REPORT TO THE ALMOND BOARD OF CALIFORNIA
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Project title: 1) Cause and control of Alternaria leaf spot, 2) bloom and foliage disease control, 3) wound dressings to control Ceratocystis canker, 4) role of brown rot in green fruit rot, and 5) validation of hull rot control by deficit irrigation.

1. CAUSE AND CONTROL OF ALTERNARIA LEAF SPOT

Problem and its significance

A leaf infection of almond has been observed in Kern County for several years. The lesions are relatively large, often 1/2 to 3/4 inch in diameter, frequently on leaf margins or tip, and a light tan color except when covered with black fungal spores. Infected leaves fall, and trees may suffer almost complete defoliation in early summer. The disease has also been observed in Tulare and Butte Counties, and similar lesions have been found on trees in Merced County.

The suspected pathogen is a fungus belonging to the genus Alternaria, probably *A. alternata*. This fungus is consistently found sporulating on the lesions and is regularly cultured from the lesions. However, *A. alternata* is a common 'weed' fungus and is usually found growing on dead tissues. Thus, lesions could be caused by some other agent, and *A. alternata* present only as a saprophyte. To confirm pathogenicity, Koch's postulates must be completed. In preliminary attempts to reproduce the disease by inoculation, the noninoculated controls also developed symptoms (probably because the fungus is essentially ubiquitous).

The disease appears to be worse in more humid situations. A disease of pistachio caused by *A. alternata* (Alternaria late blight) resembles that found on almond, and also is more severe under conditions of high humidity. Few fungicides have good efficacy against *A. alternata*, and the possibility of fungicide control for the disease in almond is further limited by the restriction on most almond fungicides to use no later than five weeks after petal fall. Control of the disease on almond may hinge on a combination of cultural practices to reduce humidity and careful fungicide choice and timing.

Objectives

1. To determine the causal agent of the leaf spot disease currently known as Alternaria leaf spot through completion of Koch's postulates.

2. Compare efficacy of several fungicide programs under two orchard floor management situations.

Procedures

Objective 1. To determine the causal agent of the leaf spot disease currently known as Alternaria leaf spot through completion of Koch's postulates.

Koch's postulates describe the steps to take in order to prove causation of a disease. They require 1) repeated isolation of the same organism from diseased tissue, 2) growth of the organism in pure culture, 3) inoculation of healthy leaves with the retrieved organism and development of identical symptoms in the test inoculations, and 4) reisolation of the test organism from the symptoms on the inoculated leaves.

Infected leaves were collected and isolations made several times during late spring and summer. The isolates were grown on several media and all appeared similar in growth habits. The fungus produced dense aerial mycelium and moderate numbers of spores. On one medium, the aerial mycelim was absent and spores were more readily produced. The fungus was grown on this medium to produce inoculum.

Shoots on Butte and Carmel trees were inoculated with 10^5 or 10^7 conidia per ml and immediately covered with plastic then paper bags for 24 to 72 hours. Detached shoots were similarly inoculated, the basal ends placed in beakers of water, the shoots and beakers covered with plastic bags, and incubated in the greenhouse for 72 hours. Leaves were either not surface sterilized or surface sterilized with a solution of 10% bleach for 15 seconds and rinsed thoroughly before inoculation.

Results

Koch's postulates were completed thus confirming that *A. alternata* is the cause of Alternaria leaf spot. Lesions similar in appearance to those found in commercial orchards developed on 20 to 35% of inoculated leaves in the greenhouse and on 10 to 15 % of leaves inoculated in the field. No lesions were found on the controls and there were no differences in the number of lesions between the surface sterilized and non surface sterilized or between the Butte and Carmel cultivars. More lesions were produced at the higher inoculum levels. The fungus was reisolated from these lesions.

Objective 2. Compare the efficacy of several fungicide programs under two orchard floor management situations.

Procedures

Trials were conducted in one orchard each in Kern and Tulare Counties. The two orchard floor management situations tested were 1) clean cultivation and 2) cover crop present. Each floor management plot was eight rows wide. Microloggers were placed in one pair of adjacent treatments in each orchard to record relative temperature, relative humidity, and leaf wetness.

The Kern County orchard was planted with Nonpareil:Price:Nonpareil:Butte in a 1row:1row: 1row:1row configuration, and irrigated with microsprinklers. Alternaria leaf spot was severe in this orchard the past two years and trees defoliated early. Round-up was applied in fall to the clean cultivation treatments and these areas were spot treated during the season to keep them weed-free. Natural vegetation was allowed to grow in the cover crop treatment.

The Tulare County orchard was planted with Nonpareil and Carmel in a 1row:1row pattern and was flood furrow irrigated. Alternaria leaf spot was present in this orchard in 1995, but scab, also present, was severe. Most defoliation in the orchard probably was due to scab though Alternaria may have contributed to leaf loss too. A barley cover crop was planted during the winter and after the barely headed out, was mowed during spring and summer. The clean cultivation treatment was disked regularly.

The efficacy of registered and nonregistered fungicides was tested. In Kern County, registered fungicides were applied by airblast sprayer to three-tree plots in the central Butte row of each floor management treatment. Among the fungicide treatments tested were four applications of each of the registered fungicides: Captan, Maneb, Rovral, and Ziram. Nonregistered materials were applied by hand-gun to single-tree plots located on Sonora trees in a neighboring block of trees, also irrigated with microsprinklers.

In Tulare County, scab was the principle disease for which the treatments were designed. Several fungicide sequences using registered materials were applied by hand-gun to single tree plots in the central Carmel row in each floor management plot. Nonregistered materials were similarly applied in one Carmel row at the edge of one clean cultivated plot.

Disease was assessed by observing leaves for lesions and the amount of defoliation at the end of the season. On the first evaluation date in Kern County, disease incidence was so low that collection of 50 or 100 leaves per tree was ineffective in measuring disease. So, in addition to using percent infected leaves as an evaluation system, we mentally delineated an area about 3 feet in depth, roughly knee to eye level around the circumference of the tree, and counted all infected leaves present in the outer periphery of that area. By the later reading, in August, disease was so prevalent that considerable defoliation had taken place and regrowth had begun. The percent of defoliation was estimated for each tree after harvest.

In the floor management trials, there were six replications of the two treatments which were the main plots in a split plot design. The fungicide treatments were the subplots and there were 12 replications of these. For the unregistered materials there were four replications of each treatment arranged in a randomized complete block design.

Results

In Kern County, differences in weed growth between the two floor management systems were obvious during spring, but once rains ceased, the distinction between them disappeared. Generally, natural weed growth was spotty. Some replications had almost no weeds, most had scattered weeds, and three plots had fairly uniform dense weed growth. These patterns were independent of the experimental design. Consequently, no differences were found between cover and clean cropping systems. However, when disease data were analyzed using weed growth as treatment, there was substantially more Alternaria leaf spot where there was lush weed growth but scab incidence did not differ (Table 1).

Rovral produced the best control of Alternaria leaf spot (Table 2). Manex and Ziram also reduced the disease, Rally did so somewhat, but Captan was completely ineffective. Three applications of Rovral, with the last one at 2 weeks after petal fall, was less effective than four Rovral applications, the last one at 5 weeks after petal fall. This could reflect either the number of treatments or the timing. Because the disease occurs later in the season, the later timing may be more useful that the extra treatment. Additional treatments, using Captan or sulfur, at 8 weeks after petal fall did not improve the performance of Rovral. However, Captan had no efficacy against the disease and sulfur probably does not either. Treatment timing and number of applications no doubt affected performance.

In the unregistered materials trial, Alternaria leaf spot appeared somewhat earlier and was more severe earlier in the summer. Based upon the August reading, early Bravo treatments followed by Rovral at 5 weeks after petal fall gave the best control (Table 3). The Rovral probably was responsible for all the control because other Bravo treatments that did not include Rovral were completely ineffective. Elite showed the greatest promise among the other materials. Abound, Indar, Dithane, and Vanguard + Maxim were inconsistent in their activity. Changes in treatment timing, number of applications, and rates may alter performance.

Alternaria was not observed in the Tulare County orchard until late summer when defoliation readings were taken. At that time, many leaves on the trees and on the ground beneath the trees had Alternaria lesions. Earlier evaluations for scab had shown very low levels of leaf infection (0 to 1.5%) and none were found on the day we assessed defoliation. From this we suspect that the defoliation in the orchard probably was due in part to Alternaria leaf spot and not to scab. In the floor management trial the overall significance of F was P =0.047 for defoliation, indicating significant differences in the experiment, but treatments did not differ according to either Duncan's multiple range or the least significant difference test for separation of means (Table 4). Numerically, defoliation was greatest in the control and least where Rovral was applied three times during the year. This agrees with the results in Kern County, further suggesting that Alternaria perhaps was responsible for the defoliation in the orchard. No differences or trends were detected in the unregistered materials trial (Table 5).

Evaluations of brown rot and scab in these trials may be found in the section on bloom and foliage disease control.

Micrologger data were incomplete in both orchards. We had difficulty in the beginning with the programming and instrumentation. Accidents occurred later: the wires to one of the sensors was severed in the Tulare County orchard and detached from the recorder in the Kern County orchard. Nonetheless, we found that there are extended periods of leaf wetness that occur during late May and through summer (Figs. 1 and 2) and relative humidity was greater than 95% for many hours in July (Figs. 3 and 4). These probably provide the conditions needed for the disease to progress. Daily maximum and minimum temperatures are shown in Figs 5 and 6.

Varietal susceptibility

On 2 September 1996, we visually estimated the percent defoliation in the variety trial in Kern County. Our ratings were 0-10%, 10-20%, 30-60%, and 60-80% defoliation. There were 15 cultivars in the first category, 10 in the second, in I the third, and 3 in the fourth (Table 6). Savana, Wood Colony, and Yokit were the most severely affected (Table 6).

2. BLOOM AND FOLIAGE DISEASE CONTROL.

Problem and Its Significance:

Almond trees are usually treated each year for control of brown rot, (*Monilinia laxa*), shot hole (*Wilsonomyces carpophilus*), and/or scab (*Cladosporium carpophilum*) diseases. Recently, a potentially very damaging disease, anthracnose (*Colletotrichum* sp.) has been observed in many orchards. Control methods for anthracnose are being developed by Jim Adaskaveg.

Considerable information regarding the efficacy of registered fungicides and appropriate timing is available for each disease (except anthracnose for which information is limited to research in Israel). Most disease control research has concentrated on the control of a given disease without much regard for the effects of the treatment on other diseases. We then combine knowledge from these independent studies to improvise strategies for control of several diseases. When control emphasis shifts to one disease, other diseases may crop up as a result of inadvertent lesser control. Little attention has been paid to comparison of disease control programs which may include alternating chemicals, varying numbers of applications, and monitoring or weather-driven decisions. Some knowledge of the relative effectiveness of various programs in use by growers or recommended by pest control advisors is needed.

