KAFFKA*, S. R.[1], and S. STODDARD[2], [1]Department of Plant Sciences, One Shields Avenue, University of California, Davis, CA 95616 and [2]University of California, Cooperative Extension, 2145 Wardrobe Avenue, Merced, CA 95340. **Evaluating best management practices for *Cercospora* leaf spot control in over-wintered beets[1].**

ABSTRACT

Cercospora beticola Sacc., or Cercospora leaf spot (CLS), is widely distributed and a serious plant pathogen in most sugarbeet growing regions of the world. In California, it has been only a minor nuisance, occurring as a damaging pathogen primarily in the Tulare County area in spring sown-autumn harvested crops in the southeastern San Joaquin Valley. Beginning in 1993-94, it began appearing at increasingly damaging levels in other areas of the San Joaquin Valley, most importantly in the spring -spring cropping area south of the San Joaquin-Sacramento River Delta. Infected fields had been defoliated periodically since, with adverse consequences for yield and sugar content. Reports from growers and field men indicated that CLS was active most months of the year. Both significant loss from CLS, and the prospect of greatly increased costs for disease control, threatened the viability of over-wintered sugar beet production. Year-round control of CLS using fungicides was considered both uneconomical and ecologically unwise, leading to the rapid development of resistance by the pathogen to the available fungicides. The production of high-yielding, but CLS susceptible varieties was a likely cause of the increased threat from CLS. High yielding varieties like *B4430* and *Phoenix* had become the basis of California's sugarbeet industry but have little to no resistance to some important diseases common in California like curly top (BCTV) and CLS. Older varieties with some apparent resistance generally result in lower yields in the absence of the disease.

There are several types of fungcides available that are effective against CLS in California. Two are strobularins (pyraclostrobin or Headline®, and trifloxystrobin or Gem®). A third is ethylene bisdithiocarbamate or Mancozeb (Penncozeb®). The last is a newer material, tetraconazole (Eminent®, a triazine type material). Mixtures of materials with different modes of action or sequences of materials are recommended in control programs to prevent resistance developing to specific fungicides (Khan et al., 2005). The University of California's IPM website (www.ipm.ucdavis.edu/PMG/r735100511.html) contains recommendations for chemical control of CLS based on repeated sprayings once infection is observed. These were developed based on limited experience with CLS in California and recommendations from other locations. Current recommendations call for treatment when 10 to 20 spots are observed on the leaves inspected, but this threshold is a greater level of infection than used in other beet growing regions where any sign of the disease is considered sufficient to initiate treatment, especially early in the growing season (Khan, et al., 2005).

CLS is active at temperatures common in California during long periods of the year. It develops in temperatures from 60 ^{o}F to 95 ^{o}F with an optimum of 75 to 95 ^{o}F, and under conditions of high relative humidity (Whitney and Duffus, 1986). Especially during irrigation events in the

1 Sugarbeet production in the area where this research was carried out ended in fall 2008 when the factory in Mendota, California, supplied by these beets, was closed. Sugarbeets had been grown continuously in northern California since 1870 up to that point.

spring to fall period, but also during rainfall events in the fall to early spring period, appropriate combinations of temperature and humidity can occur to support infection. Since spores are wind borne and also disperse by splashing from older, infected leaves, the potential for recurrence from year to year and in-season re-infection was greater for long term crops than anywhere else in the sugarbeet producing regions of the world, with the exception of parts of Spain or Morocco. Sugarbeet growers in this region needed guidance developed under their own field conditions about how to manage CLS.

Methods. We carried out research to quantify the risk of CLS infection in spring-planted, over-wintered sugarbeet fields in the northern San Joaquin Valley during the 2006-07 and 2007-08 growing seasons, to develop improved guidelines for the management of CLS in California's over-wintered region, and to evaluate the usefulness of weather-based prediction models for the management of CLS in over-wintered areas. The overall goal of the research was to determine the minimum amount of control necessary to prevent economic loss from CLS on over-wintered beets. Only results from field trials are reported here. Model evaluation including weather data analysis will be reported elsewhere. The two farm locations were located in the eastern (south of Merced, El Nido) and western portions of the over-wintered district (west of Dos Palos and north of Firebaugh) and had experienced recent high levels of CLS infestation in their fields. Two varieties were grown in randomized plots with 3 replications of each variety (*B4430*-Betaseed)-considered highly susceptible, and *Alpine*-(Holly Hybrids) partially resistant). Five treatments or levels of fungicide applications were compared by spraying four row subplots of each variety. The treatments ranged from no spraying or control to a very aggressive treatment aimed at complete prevention, with treatments in-between (Table 1A&B). Amounts applied are listed in the table. A sequence of fungicides was used following industry practice to keep CLS from developing resistance to any one material or family of fungicides, especially to the newest one, triaconazole or Eminent®. Treatments varied slightly in each year.

