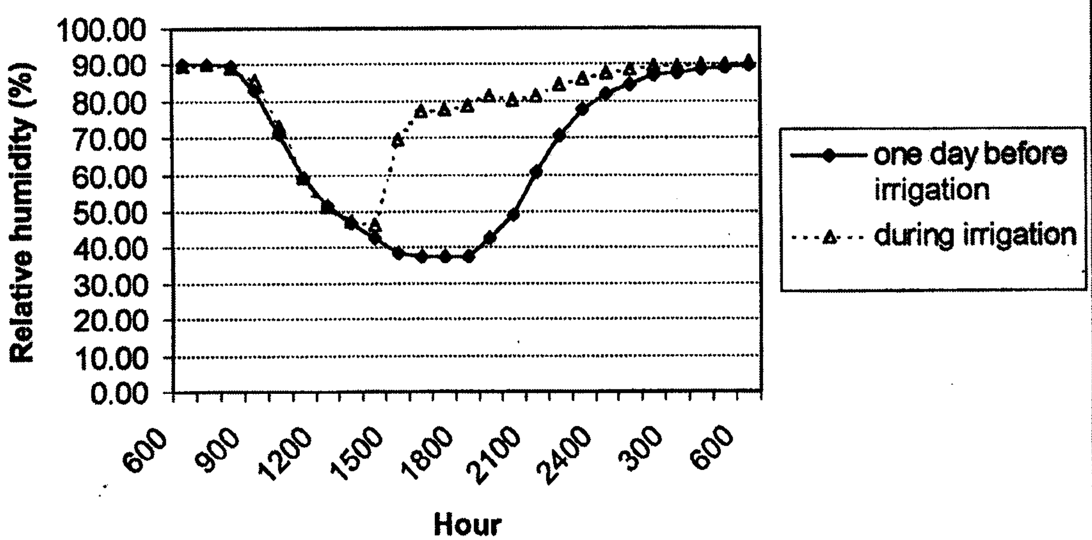


Figure 15. Relative humidity changes in irrigation regime D compared to the day before irrigation

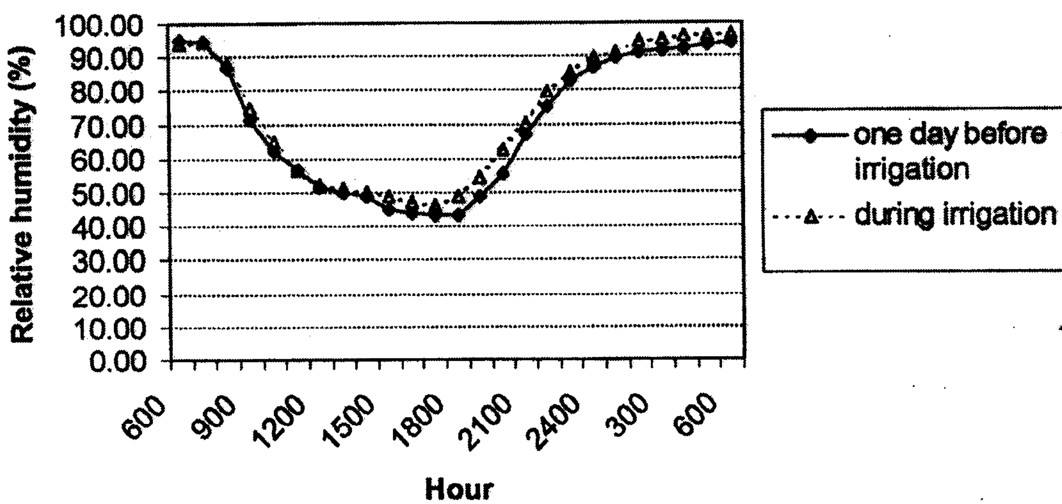
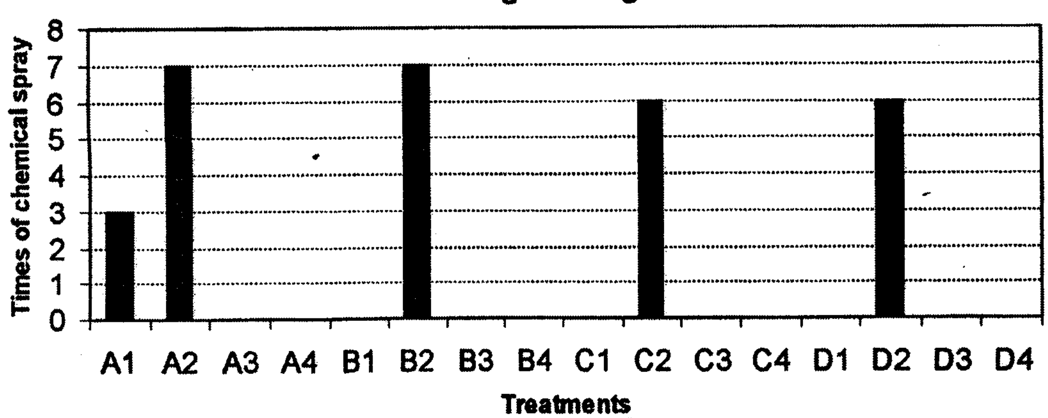


Figure 16. Number of times of fungicide application recommended by different decision support systems under different irrigation regimes



Note: A, B, C and D represent irrigation regimes;
A (8:00-19:00); B (19:00-6:00); C (14:00-19:00);D (1:00-6:00)
1, 2, 3 and 4 represent different decision support systems: 1–Blitecast; 2–modified Downy Mildew Model; 3–PhytoPRE+2000; 4–Untreated