Objectives:

1. Compare various fungicide programs for control of spring diseases.

2. Assist Jim Adaskaveg in fungicide testing and survey collections for anthracnose.

Procedures:

Objective 1. Compare various fungicide programs for control of spring diseases.

Tests were conducted in Colusa, Merced, Madera, Tulare, and Kern Counties and at the Kearney Agricultural Center. We tested various sequences of fungicides selected on the basis of the disease problems in each orchard. Efficacy testing also was conducted in several locations to evaluate new fungicides not yet registered. The details of each experiment may be found on the accompanying tables (Tables 7-13).

Results and Discussion

Brown rot: There appear to be several choices of fungicide sequences that delivered good and equivalent control of brown rot (Table 8). The disease was best controlled by application at pink bud and full bloom. Application at pink bud and full bloom gave better control than application at pink bud and petal fall. Waiting until petal fall for the second application significantly reduced the level of control.

The relative efficacy of registered fungicides did not vary from results of previous years (Tables 8 and 9). Rovral, Benlate, Topsin, Funginex, and Rally were more effective brown rot control fungicides than were Captan, Maneb, or Ziram. Ziram performed better against brown rot than has been the historical belief. Dormant treatments with copper or sulfur did not improve control (Table 7).

The unregistered materials Abound (Zeneca), Bravo (IKS Biotech), Elite (Miles), and Vanguard + Maxim (Ciba) produced good control of brown rot (Table 10).

Scab: The disease made a late appearance in our orchards and in most orchards throughout the state. In all of our test orchards, no defoliation had begun by our latest leaf reading which in each case occurred just before harvest. It is not clear why the disease was so late in developing.

The low incidence and late onset of scab resulted in very little differentiation among treatments this year. Programs that included Benlate or Topsin usually outperformed those that did not (Tables 7, 8, and 11). In one test in Kern County, fungicides were applied four times and in this test Rally and Rovral were better than the nontreated control but neither was as efficacious as were Captan, Maneb, and Ziram (Table 9). Generally Rally tended to show some efficacy against scab but Rovral did not (Tables 7, 9, and 12). Dormant treatment with liquid lime sulfur improved scab control; dormant treatment with copper did not Tables 7 and 11).

The unregistered fungicides Abound (Zeneca), Bravo (ISK BioTech), Dithane (Rohm and Haas), and Elite (Miles) showed good promise as future materials to control almond scab (Tables 10 and 13).

Shot hole: Shot hole was absent in most of our trial orchards this season, and scanty where it did occur (Table 7). Nothing new was learned about shot hole this year.

Alternaria leaf spot: This disease is discussed under the first section of this report. The data are also present in Tables 9 and 10.

Combined disease control: Fungicide programs that rely on three or fewer applications during the season risk inadequate control of one or more diseases. For instance, in a three-application program, two applications during bloom are necessary for a reliable brown rot control program. This leaves only one application to control shot hole and scab (and anthracnose where it too is present). Thus, in designing control programs, knowing which diseases are the greatest threat in an orchard is essential.

Objective 2. Assist Jim Adaskaveg in fungicide testing and survey collections for anthracnose.

All anthracnose work was lead by Jim Adaskaveg. During the year, we aided in identification of the disease and shipped to Jim cultures of all anthracnose fungi isolated in this laboratory.

3. WOUND TREATMENTS TO CONTROL CERATOCYSTIS CANKER.

<u>Problem and Its Significance</u>:

Most Ceratocystis cankers, caused by the fungus *Ceratocystis fimbriata*, are associated with wounds caused by harvesting equipment. The fungus also invades pruning and inconspicuous bark wounds, but these avenues of entry are less common than are those inflicted during harvest. The fungus is transmitted by several insect species, nitidulid beetles and drosophilid flies being the most important vectors. The disease is generally a warm weather phenomenon because insect vectors are prevalent and active, the fungus grows rapidly, and harvest injuries are fresh during the late summer. Ceratocystis cankers usually expand slowly, only a few inches per year. Infections often are well established and may be several years old before the orchardist realizes that there is a problem.

Some growers have adopted surgical programs in attempts to remove infected tissues from their trees. Surgery is followed by application of any of several wound dressing concoctions. The efficacy of wound dressings has not been substantiated by experimental tests; the success of these programs may depend largely or wholly on the success of the surgical removal of infected tissue.

<u>Objectives</u>:

1. Test several wound dressing materials for prevention and control of Ceratocystis infections.

2. Evaluate several wound dressing materials for wound healing characteristics.

3. Determine the relationship of time between wounding and infection and infection and treatment on control of current season infections.

4. Test effectiveness of surgery and topical treatment on established cankers.

Procedures

All experiments were conducted in a mature almond orchard planted on a 1 row:1 row Nonpareil:Mission pattern and grown at the Kearney Agricultural Center. The orchard was flood irrigated and no fungicides were applied for disease control.

Wounds made with a cork were about ½ inch in diameter and were located on 3 to 6 year old tertiary limbs.

Objective 1. Test several wound dressing materials for prevention and control of Ceratocystis infections.

On 11 October 1995, bark wounds on cv Mission almond trees were treated immediately with Benlate, Benlate plus oil, Benlate + Asana, elixir (a combination of Kocide 101, boiled linseed oil, and hexsol), Nectec, Rovral, Rally, Spinout (a copper material), Stickum, and Treeseal. Nontreated controls were included. The materials were allowed to dry for 1 to 3 hours then the wounds were inoculated. Inoculum consisted of 10^5 conidia per ml of *C. fimbriata* in 0.5% water agar. Approximately 0.1 0.2 ml inoculum was placed in each wound such that the entire wound surface was covered. Inoculated and noninoculated wounds were covered with duct tape for three days. There were 5 replications of each treatment arranged in a randomized complete block design.

Results

Very little gumming was associated with the Stickum and Nectec treatments the following spring (Table 14). However, by 25 July, cankers had formed at all wounds except the nontreated, noninoculated control. None of the materials tested in this experiment prevented infection.

Objective 2. To evaluate several wound dressing materials for wound healing characteristics.

Bark wounds were made on cv Mission trees on 6 September 1995 and treated immediately with Benlate, Benlate plus oil, Benlate + Asana, elixir, Nectec, Rovral, Rally, Spinout, Stickum, and Treeseal. Nontreated controls were included. There were 5 replications of each treatment arranged in a randomized complete block design.

Results

Wounds healed best when treated with Benlate, elixir, Nectec, Treeseal, or left untreated (Table 15). Healing was least in wounds treated with Benlate + Asana, Rally, or Stickum.

Objective 3. To determine the relationship of time between wounding and infection and infection and treatment on control of current season infections.

Bark of cv Nonpareil limbs were wounded and inoculated on 20 September 1995. Inoculum consisted of agar plugs, 1/4th inch in diameter, cut from 14 to 21 day-old cultures. The agar pugs were placed in the wounds and the inoculated wounds treated immediately or 7, 14, and 21 days later with Benlate + oil, Nectec, or Spinout, or left untreated. Inoculated and noninoculated wounds were covered with duct tape for 3 days. There were 6 replications of each treatment. Time after inoculation was the main plot and fungicide treatment the subplots.

Results:

Cankers formed at all wounds treated 7, 14, or 21 days after inoculation (Table 16). Where wounds were treated immediately after inoculation, Benlate + oil and Nectec prevented infection in most wounds.

Objective 4. To test effectiveness of surgery and topical treatment on established cankers.

The primary scaffolds of Mission almond trees had been inoculated with *C. fimbriata* the previous season. These infections were well established and gumming profusely when used for this experiment. On 6 October 1995, the gumballs were removed then the cankered area and 6 to 10 inches beyond the margins were swabbed with Benlate + oil, elixir, Nectec, Spinout, or left untreated.

Results

None of the topical treatments arrested the growth or gumming of the cankers.

Conclusions

We had technical difficulties with several experiments (including some not reported here). The conflicting results of preventive treatment perhaps can be attributed to problems with one or more of the tests. Overall, we have had more results showing that Nectec provides protective control, but the lack of control in one experiment this year calls into question the efficacy of the material. This experiment in now being repeated. Another material, enzone, also is under test at this time.

The lack of control after 7 or more days is not surprising because by that passage of time the fungus should be well established inside the tissues and no linger subject to control by topical applications.

The excellent wound healing observed with several materials suggests that natural healing, if it can be hastened, might be a useful tool in disease management.

4. ROLE OF BROWN ROT IN GREEN FRUIT ROT

<u>Problem and Its Significance</u>:

Young green almond fruit are subject to infection by several fungi. Green fruit rot (also called jacket rot) usually is attributed to infection by *Botrytis cinerea* and sometimes *Sclerotinia sclerotiorum*. Recently, the brown rot fungus, *Monilinia fructicola*, has been found frequently in rotted young fruit. While outbreaks of Botrytis and Sclerotinia are erratic and scattered, brown for infections of young fruit seems to be present every year and is not difficult to find in most orchards where brown rot is present. The brown rot infections commonly are found where fruit touch each other or where cast floral cups or petals rest on the fruit. Cultivars with fruit that tend to cluster sustain the greatest damage. The disease is worst when rains are frequent.

The role of the cast floral parts in infection may be several-fold. The pathogen may need to colonize the cast floral part to establish a food base to help the fungus penetrate the green fruit. Botrytis is known to follow this procedure in rots of other hosts. The need for a food base is not known for the brown rot fungus. The cast floral part resting on the green fruit may simply provide a dark, moist environment on the fruit surface, ideal for fungal spore germination and infection. In the latter case, colonization of the floral part by the fungus would not necessarily precede infection of the green fruit.

If colonization of the floral part is a prerequisite for infection of the green fruit, then the right environment and sufficient time must be allowed for such colonization to occur before green fruit rot would commence. If the cast floral part acts solely as a cover, then fungal spores would germinate and penetrate the green fruit directly.

Objectives:

1. To determine the role of dead floral parts in establishment of fruit infections.

2. To determine the effects of several wetness periods on the development of green fruit rot.

3. To compare infection and rot of young green fruit by *M. laxa* and *B. cinerea* and to determine susceptible stages of fruit development.

<u>Procedures and Results</u>

Parts of each objective appear in different experiments so the objectives will not be repeated here.

The experiments were conducted on Carmel almond trees grown at the Kearney Agricultural Center.

Cast floral cups and petals were collected and stored dry in the laboratory.

Wetness duration and comparison of pathogens Floral cups were autoclaved then incubated in conidial suspensions of *M. laxa* and *B. cinerea* for 24 hr immediately before use. At the end of the incubation period, the floral cups were surface sterilized for 30 seconds in 10% household bleach to kill any fungal spores or mycelium that would be present on the outside of the floral cup. The surface sterilized floral cups were rinsed twice in sterile deionized water and placed in a clean petri dish for transport to the field.