CLS infection levels were monitored from mid-summer onwards, including through the winter, until harvest. There are no data available to quantify CLS behavior in over-wintered beets. Fields were assessed for CLS 10 times in 2006-07, and 6 times in 2007-08. Twenty plants in each plot were evaluated for presence or absence of CLS, the number of leaves with symptoms, the number of CLS lesions, and a CLS scale adapted from Windels et al. (1998).

In evaluating the amount of disease, 20 plants selected at random in each treatment from 2 or 3 replications were observed periodically during the growing season. We noted whether the plant had any leaf spots, how many leaves were infected, and estimated the number of spots on average per leaf per plant. Root yields and sugar contents from the various plots were collected in April 2007 and in March 2008 immediately prior to harvest.

Results. Since CLS has not been a severe problem in the over-wintered sugarbeet area in the past, it is difficult to describe with confidence average conditions and levels for disease occurrence. But in the 2006-2007 growing season (April 2006 to May 2007), there was very little CLS pressure at the El Nido location, and almost none at the site south of Dos Palos. CLS was first observed in October, 2006. In contrast by late fall 2007 (the second year's trial), CLS had severely infected untreated beets at the El Nido site, but was not observed near Dos Palos. It appeared earlier in the second trial in 2007-08 (late August-early September). Based on these observations, was consistently greater in the eastern portion of the district than in the western. Consequently, in this report, we have concentrated on results from the El Nido site.

During the 2006-2007 growing season, with light disease pressure, CLS was controlled effectively by a series of fungicide applications. Two or three applications, starting in late October/early November, were as effective as 5 to 8 applications, initiated earlier in the season. The new fungicide, Eminent® (tetraconazole) helped reduce CLS infection when used in series with other materials under the conditions of this experiment (Fig 1a, 1b). Since fungicides were used in sequence, we did not evaluate the effects of Eminent® used alone. Similarly in 2007-2008, two to three spray applications starting in fall was as effective at preventing defoliation as more aggressive treatments. In 2007-2008, CLS developed rapidly in late summer and applications were more remedial than preventative. Infection pressure over all was more severe, and by harvest, nearly all plants had some CLS. However, fungicide applications to new leaves during the over-wintered period kept CLS from becoming epidemic up until harvest the following April (Fig. 2a, 2b).

Yields were not affected at either location by CLS and were not influenced by the treatments applied in either year (data not shown). At the El Nido location, stands within the plots were variable in both years, making the detection of yield differences related to treatment effects uncertain.

CLS appeared to be controllable in the over-wintered area, if treatment began near the time that disease was observed in late summer or early fall, and two applications of fungicides were applied subsequently during late fall or early winter as possible using a series of fungicides.

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Acknowledgements: Support was provided by the California Sugarbeet Industry Research Committee, by Sipcam Agro USA, Inc., and by BASF. David and Peggy Farmer and Joe Munoz, Jr. of Redfern Ranch, provided sites for research and carried out all farming operations other than disease control.

Table 1A. Treatments (2006-2007).

Level	Control (#1)	Minimum (#2)	Moderate (#3)	Aggressive (#4)	Preventative (#5)
Guidelines	never	1st sign of CLS, and a high threshold for next treatment	1st sign of CLS and moderate threshold	1st sign of disease, next treatment based on label or approx. monthly	Soon after row closure, approx 3 to 4 week intervals
Target range	0	2 to 3	3 to 4	up to 6	up to 8
Actual # of treatments	0	2	4	5	8
Application dates and materials	--- --- --- --- --- --- --- ---	--- --- --- --- EM GEM --- ---	--- --- --- --- EM GEM PENN HL	--- --- EM GEM PENN HL EM ---	EM (8/10/06) GEM (8/29/06) PENN (9/19/06) HL (10/13/06) EM (11/17/06) GEM (1/10/07) PENN (3/7/07) HL (4/12/07)

EM (Eminent®): 13 oz/ac; GEM®: 7 oz/ac; PENN (Penncozeb®): 1.5 lba/ac; HL (Headline®): 9 oz/ac.