Fruit were thoroughly wetted with water before inoculation. A floral cup was placed over the fruit surface and secured with a twistem tie or fruit were misted with suspensions of 10^4 conidia per ml of each pathogen and a twistem tie wrapped around the fruit. Inoculated fruit were covered with plastic then paper bags for 0, 24, and 48 hours. There were four replications 12 fruit arranged in a randomized complete block design.

The experiment was conducted on 26 and 28 March. Average fruit length was 24.9 and 25.5 mm on 26 and 28 March, respectively.

No infection of green fruit was found in any treatment.

Incubation period of floral cups The time required to colonize the floral cups was tested by incubating autoclaved floral cups in conidial suspensions as described above for 3 seconds (a quick dip), 24, or 48 hr. Floral cups that had been surface sterilized by a 2 minute soak in 10 % bleach instead of the autoclave were similarly incubated with the pathogens. The incubation periods were initiated so that all would be completed at the same time and just prior to use as inoculum. At the end of the incubation period, the floral cups were surface sterilized for 30 seconds in 10% bleach. Fruit were inoculated as described above, and covered with plastic then paper bags for 48 hr.

The experiment was conducted on 28 March using fruit of average length 24.9 mm.

No infection of green fruit was found in any treatment.

Fruit size and susceptibility and comparison of floral cups and petals as inoculum sources

The experiment was conducted on cv Butte almond trees grown at the Kearney Agricultural Center.

Autoclaved floral cups were incubated for 24 and 48 hr and non sterile petals were incubated for 48 hr in conidial suspensions of *M. laxa* as described above. The floral cups and petals were not surface sterilized after incubation. Small, medium, and large, (average lengths 16.5, 23.0, and 27.0 mm, respectively) fruit were inoculated by placing a floral cup or petal on the fruit surface, positioning a detached fruit over the floral cup then securing them with a twistem tie. In this way, the floral cup or petal was the 'filling' and the two fruit the 'bread' in a sandwich. Floral cups and petals also were affixed to fruit with twistem ties. Inoculated fruit were covered with plastic then paper bags for 48 hr. There were 12 fruit in each of four replications arranged in a randomized complete block design. The experiment was initiated on 2 April and evaluated on 11 April 1996.

Fruit of all sizes were infected and generally larger fruit were less susceptible Table 17). Equivalent amounts of fruit rot developed in the sandwich and twistem tie treatments and the length of incubation of the floral cups and petals did not differ. Petals and floral cups also were similar in the amount of rot that developed.

Autoclaved floral cups incubated for 24 hr in a conidial suspension of *M. laxa* were secured to green fruit with twistem ties and covered with plastic then paper bags for 48 hr. Average fruit length was 33.4 mm.

No infection was observed.

Controls: in all experiments described, appropriate noninoculated controls were included.

Discussion:

The failure to achieve infection in the early experiments seems to be attributable to the surface sterilization of the incubated floral cups. The purpose of the bleach rinse was to exclude any fungal spores or mycelium that would cling to the floral cups when they were removed from the incubation suspension. However, the surface sterilization apparently was too harsh or the effective inoculum was on the surface of the floral cups and not internal. When we used floral cups directly from the incubation suspensions, infection was obtained. In these cases, we cannot say for certain that the fungus grew from a colonized floral cup or just from the surface contaminants.

Fruit are susceptible to infection for a short time during early development. This short time span hinders research in that only a few experiments can be conducted in any year, and there is little chance to repeat an experiment or to incorporate knowledge gained from one experiment into another experiment in the same season.

5. VALIDATION OF HULL ROT CONTROL BY DEFICIT IRRIGATION

Problem and Its Significance:

Hull rot develops in late summer and causes death of fruiting wood and small branches. It is most severe on vigorous, heavily-cropped Nonpareil trees. The disease results from infection of the hull by any of these fungi: *Monilinia fructicola*, *M. laxa* (brown rot fungi), *Rhizopus stolonifer* or *R. arrhizus* (bread mold fungi). *M. fructicola* and *R. stolonifer* are the most frequent incitants of hull rot. Hulls are susceptible to infection as soon as they begin to split. The fungi enter through the natural opening, invade the hull, and apparently produce a toxin that is transported into the shoot and leaves causing death of those tissues.

Hull rot is not controlled by fungicide application. Because the disease is associated with vigorous orchards that receive ample water and nitrogen, hull rot is a good candidate for management through cultural practices. We have shown recently that increases in nitrogen fertilization are accompanied by increased hull rot. Experiments conducted in Dr. Dave Goldhamer's irrigation cut-off and regulated deficit irrigation trials in Kern County demonstrated that the amount and timing of reduced irrigation schemes affected the severity of hull rot. Of most interest is one treatment in the regulated deficit irrigation study. This treatment employed reduction to 50% of normal the amount of water applied during the first two weeks of July, when hull split was just beginning. This caused a mild stress in the trees (-12 to -20 bars predawn leaf water potential). No visible harm was seen in the trees, and yield was not affected. Similar experiments conducted in Yolo County for the past several years also showed reduced irrigation, and presumable mild stress, at early hull split resulted in dramatic reduction in hull rot. Manipulating this system such that growers in various orchard situations could use irrigation to mitigate hull rot would be useful.

Objectives:

1. Validate the effect of reduced irrigation and imposition of mild stress during early hull split as a means to reduce incidence of hull rot disease.

2. Devise a method by which growers can determine when to return their orchards to full irrigation.

Materials and Methods

Experiments were located in one orchard each in Kern and Yolo Counties and in two orchards in Fresno County (Kerman and Huron). All trees received normal full irrigation until the experiment began. There were two treatments in the Kern and Kerman orchards: 1) full irrigation and 2) irrigation curtailed at early hull split and resumed when predawn leaf water potentials reached -14 bars (mild stress). A third treatment, water reduced to 50% of normal until mildly stressed, also was included in the Huron orchard.

The Kern orchard was planted with cultivars Nonpareil and Carmel in a 1 row:1 row pattern and irrigated with microsprinklers. Each plot was three rows wide and 18 trees long with a Nonpareil row in the center. In the deficit irrigation treatment, irrigation was curtailed beginning 24 June and restored 6 July. Data were collected from the center Nonpareil row. Fruit was observed informally (no counts were taken) when the experiment began and fruit split was infrequent. Three days after irrigation resumed, 100 fruit per replication were observed, on 9 July, and 16.7 and 17.0 % of fruit were split in the full and deficit irrigation treatments, respectively.

Trees were shaken and hull rot incidence evaluated on 8 and 9 August, respectively. All hull rot strikes were counted and inches dead wood estimated in the central 10 trees of each data row. Samples of fruit were collected from beneath the same 10 trees and returned to the laboratory. There, 100 fruit from each sample were observed for hull lesions and the pathogen(s) identified. Kernel quality was assessed for two groups of 50 nuts each from each replication. After counting the number of shriveled, lacquered, or infested kernels, these damaged kernels were replaced with healthy kernels and each group of 50 were air dried for 72 hr at 65C in a forced air oven then weighed and measured.

The Kerman orchard was planted with alternating trees of Nonpareil and Kapareil. Trees were flood irrigated, with valves placed between each tree row. No water was delivered along both sides of each data row from 23 June until 17 July. Fruit had not begun to split when the experiment was initiated. Trees were shaken and hull rot evaluated on 10 and 12 August, respectively. All strikes were counted and inches dead wood estimated in 10 each adjacent Nonpareil and Kapareil trees, beginning with the third tree from the east side of the orchard, in each replication. Fruit samples were not collected for kernel quality assessment.

The Huron orchard was planted in a row pattern of 1 Nonpareil:1 Sonora:1 Nonpareil:1 Carmel. Trees were irrigated with a double line drip system. The experiments was located in the Sonora row and each plot was one row wide and 26 trees long. The water was turned off on both drip lines for the complete cessation treatment and for one drip line for the 50% water reduction treatment. Treatments were initiated on 24 June. The water was inadvertently restored in the full cessation treatment within the next few days and again turned off on 1 July. Water restoration in the complete cessation treatment occurred again sometime between 15 and 22 July. Trees were shaken and hull rot evaluated on 21 and 23 August, respectively. All strikes were counted and inches dead wood estimated in 10 trees, beginning with the third tree from the south side of the orchard, in each replication. Fruit samples were not collected for kernel quality assessment.

Tree water status was measured in each orchard at pre-dawn and mid-day at weekly intervals beginning just before deficit irrigation treatments were imposed until water was restored. Leaves used for pre-dawn readings were collected during the hour before sunrise from anywhere in the tree canopy, usually the lower periphery of the tree. Mid-day readings were taken from covered and exposed leaves collected from noon to 1:30 p.m.. Covered leaves were chosen from the inside tree canopy, as close to the trunk as possible, and encased in small, black plastic bags at least one hour before leaf water potential was measured. Exposed leaves were taken from sunlit areas of the outer periphery of the canopy. All leaves were mature, fully expanded, and tested immediately after removal from the tree. In each location, leaves were collected from two trees per replication, each tree situated four to six trees from each end of the plot.

Treatments were replicated times and arranged in a randomized complete block design. An arcsine transformation was performed on data for percent hull infection, shriveled, and lacquered kernels before analysis of variance. Means were separated by Duncan's multiple range test.

<u>Results</u>

In the Kern County orchard, predawn leaf water potential reached an average of -13.2 bars on 5 July in the deficit irrigation treatment in comparison to an average of -7.1 bars in the fully irrigated treatment (Table 18). Comparable higher readings in the deficit irrigation treatment were found in the covered and exposed leaf mid-day readings. The pre-dawn reading was close enough to the target of -14 bars to trigger restoration of water, which was accomplished the following day. Trees in this treatment had significantly fewer hull rot strikes, inches dead wood, and infected hulls than those in the fully irrigated treatment (Table 19). Kernel quality was unaffected by the treatments. Kernel weight, length, shrivel, and lacquer for normal and deficit irrigation treatments, respectively, were 1.23 and 1.22 g, 25.0 and 25.4 mm, 2.8 and 3.2%, and 0.0 and 0.2%.

Pre-dawn leaf water potentials did not reach the target range of -14 bars in either the Kerman or the Huron orchards before water was restored (Tables 20 and 21). Hull rot incidence in the deficit irrigation treatments did not differ from the fully irrigated treatments in either orchard (Table 19). Fruit evaluations were not made because there were no differences in leaf water potentials or hull rot.

Discussion

Hull rot incidence was relatively low in the Kern County orchard but differences nonetheless were measurable. It is encouraging that we were able to reduce hull rot using plant-based measurements upon which to base irrigation decisions: early hull split signaled the time to shut the water off and leaf water potential determined when to resume irrigation. Hull rot incidences were much higher in the Kerman and Huron orchards. The effects of water reduction under these greater disease conditions were not measured because water was restored before the target leaf water potential was reached and hull rot incidence was not affected.

Kernel quality was not harmed by the short duration of water withdrawal in the Kern County orchard. Complete yield measurements were not attempted, but data from other work by Goldhamer indicate that yield should not be reduced by this practice.

Table 1. Incidence of Alternaria leaf spot and scab of almond cv Butte associated with different amounts of natural vegetation, Kern County, 1996.

Amount of weed growth	Alternaria				Scab
	# lesions	Infected leaves (%)		Defoliation	Infected leaves (%)
	22 July	22 July	19 Aug	20 Sep	19 Aug
Uniform, lush	218.1	27.2	44.9	91.1	11.2
Scattered to none	104.1	20.9	32.8	84.0	14.3
P =	.000	.063	.034	.033	NS

Table 2. Efficacy of registered fungicides for control of Alternaria leaf spot on Butte almond grown under two orchard floor management systems, Kern County, 1996.

Treatments and application dates					Disease evaluation			
		Weeks after petal fall			Infected leaves			Defoliation (%)
Pink bud 22 Feb	Petal fall 7 Mar	2 Weeks 28 Mar	5 Weeks 19 Apr	8 Weeks 10 May	Number 22 Jul	Percent 22 Jul	Percent 19 Aug	20 Sep
ROV	ROV	ROV	ROV	CAP	73.0 d	14.7 d	20.0 e	87.5 bcd
ROV	ROV	ROV	ROV	SUL	108.0 cd	20.2 cd	22.8 de	75.0 d
ROV	ROV	ROV	ROV		85.3 cd	17.2 cd	25.0 de	81.5 cd
ZIR	ZIR	ZIR	ZIR		125.2 cd	24.1 abc	35.8 cd	76.7 d
MX	MX	MX	MX		143.7 bc	23.3 abc	29.8 cde	82.5 bcd
ROV	ROV	ROV			143.7 bc	23.3 abc	33.0 cde	91.3 bc
RAL	RAL	RAL	RAL		148.6 bc	22.4 bc	41.0 bc	91.9 ab
CAP	CAP	CAP	CAP		216.4 a	31.2 a	67.8 a	97.3 a
Control	---	---	---	---	200.9 ab	28.7 ab	51.6 b	91.2 abc
Cover					145.3	22.5	35.7	87.5
Clean					131.4	23.1	37.1	84.7
Significance of *F*, *P* =								
Fungicides (F)					.000	.000	.000	.000
Cover crop (C)					NS	NS	NS	NS
F x C					NS	NS	NS	NS

Code	Material	Rate a.f./acre
CAP	Captan 50W	9.0 lb
MX	Manex 37F	6.0 qt
RAL	Rally 40W + L*	8.0 oz
ROV	Rovral 50W	1.0 lb
SUL	Microthiol	10.0 lb
ZIR	Ziram 76W	8.0 lb

Application:	Speed sprayer
Psi:	90
Gal/acre:	90
Tree spacing:	22' x 24'
Trees/acre:	90

Design:	Split plot
Main factor:	(6 replications, 8-row plots)
Cover crop	
Clean cultivation	
Subplots:	(12 replications, 3-tree plot)
Fungicides	
Data:	Data collected from center tree in each plot Number - all infected leaves in a 3' band around lower part of tree Percent - 100 (22 Jul) and 50 (19 Aug) leaves/tree

Table 3. Efficacy of unregistered fungicides for control of Alternaria leaf spot on Sonora almond trees, Kern County, 1996.

Treatment and application dates				Disease evaluation			
	Weeks after petal fall			Infected leaves			Defoliation (%)
Pink bud 14 Feb	2 Weeks 14 Mar	5 Weeks 2 Apr	8 Weeks 23 Apr	Number 22 Jul	Percent 22 Jul	Percent 7 Aug	20 Sep
EL	EL	EL	---	141.5 c	10.5	23.5 cd	73.8 a
	AB	AB	AB	151.3 c	13.2	38.0 abcd	82.0 a
	EL	EL	EL	188.8 bc	11.0	29.5 cd	58.8 b
BR	BR	ROV	---	202.8 bc	15.7	20.0 d	61.4 b
	IND	IND	IND	217.8 bc	13.0	38.5 abcd	80.0 a
AB	AB	AB	---	233.8 abc	14.0	34.5 bcd	73.9 a
	V + M	V + M	V + M	270.5 abc	15.5	58.0 a	86.2 a
V + M	V + M	V + M	---	280.8 abc	15.2	33.5 bcd	82.2 a
	DIT	DIT	DIT	325.0 ab	16.2	38.5 abcd	78.1 a
BR	BR	---	---	329.5 ab	21.2	53.0 ab	85.5 a
BR	BR	BR	---	329.8 ab	21.7	50.5 ab	87.6 a
Control				371.5 a	16.6	42.5 abc	83.6 a
					NS		

Code	Material	Rate a.f./acre
AB	Abound 80W + L*	4.0 oz
BR	Bravo 720	4 1/8 pt
EL	Elite 45 DF	8.0 oz
DIT	Dithane 75DF + L*	8.5 lb
IND	Indar 75W (RH7592)	2.0 oz
M	Maxim 50W (CGA 173506)	4.3 oz
ROV	Rovral 50W	1.0 lb
VAN	Vanguard 75W	4.8 oz
*L	Latron B1956	0.06% (8.0 oz/100 gal)

Application:	Hand-gun
Psi:	250
Gal/tree:	4.0
Tree spacing:	22' x 24'
Trees/acre:	90

Design:	Randomized complete block
Replication:	4 single-tree
Data:	Percent = 50 (7 Aug) and 100 (22 Jul) leaves from lower portion of tree Number = all infected leaves in 3 foot band around lower part of tree

Table 4. Comparison of several fungicide programs for control of Alternaria leaf spot and scab diseases in Carmel almond trees, Tulare County, 1996.

Treatments and application dates			Disease evaluation	
	Weeks after petal fall		Scab-infected	Defoliation (%)
Pink bud	2 weeks	5 weeks	fruit (%)	(probably Alternaria)
24 Feb	20 Mar	11 Apr	22 Aug	1 Oct
ROV	TOP + CAP	TOP + CAP	2.4 d	55.5
ROV	CAP	CAP	1.4 d	46.5
ROV	BEN + CAP	CAP	2.4 d	61.0
ROV	CAP	BEN + CAP	2.7 d	53.5
BEN + CAP	CAP	BEN + CAP	3.6 d	56.0
ROV	BEN + CAP		3.0 d	53.5
ROV		BEN + CAP	8.2 bc	54.5
ROV	ROV	ROV	9.3 b	40.0
RAL	RAL	RAL	4.4 cd	55.5
CAP	CAP	CAP	2.9 d	55.5
Control			20.8 a	67.0
Cover			5.6	NS
Clean			5.4	NS
Significance of *F*, *P* =				
Fungicides (F)			.000	NS
Cover crop (C)			NS	NS
F x C			NS	NS

Code	Material	Rate a.f./acre
BEN	Benlate SP	1.5 lb
CAP	Captan 50W	6.0 lb (comb); 9.0 lb (alone)
RAL	Rally 40W + L*	8.0 oz
ROV	Rovral 50W	1.0 lb
TOP	Topsin 70W	1.5 lb
*L	Latron B 1956	0.06% (8 oz/100 gal)

Application:	Hand-gun
Psi:	200
Gal/tree:	4.0
Tree spacing:	20'x 24'
Trees/acre:	90

Design:	Split plot
Main factors:	(6 replications 8 full rows)
Cover crop	
Clean cultivation	
Sub plots:	(12 single-tree replications)
Fungicides	
Data:	50 fruit and leaves/tree; leaves evaluated in control only

Table 5. Efficacy of unregistered fungicides for control of Alternaria leaf spot and scab diseases on Carmel almond trees, Tulare County, 1996.

Treatments and application dates			Disease evaluation	
	Weeks after petal fall		Scab-infected	Defoliation (%)
Pink bud	2 weeks	5 weeks	fruit (%)	(probably Alternaria)
22 Feb	20 Mar	12 Apr	22 Aug	1 Oct
BR	BR	BR	0.5 c	36.6
BR	BR	ROV	1.5 c	29.5
BR	BR	---	3.0 bc	40.6
ROV	BEN + CAP	CAP	1.0 c	31.7
ROV	AB-4	AB-4	4.5 bc	50.2
AB-5	AB-3.5	AB-3.5	2.0 bc	52.3
ELITE	ELITE	ELITE	8.5 bc	44.4
RUB - 18	RUB-18	RUB-18	15.0 b	45.4
RUB - 24	RUB-24	RUB-24	9.5 bc	29.5
VAN	VAN	VAN	19.5 b	41.1
VAN + MAX	VAN + MAX	VAN + MAX	13.0 bc	41.2
Control			43.0 a	30.0
				NS

Code	Material	Rate a.f./acre
AB-5	Abound 80W	5.0 oz
AB-4	Abound 80W	4.0 oz
AB-3.5	Abound 80W	3.5 oz
BEN	Benlate 50W	1.5 lb
BR	Bravo 720	4 1/8 pts
CAP	Captan 50W	6.0 lb (comb.); 9.0 lb (alone)
ELITE	Elite 45 DF	6.0 oz
MAX	Maxim 50W (CGA 173506)	4.3 oz
ROV	Rovral 50W	1.0 lb
RUB	Rubigan IE	18.0 fl oz
RUB 24	Rubigan IE	24.0 fl oz
VAN	Vanguard 75W	4.8 oz

Application:	Hand-gun
Psi:	400
Gal/tree:	4.0
Trees/acre:	90

Design:	Randomized complete block
Replications:	4 single-tree
Data:	50 leaves and fruit/tree

Table 6. Relative defoliation of several almond cultivars infected with Alternaria leaf spot, Kern County, 1996.

Defoliation (%), 2 Sep			
0-10	10-20	30-60	60-80
Aldrich	Carmel	Fritz	Savana
Butte	Donna	Kahl	Wood Colony
Chips	Jiml	Mission	Yokit
Jenette	Kapareil	Sonora	
Johlyn	Mission	2-43	
Livingston	Morley		
Monterey	Price		
Nonpareil	Ruby		
Padre	Sano		
Plateau	102W		
Rosetta			
1-87			
2-19			
13-1			
25-75			

Table 7. Comparison of various fungicide programs for control of brown rot, shot hole, and scab diseases of cv Carmel almond trees, Colusa County, 1996.