Table 1B. Treatments in 2007-2008/ Farmer Ranch

Level	Control (#1)	Minimum (#2)	Moderate (#3)	Aggressive (#4)	Preventative (#5)
Guidelines	never	1st sign of CLS, and a high threshold for next treatment	1st sign of CLS and moderate threshold	1st sign of disease, next treatment based on label or approx. monthly	Soon after row closure, approx 3 to 4 week intervals
Target range	0	2 to 3	3 to 4	up to 6	up to 8
Actual # of treatments	0	2	3	4	6
Application dates and materials	--- --- --- --- --- ---	--- EM --- --- GEM	--- EM GEM --- --- PENN	--- EM GEM PENN --- HL	EM (7/31/07) GEM (10/16/07) PENN (11/14/07) HL (12/4/07) EM (1/10/08) GEM (2/15/08)

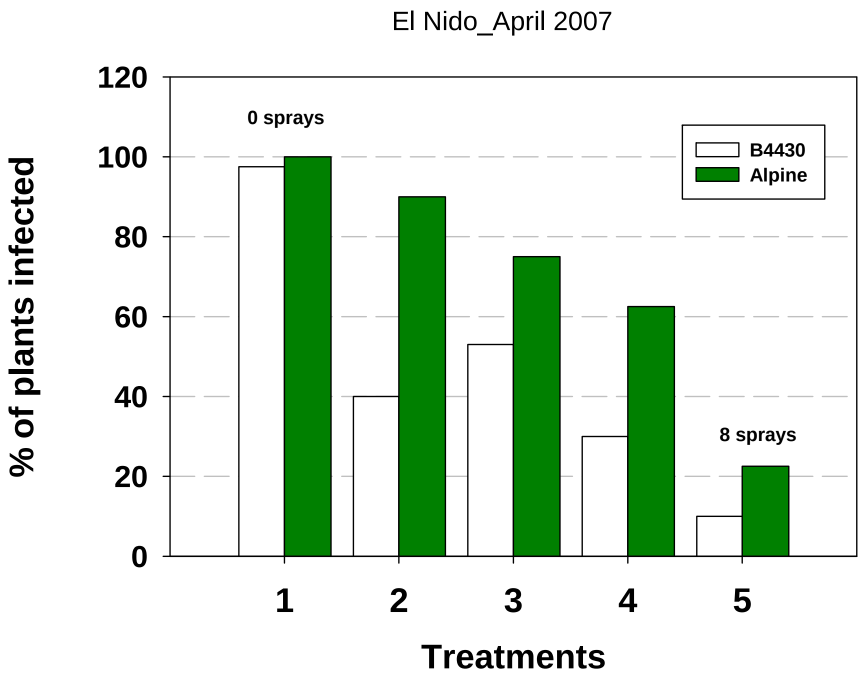

Fig. 1a Number of plants infected at the El Nido site at harvest in spring 2007.

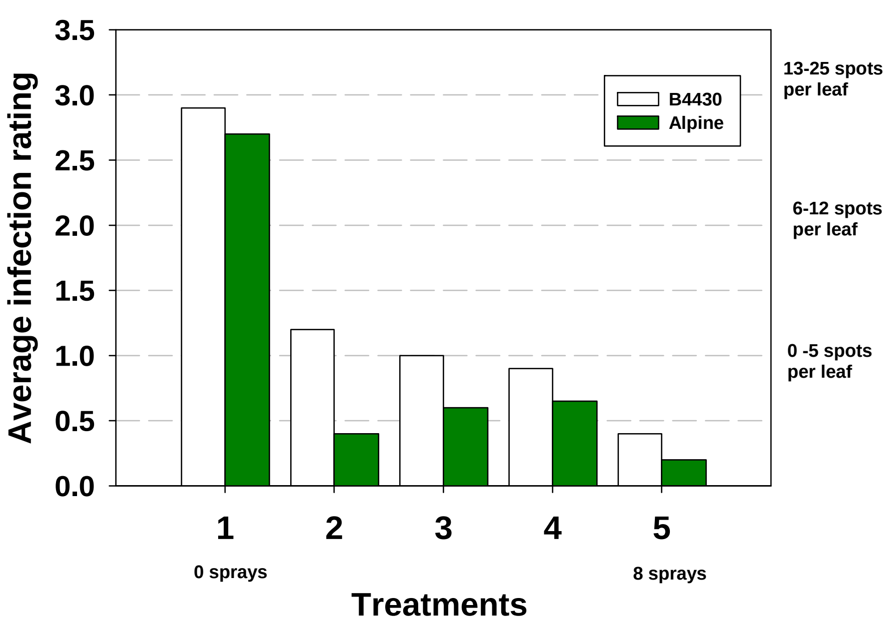

Fig. 1b. Infection rating at the El Nido site at harvest in spring 2007 (after Windels et al.,1998).

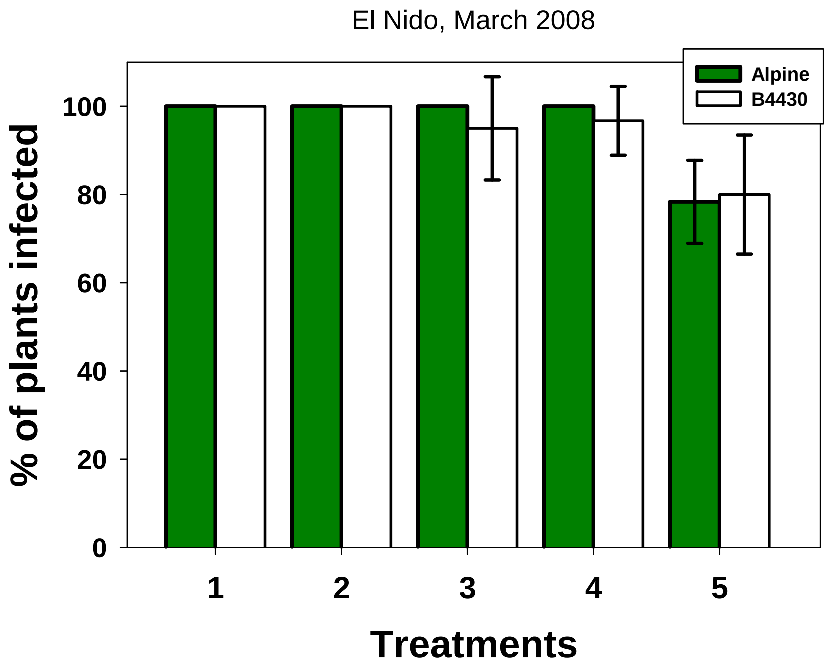

Fig. 2a. Percent plants infected in El Nido at harvest, spring 2008

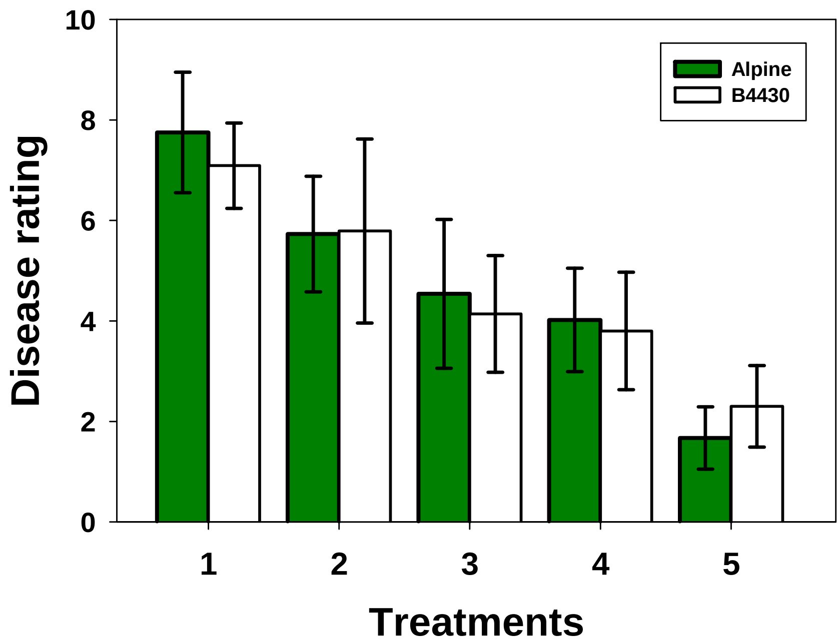

Fig. 2b. Disease rating at harvest in El Nido, spring 2008