Treatments and application dates						Disease evaluation			
				Weeks after petal fall		Brown rot	Shot hole	Scab	
Dormant 15 Feb	Pink bud 1 Mar	Full bloom 1 Mar	Petal fall 8 Mar	2 Weeks 22 Mar	5 Weeks 12 Apr	Number of strikes 16 Apr	Infected fruit (%) 16 May	Infected leaves (%) 13 Aug	Infected fruit (%) 13 Aug
	ROV	TOP	CAP	CAP	MX	9.2 cd	0.7 c	0.7 ab	1.3 d
	ROV	TOP	CAP		MX	7.0 cd	2.7 bc	0.7 ab	20.0 bcd
	ROV	ROV			MX	2.9 d	5.3 abc	2.7 ab	47.3 ab
	ROV	FUN			MX	9.5 cd	23.3 a	7.3 ab	58.7 a
	TOP	FUN			MX	4.5 cd	5.3 abc	6.0 ab	36.7 ab
	CAP	CAP			MX	6.0 cd	1.3 bc	1.3 ab	50.7 ab
	RAL	RAL			MX	12.2bcd	18.0 ab	0.7 ab	57.3 a
	TML	TML			MX	7.7 cd	16.0 ab	9.3 ab	47.3 ab
	TMH	TMH			MX	9.2 cd	10.7 abc	12.7 a	59.3 a
	ROV		ROV		MX	16.5 bc	9.3 abc	12.7 a	63.3 a
	ROV		TOP		MX	12.7 bcd	6.0 abc	1.3 ab	17.3 bcd
COP	ROV		TOP		MX	10.7 bcd	12.7 abc	1.3 ab	7.3 cd
LLS	ROV		TOP		MX	15.2 bcd	10.0 abc	0.0 b	30.7 abc
	CAP		CAP		MX	10.7 bcd	2.0 bc	3.3 ab	53.3 ab
	RAL		RAL		MX	11.0 bcd	10.0 abc	0.7 ab	48.7 ab
	RAL		CAP		MX	21.75 b	0.7 c	4.0 ab	64.0 a
Control						37.5 a	19.3 a	12.7 a	44.0 ab

Code	Material	Rate a.f. per 100 gal
CAP	Captan 50W	9.0 lb
FUN	Funginex	12.0 fl oz
MX	Manex 37F	1.5 qt
RAL	Rally 40W + CS7*	6.0 oz
ROV	Rovral 4F	0.25 pt
TML	TM 402, 50WDG	1.5 lb
TMH	TM 402, 50WDG	3.0 lb
TOP	Topsin 70W	1.5 lb
LLS	Liquid lime sulfur	16.0 gal
COP	Kocide DF	8.0 lb
*CS7	CS7	8.0 oz

Applicaton:	Hand-gun
Psi:	300
Gal/tree:	2.0
Tree spacing:	12 x 18
Trees/acre:	202

Data:	Brown rot = number strikes on 20 feet of fruitful wood Shot hole = 50 fruit/rep Scab = 50 leaves and fruit/rep
Design:	Randomized complete block
Replication:	4 (brown rot only) or 3 single-tree

Table 8. Comparison of various fungicide programs for control of brown rot and scab diseases of cv Carmel almond trees, Tehama County, 1996.

Treatments and application dates			Disease evaluation			
			Brown rot	Scab		
Early bloom 21 Feb	Late petal fall 5 Mar	5 Weeks 4 Apr	Number strikes/tree 15 Apr	Infected leaves (%) 14 Aug	Infected fruit (%) 14 Aug	Defoliation (%) 25 Sep
ROV	TOP + ZIR	TOP + ZIR	8.5 b	0.0 c	31.5 c	11.0 cd
TOP + ZIR	CAP	MN	4.5 b	0.0 c	33.0 c	21.0 b
ROV	TOP	ZIR	2.5 b	0.8 c	40.0 c	14.0 bcd
ROV	TOP + ZIR	ZIR	4.7 b	1.2 bc	30.0 c	7.0 d
ROV	ZIR	TOP + ZIR	4.1 b	1.2 bc	58.0 bc	19.0 bc
RAL	CAP	MN	3.6 b	1.2 c	42.0 bc	14.0 bcd
ROV	ZIR	BEN + ZIR	4.3 b	1.6 bc	46.0 bc	13.0 bcd
ROV	BEN + ZIR	ZIR	10.2 b	2.8 bc	44.0 bc	22.0 b
RAL	TOP + ZIR	ZIR	10.3 b	3.2 bc	50.0 bc	17.0 bc
Control	---	---	15.8 b	6.4 b	72.0 ab	22.0 b
Control	---	---	31.6 a	14.4 a	87.5 a	38.0 a

Code	Material	Rate a.f./acre
BEN	Benlate SP	1.5 lb
CAP	Captan 50W	9.0 lb
MN	Maneb 75DF	8.0 lb
RAL	Rally 40W + L*	6.0 oz
ROV	Rovral 50W	1.0 lb
TOP	Topsin 50W	1.5 lb
ZIR	Ziram 76W	8.0 lb
*L	CS7	0.06% (8 oz/100 gal)

Application	Hand-gun
Psi:	350
Gal/tree:	5.0
Tree spacing:	25’ x 25’
Trees/acre:	70

Design:	Randomized complete block
Replication:	5 (leaves), 4 (fruit), single-tree
Data:	50 leaves and fruit/tree

Table 9. Efficacy of registered fungicides for control of Alternaria leaf spot, brown rot, and scab diseases of cv. Butte almond trees, Kern County, 1996.

Treatments and application dates					Disease evaluation			
Pink	Petal	Weeks after petal fall				Infected leaves (%)		Defoliation (%)
bud	fall	2 weeks	5 weeks	8 weeks	Brown rot	Alternaria	Scab	
22 Feb	7 Mar	28 Mar	19 Apr	10 May	9 May	13 Aug	13 Aug	20 Sep
ROV	ROV	ROV	ROV	SUL	2.9 e	19.2 e	18.3 bc	75.0 d
ROV	ROV	ROV	ROV	CAP	1.8 e	19.5 de	14.5 bc	87.5 bcd
ROV	ROV	ROV	ROV	---	1.7 e	21.2 cde	18.8 b	81.5 cd
MX	MX	MX	MX	---	16.9 c	25.8 cde	1.5 d	82.5 bcd
ROV	ROV	ROV	---	---	2.6 e	30.3 cd	19.5 ab	91.3 bc
ZIR	ZIR	ZIR	ZIR	---	12.5 cd	31.2 cd	0.2 d	76.7 d
RAL	RAL	RAL	RAL	---	4.6 de	37.9 bc	11.3 c	91.1 ab
CAP	CAP	CAP	CAP	---	28.1 b	59.7 a	1.7 d	97.3 a
Control					39.0 a	48.5 ab	29.0 a	91.2 abc

Code	Material	Rate a.f./acre
CAP	Captan 50W	9.0 lb
MX	Manex 37F	6.0 qt
RAL	Rally 40W + L*	8.0 oz
ROV	Rovral 50W	1.0 lb
SUL	Microthiol	10.0 lb
ZIR	Ziram 76W	8.0 lb

Application:	Speed sprayer
Psi:	90
Gal/acre:	90
Tree spacing:	22' x 24'
Trees/acre:	90

Design:	Split plot
Main factor:	(6 replications, 8-row plots)
Cover crop	
Clean cultivation	
Subplots:	(12 replications, 3-tree plot)
Fungicides	
Data:	Data collected from center tree in each plot
	Number - all infected leaves in a 3' band around lower part of tree
	Percent - 100 (22 Jul) and 50 (19 Aug) leaves/tree

Table 10. Efficacy of unregistered materials for control of Alternaria leaf spot, brown rot, and scab diseases of cv Sonora almond trees, Kern County, 1996.

Treatments and application dates				Disease evaluation			
Pink	Weeks after petal fall				Infected leaves (%)		Defoliation (%)
bud	2 Weeks	5 Weeks	8 Weeks	Brown rot	Alternaria	Scab	
14 Feb	14 Mar	2 Apr	23 Apr	9 May	19 Aug	19 Aug	20 Sep
AB	AB	AB	---	1.0 d	34.5 bcd	1.5 d	73.9 a
V+M	V+M	V+M	---	1.0 d	38.5 abcd	23.0 a	82.2 a
EL	EL	EL	---	1.2 d	23.5 cd	6.5 cd	73.8 a
BR	BR	---	---	3.1 cd	53.0 ab	4.5 cd	85.5 a
BR	BR	ROV	---	4.0 bcd	20.0 d	2.5 d	61.4 b
BR	BR	BR	---	4.4 bcd	50.5 ab	2.0 d	87.6 a
	AB	AB	AB	9.4 abc	38.0 abcd	2.5 d	82.0 a
	V+M	V+M	V+M	9.9 abc	58.0 a	17.5 ab	86.2 a
	DIT	DIT	DIT	11.1 abc	38.5 abcd	1.5 d	78.1 a
	EL	EL	EL	11.7 abc	29.5 cd	9.0 bc	58.8 b
	IND	IND	IND	15.2 a	38.5 abcd	17.0 ab	80.0 a
Control				16.6 a	42.5 abc	23.5 a	83.6 a

Code	Material	Rate a.f./acre
AB	Abound 80W + L*	4.0 oz
BR	Bravo 720	4 1/8 pt
EL	Elite 45 DF	8.0 oz
DIT	Dithane 75DF + L*	8.5 lb
IND	Indar 75W (RH7592)	2.0 oz
M	Maxim 50W (CGA 173506)	4.3 oz
ROV	Rovral 50W	1.0 lb
VAN	Vanguard 75W	4.8 oz
*L	Latron B1956	0.06% (8.0 oz/100 gal)

Application:	Hand-gun
Psi:	250
Gal/tree:	4.0
Tree spacing:	22' x 24'
Trees/acre:	90

Design:	Randomized complete block
Replication:	4 single-tree
Data:	Percent = 50 (7 Aug) and 100 (22 Jul) leaves from lower portion of tree Number = all infected leaves in 3 foot band around lower part of tree

Table 11. Comparison of various fungicide programs for control of scab disease of cv Carmel almond trees, Madera County, 1996.

Treatments and application dates			Disease evaluation		
25% bloom	Weeks after petal fall		Infected leaves (%)	Infected leaves (%)	Defoliation (%)
	3 weeks	5 weeks			
26 Feb	4 Apr	18 Apr	24 July	21 Aug	26 Sep
BEN + CAP	ROV	MN	6.8 e	7.8 d	41.1 bcd
BEN + CAP	ROV	MN	9.7 e	9.3 d	33.8 bc
CAP	CAP	CAP	9.2 e	14.5 cd	40.0 bcd
RAL	BEN + CAP	MN	11.7 de	19.7 bc	32.6 d
ROV	BEN + CAP	MN	17.5 cd	23.3 bc	43.9 bcd
RAL	CAP	MN	21.5 bc	28.3 b	32.4 d
ROV	CAP	MN	22.0 bc	27.3 b	48.8 b
RAL	RAL	MN	22.2 bc	30.7 b	36.6 bcd
ROV	ROV	MN	31.5 ab	30.3 ab	46.6 ab
Control	---	---	38.3 a	40.2 a	59.8 a
Dormant treatments (29 Jan)					
Liquid lime sulfur			11.9 b	11.0 b	37.1
Kocide DF			19.9 ab	29.3 a	42.2
Nontreated			25.2 a	29.1 a	44.9
Significance of *F*, *P* =					
Fungicide (F)			.000	.000	.000
Dormant (D)			.031	.001	NS
D x F			NS	NS	NS

Code	Material	Rate a.f./acre
BEN	Benlate SP	1.5 lb
CAP	Captan 50W	6.0 lb (comb); 9.0 lb (alone)
MN	Maneb 74DF	8.0 lb
RAL	Rally 40W + L*	6.0 oz
ROV	Rovral 50W	1.0 lb
L*	Latron B1956	0.06% (8 oz/100 gal)

Application:	Dormant, speed sprayer
Psi:	90
Gal/acre:	70
	In season, hand-gun
Psi:	200
Gal/tree:	3.0 (bloom), 4.0 (3&5 weeks)
Tree spacing:	24’ x 16’
Trees/acre:	101

Design:	Split plot
Replication:	Main factor: dormant treatments
	Subplot factors: fungicides
Main factor:	4 (10-tree plots)
Subplots:	12 single-tree
Data:	Data collected from center tree in each plot, 50 leaves/tree

Table 12. Comparison of various fungicide programs for control of scab disease of cv Carmel almond trees, Tulare County, 1996.

Treatments and application dates			Disease evaluation	
	Weeks after petal fall		Infected fruit (%)	Defoliation (%)
Pink bud	2 weeks	5 weeks		
24 Feb	20 Mar	11 Apr	22 Aug	1 Oct
ROV	TOP + CAP	TOP + CAP	2.4 d	55.5
ROV	CAP	CAP	1.4 d	46.5
ROV	BEN + CAP	CAP	2.4 d	61.0
ROV	CAP	BEN + CAP	2.7 d	53.5
BEN + CAP	CAP	BEN + CAP	3.6 d	56.0
ROV	BEN + CAP		3.0 d	53.5
ROV		BEN + CAP	8.2 bc	54.5
ROV	ROV	ROV	9.3 b	40.0
RAL	RAL	RAL	4.4 cd	55.5
CAP	CAP	CAP	2.9 d	55.5
Control			20.8 a	67.0
Cover			5.6	NS
Clean			5.4	NS
Significance of *F*, *P* =				
Fungicides (F)			.000	NS
Cover crop (C)			NS	NS
F x C			NS	NS

Code	Material	Rate a.f./acre
BEN	Benlate SP	1.5 lb
CAP	Captan 50W	6.0 lb (comb); 9.0 lb (alone)
RAL	Rally 40W + L*	8.0 oz
ROV	Rovral 50W	1.0 lb
TOP	Topsin 70W	1.5 lb
*L	Latron B 1956	0.06% (8 oz/100 gal)

Application:	Hand-gun
Psi:	200
Gal/tree:	4.0
Tree spacing:	20'x 24'
Trees/acre:	90

Design:	Split plot
Main factors:	(6 replications 8 full rows)
Cover crop	
Clean cultivation	
Sub plots:	(12 single-tree replications)
Fungicides	
Data:	50 fruit and leaves/tree; leaves evaluated in control only

Table 13. Efficacy of unregistered fungicides for control of scab disease of cv Carmel almond trees, Tulare County, 1996.

Treatments and application dates			Disease evaluation		
	Weeks after petal fall		Infected fruit (%)	Infected leaves (%)	Defoliation (%)
Pink bud	2 weeks	5 weeks			
22 Feb	20 Mar	12 Apr	22 Aug	22 Aug	1 Oct
BR	BR	BR	0.5 c	0.0	36.6
BR	BR	ROV	1.5 c	3.5	29.5
BR	BR	---	3.0 bc	1.0	40.6
ROV	BEN + CAP	CAP	1.0 c	0.0	31.7
ROV	AB-4	AB-4	4.5 bc	1.0	50.2
AB-5	AB-3.5	AB-3.5	2.0 bc	1.0	52.3
ELITE	ELITE	ELITE	8.5 bc	0.5	44.4
RUB - 18	RUB-18	RUB-18	15.0 b	1.5	45.4
RUB - 24	RUB-24	RUB-24	9.5 bc	1.5	29.5
VAN	VAN	VAN	19.5 b	1.5	41.1
VAN + MAX	VAN + MAX	VAN + MAX	13.0 bc	1.5	41.2
Control			43.0 a	3.5	30.0
				NS	NS

Code	Material	Rate a.f./acre
AB-5	Abound 80W	5.0 oz
AB-4	Abound 80W	4.0 oz
AB-3.5	Abound 80W	3.5 oz
BEN	Benlate 50W	1.5 lb
BR	Bravo 720	4 1/8 pts
CAP	Captan 50W	6.0 lb (comb.); 9.0 lb (alone)
ELITE	Elite 45 DF	6.0 oz
MAX	Maxim 50W (CGA 173506)	4.3 oz
ROV	Rovral 50W	1.0 lb
RUB	Rubigan IE	18.0 fl oz
RUB 24	Rubigan IE	24.0 fl oz
VAN	Vanguard 75W	4.8 oz

Application:	Hand-gun
Psi:	400
Gal/tree:	4.0
Trees/acre:	90

Design:	Randomized complete block
Replications:	4 single-tree
Data:	50 leaves and fruit/tree

Table 14. Prevention by fungicides of infection of cv Mission almond bark wound by *Ceratoceptis fimbriata*, Kearney Agricultural Center.

Treatment 11 oct 1995	January 26 Apr 1996	Canker length, cm 25 Jul 1996
Benlate	3.0	6.6
Benlate + Asana	1.8	7.4
Stickum	0.0	8.2
Nectec	0.6	8.8
Rally	4.0	8.8
Rovral	4.0	8.9
Benlate + oil	3.2	10.2
Treeseal	3.8	10.4
Elixir	2.6	10.7
Spinout	3.2	12.2
Inoculated control	3.6	8.6
Noninoculated control	0.0	0.0
Scale	0-5	---

Table 15. Healing of cv Mission almond bark wounds treated with fungicides, Kearney Agricultural Center.

Treatment 6 Sept 1995	Wound gumming 27 Nov 1995	Wound closure 25 Jul 1996
Treeseal	0.0	1.0
Nectec	0.0	1.2
Elixir	3.0	1.2
Benlate	3.0	1.4
Spinout	2.4	1.8
Rovral	1.2	1.8
Benlate + oil	2.4	1.9
Benlate + Asana	0.0	2.2
Rally	1.6	2.2
Stickum	0.0	2.8
Control	1.8	1.4
Scale	0-5	1-4

Table 16. Effect of time between inoculation and treatment on efficacy of fungicides to control Ceratoceptis canker on cv Nonpareil almond trees, Kearney Agricultural Center.

	Canker length, cm (25 Jul 96)[1]			
	Days after inoculation when treated			
	0	7	14	21
Benlate + oil	0.3	7.3	8.0	9.3
Nectec	2.7	10.9	10.2	10.0
Spinout	10.4	9.3	9.1	10.0
Inoculated control	0.0	0.6	1.6	0.4
Noninoculated control	0.0	0.6	1.6	0.4

[1] Wounded and inoculated 20 Sep 1995.

Table 17. Use of cast floral cups and petals as inoculum sources for *Monilinia laxa* and effect of inoculation period on green fruit rot of almond, Kearney Agricultural Center, 1996.

	Infected fruit (%)					
	Floral cups[z]				Petals[z]	
Average fruit length, mm	24 hr		48 hr		48 hr	
	Sandwich	Twistem	Sandwich	Twistem	Sandwich	Twistem
16.5	31.0	0.0	27.0	---	25.8	---
23.0	18.6	23.5	7.9	6.8	22.0	18.6
27.0	11.4	11.1	22.1	---	21.5	---

[z] Floral cups and petals incubated in suspension of 10^4 conidia/ml of *M. laxa* for 24 or 48 hr. Floral cups and petals secured to green fruit with a twistem tie or sandwiched between two fruit.

Table 18. Leaf water potential readings of Nonpareil almond trees, Kern County, 1996.

		Leaf water potential (-bars)[1]		
		Predawn	Mid-day[2]	
Date	Irrigation[3]		Covered	Exposed
19 June	None	7.2	---	18.3
	Full	6.7	---	17.4
24 June	None	4.9	7.9	18.8
	Full	4.7	8.0	18.2
5 July	None	13.2	22.2	26.9
	Full	7.1	8.6	17.4
12 July	None	3.8	10.1	15.9
	Full	3.5	8.6	14.9

1 Average of two readings per replication; one leaf each from the 4th and 11th trees in each plot.

2 Midday covered leaves were enclosed in with a paper bag at least one hour before measured. Bags were removed between noon and 2 pm. Midday exposed leaf was not covered.

3 None = no water supplied to trees from 24 June to 6 July; full = normal irrigation.

Table 19. Incidence of hull rot under normal and reduced irrigation schedules, 1996.

	Strikes/tree (number)				Dead wood (inches)				Infected hulls (%)
	Nonpareil			Kapareil	Nonpareil			Kapareil	Nonpareil
Irrigation	Kern	Huron	Kerman	Kerman	Kern	Huron	Kerman	Kerman	Kern
None	5.4	20.4	30.4	65.5	1.3	24.4	42.0	206.4	6.5
50%	---	20.8	---	---	---	19.8	---	---	---
Full	8.9	27.8	28.0	56.8	4.1	24.9	39.3	196.4	10.2
Monilinia									12.6
Rhizopus									4.1
Significance									
Irrigation (I)	.048	NS	NS	NS	.003	NS	NS	NS	.021
Fungus (F)	---	---	---	---	---	---	---	---	.000
I x F	---	---	---	---	---	---	---	---	NS

Table 20. Leaf water potential readings of Nonpareil almond trees, Fresno County (Kerman), 1996.

Date	Irrigation[3]	Leaf water potential (-bars)[1]		
		Predawn	Mid-day[2]	
			Covered	Exposed
20 June	None	8.5	11.5	21.9
	Full	8.5	12.7	22.6
26 June	None	5.4	3.0	3.6
	Full	6.1	3.5	3.7
3 July	None	5.0	9.5	22.4
	Full	4.8	8.9	23.7
10 July	None	6.1	---[4]	---[4]
	Full	4.7	---	---

1 Average of two readings per replication; one leaf each from the 5th and 11th trees in each plot.

2 Midday covered leaves were enclosed in a paper bag at least one hour before measured. Bags were removed between noon and 2 pm. Midday exposed leaf was not covered.

3 None = no water supplied to trees from 23 June until 17 July; full = normal irrigation.

4 Omite spray precluded reading.

Table 21. Leaf water potential readings of Nonpareil almond trees, Fresno County (Huron), 1996.

		Leaf water potential (-bars)[1]		
		Predawn	Mid-day[2]	
Date	Irrigation[3]		Covered	Exposed
22 June	None	4.1	7.1	18.1
	50%	4.5	7.1	20.9
	Full	4.2	6.4	18.3
1 July	None	4.6	10.9	18.5
	50%	3.8	10.2	17.7
	Full	3.8	9.7	16.6
8 July	None	6.3	11.2	18.5
	50%	7.5	14.4	19.6
	Full	5.4	9.8	16.5
15 July[4]	None	8.1	13.0	18.4
	50%	5.4	8.5	15.7
	Full	4.6	8.2	16.9
22 July	None	4.9	9.5	16.1
	50%	3.9	8.2	17.4
	Full	3.5	8.0	16.5

[1] Average of two readings per replication; one leaf each from the 6th and 18th trees in each plot.

[2] Midday covered leaves were enclosed in a paper bag at least one hour before measured. Bags were removed noon and 2 pm. Midday exposed leaf was not covered.

[3] None = no water supplied beginning 1 July but inadvertently restored between 15 and 22 July. 50% = water reduced to 50% of normal from 22 June to 23 July. Full = normal full irrigation.

[4] Three replications only.

Fig. 1 Hours of Leaf Wetness on Almond Trees, Kern County 1996

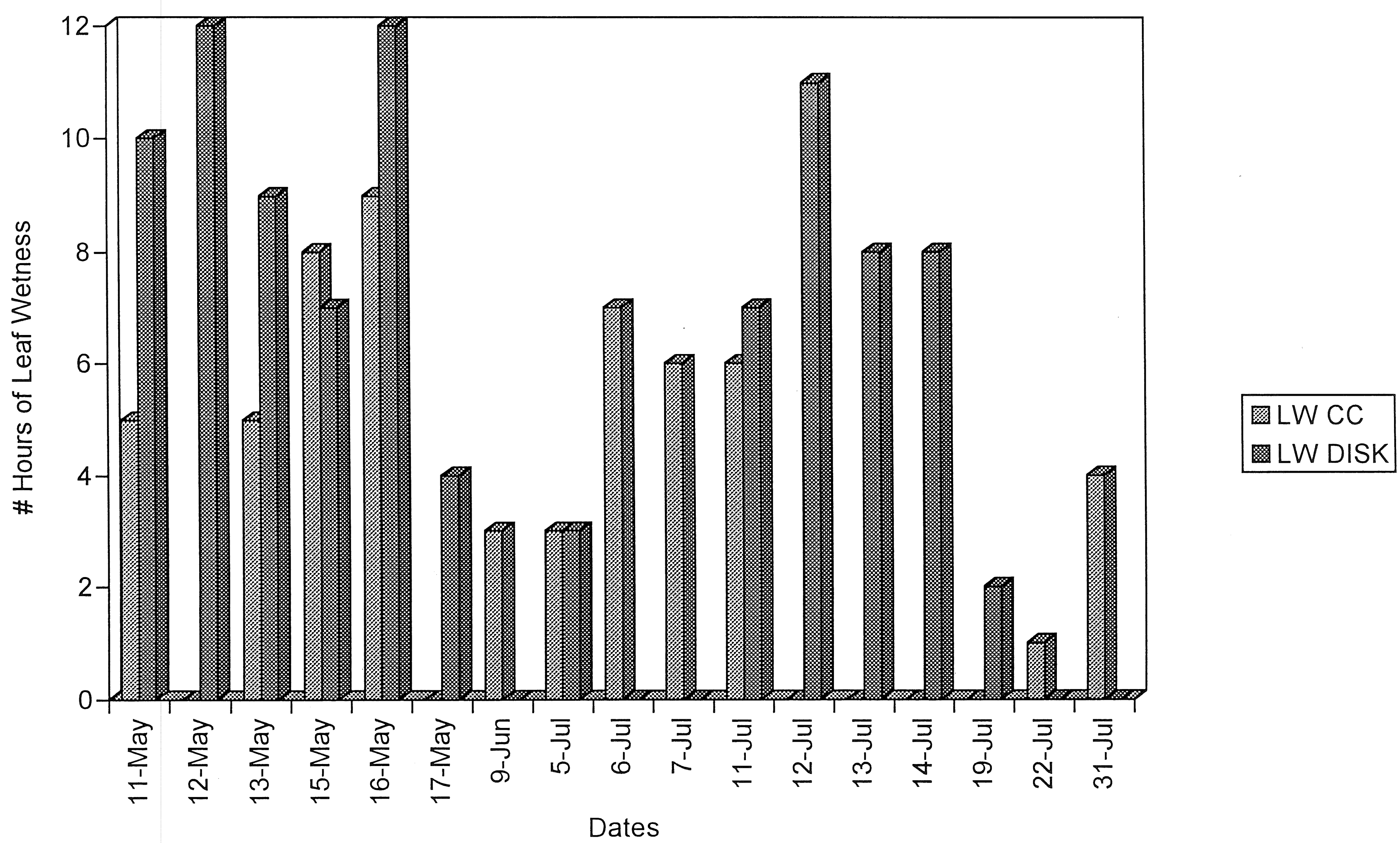

Fig. 2 Hours of Leaf Wetness on Almond Trees, Tulare County 1996

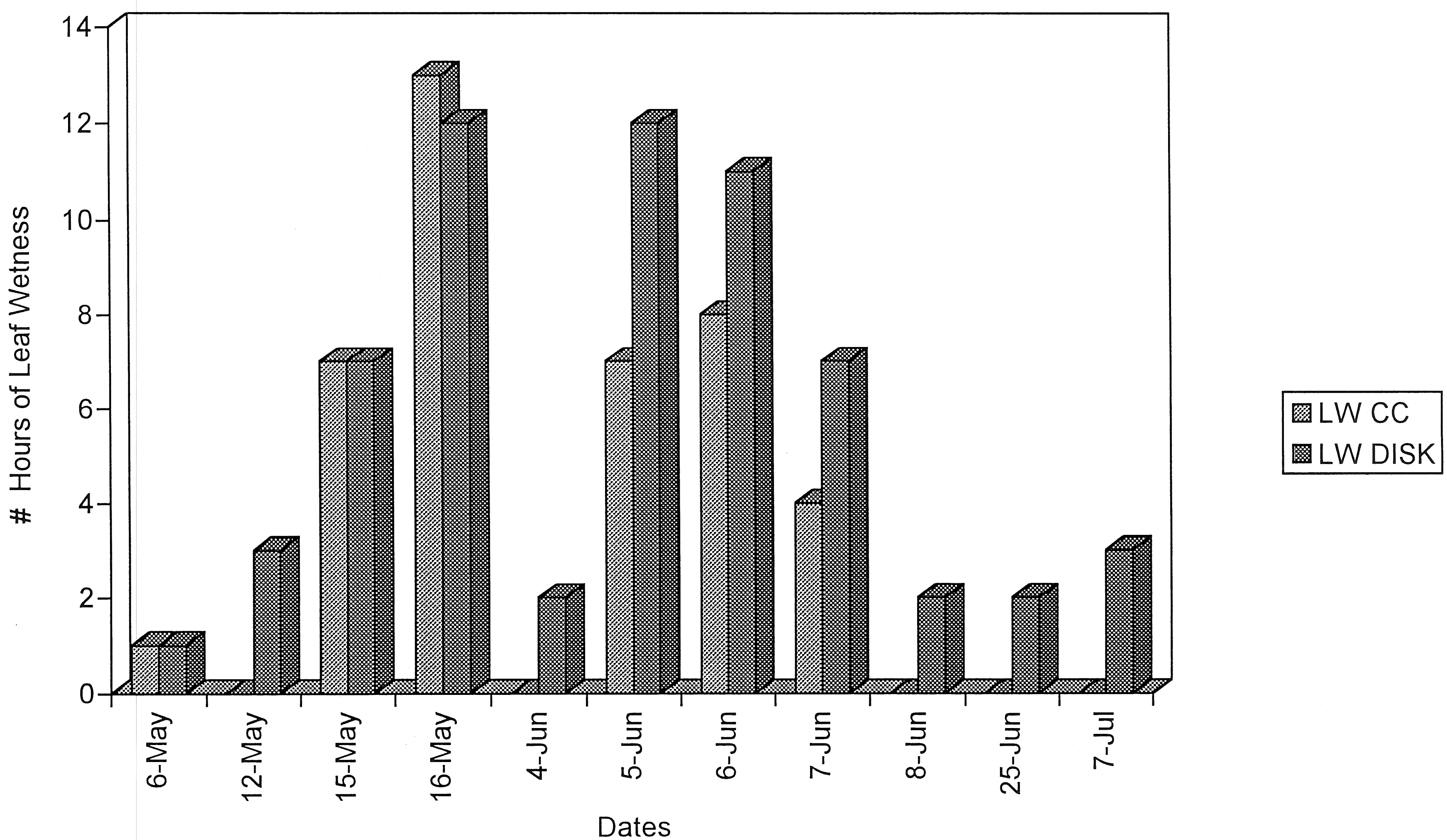

Fig. 3 Hours of Relative Humidity above 95%, Kern County 1996

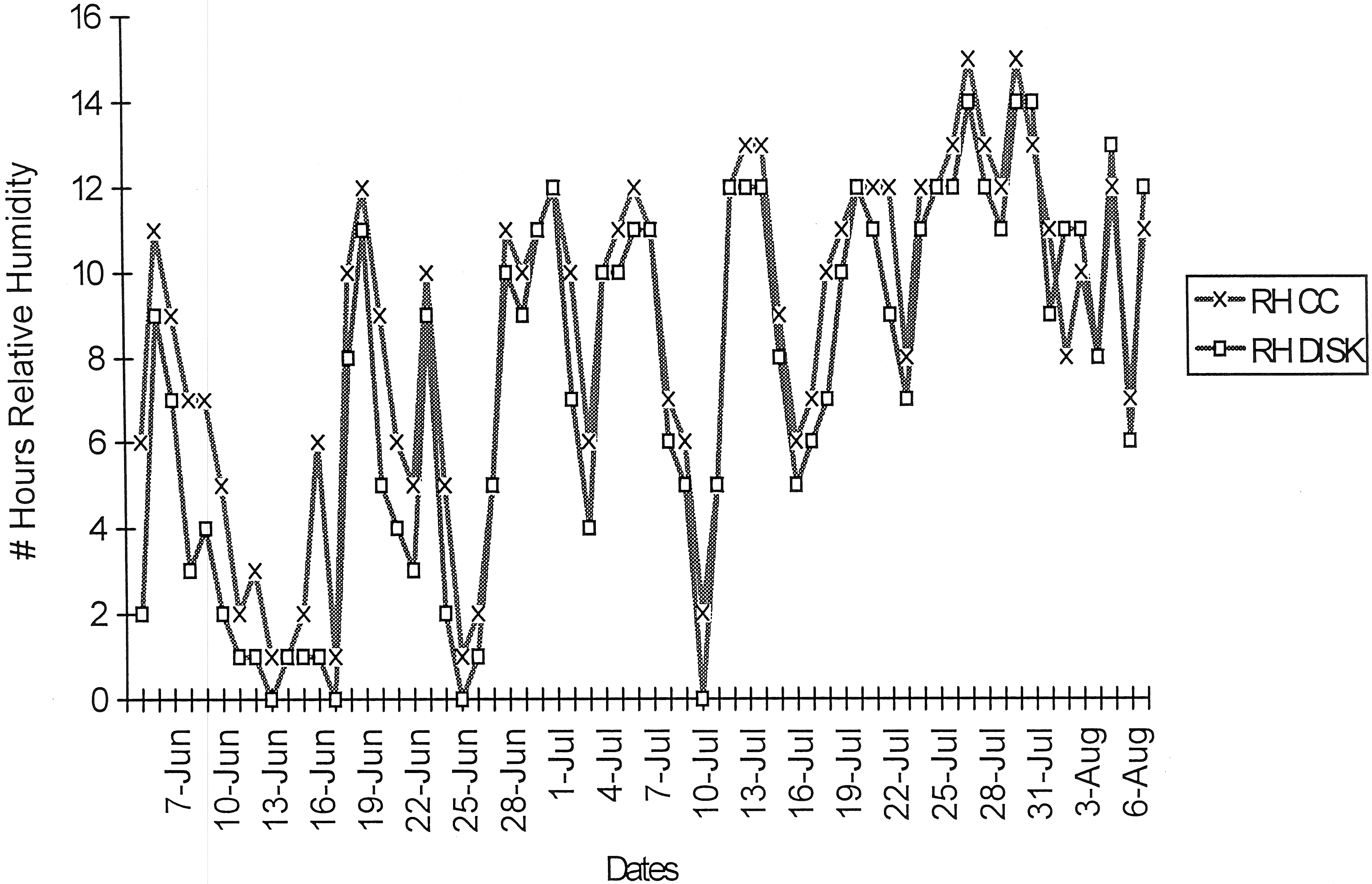

Fig. 4 Hours of Relative Humidity above 95%, Tulare County 1996

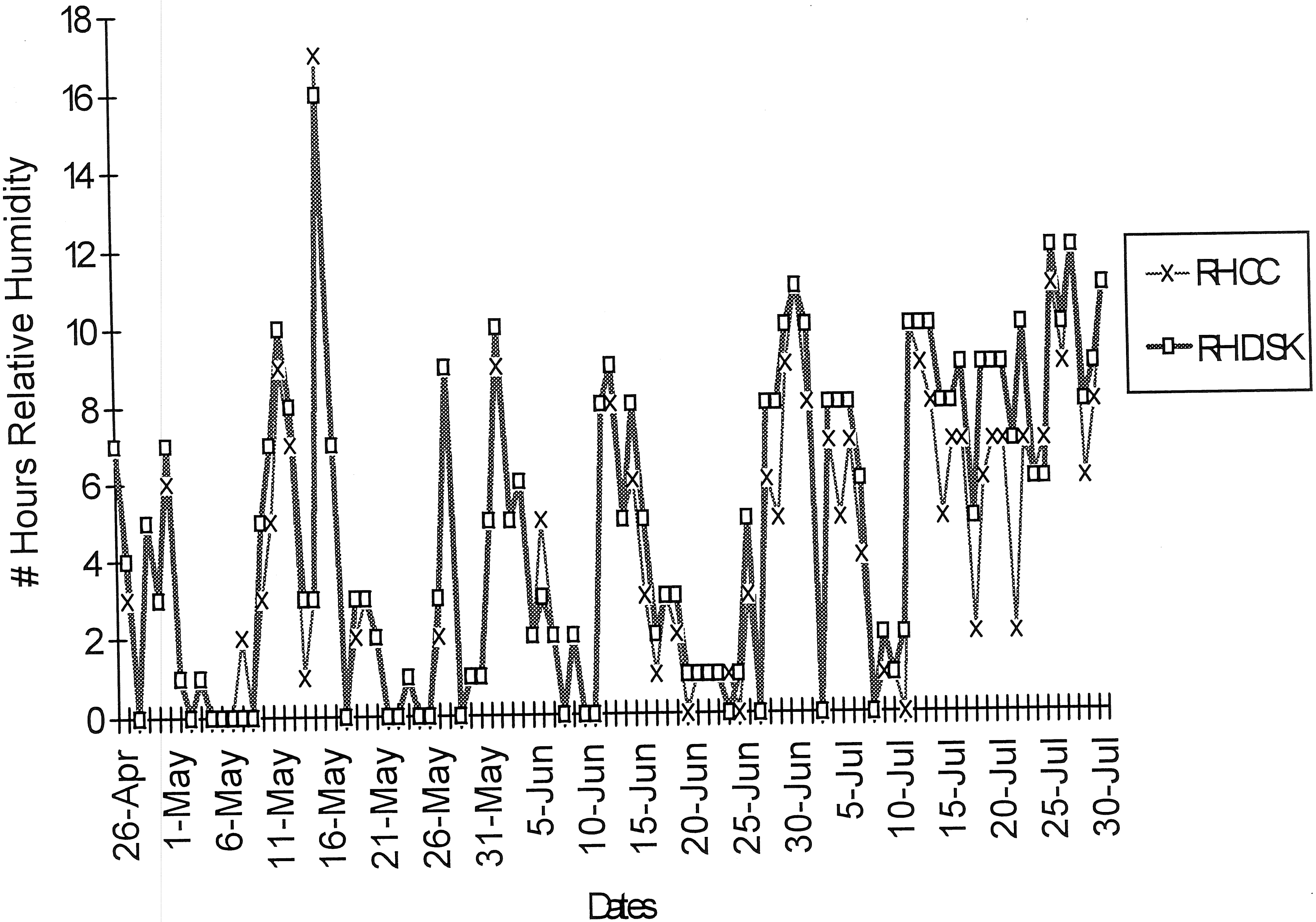

Fig. 5 Daily Maximum and Minimum Temperature in Degrees Celsius, Kern County 1996

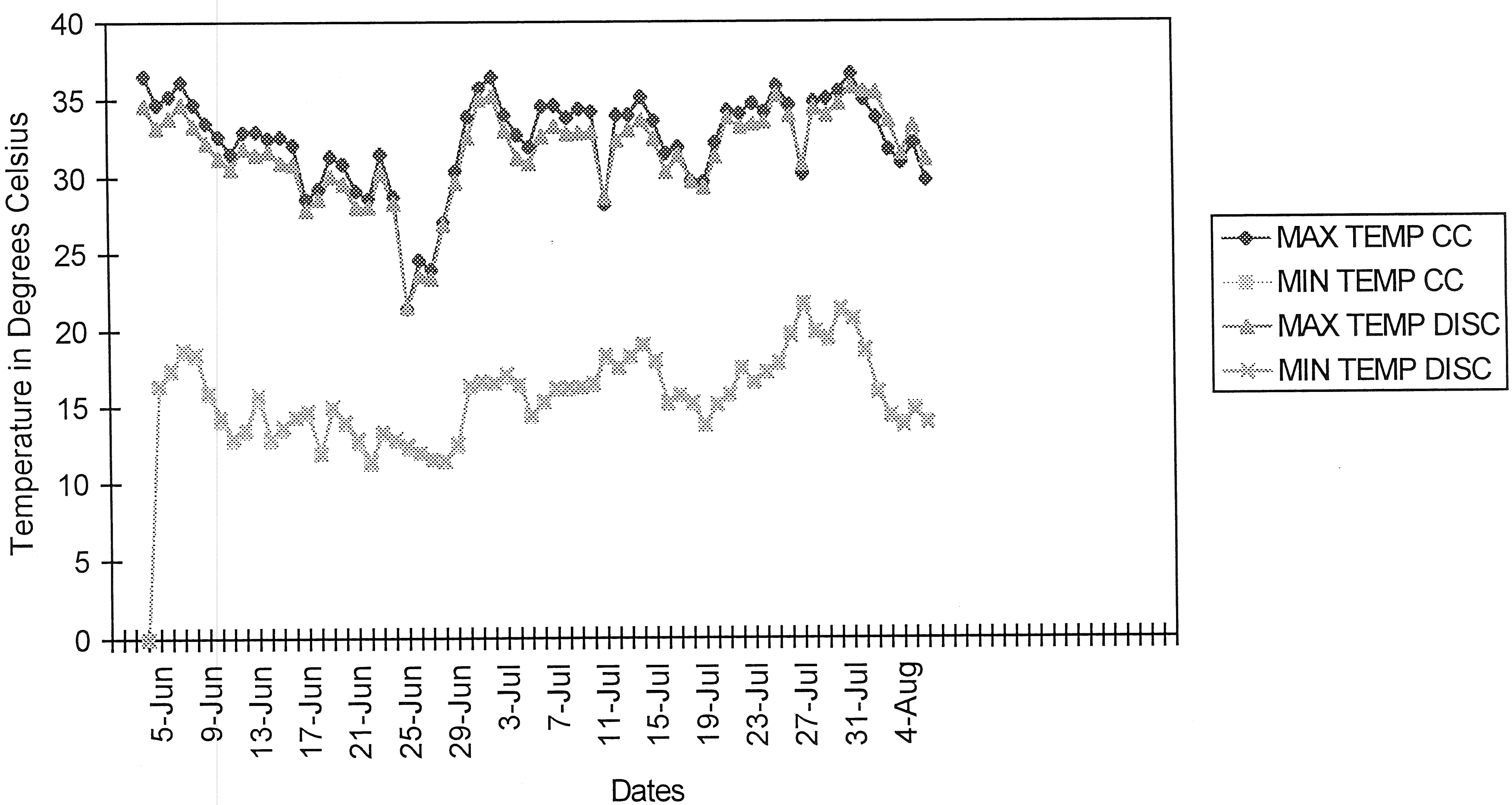

Fig. 6 Daily Maximum and MinimumTemperature in Degrees Celsius, Tulare County 1996