Relationship Between Fertilization and Pistachio Diseases

Themis J. Michailides, Plant Pathologist
Department of Plant Pathology
University of California, Davis, Kearney Agricultural Center
9240 S. Riverbend Ave., Parlier, CA 93648
(tel.: 559-646-6500; fax: 559-646-6593; e-mail: themis@uckac.edu)

Patrick Brown, Horticulturist
Department of Pomology
University of California, Davis
One Shields Ave., Davis, CA 95616
(tel. 530-752-0929; fax 530-752-8502; e-mail: phbrown@ucdavis.edu)

Zhonghua Ma, Postdoctoral Research Associate
Kearney Agricultural Center

David P. Morgan, Staff Research Associate
Kearney Agricultural Center

Dan Felts, Laboratory Assistant
Kearney Agricultural Center

Introduction:

Fertilization side effects, both good and bad, make it increasingly important to apply fertilizers as efficiently as possible. This is particularly true since the amounts of fertilizers applied can influence pathogens and insect pests of fruit and nut trees. It has long been recognized that nitrogen (N) fertilization affects not only the yield of plants but also levels of plant disease (Huber and Watson, 1974). Fertilization of pistachio trees from a very young age is routinely applied in commercial pistachio production in California. Botryosphaeria panicle and shoot blight caused by *Botryosphaeria dothidea* has become a disease of major importance for pistachios grown in California since the late 1980s. Initially only pistachios grown in the Sacramento Valley were affected but in 1995 and 1996, severe levels of the disease reduced yields and fruit quality in many orchards in the Central Valley. Botryosphaeria blight losses in the San Joaquin Valley were minimal in 1997 but continued to be severe in Sacramento Valley orchards. In 1998, the disease was very severe throughout pistachio plantings, except those in the southern part of Kern County and orchards west of freeway 99 in the Central Valley. Because Botryosphaeria blight attacks fruit clusters and kills them within a short time and because of the magnitude of the destruction this disease can cause, it may be considered the most serious threat to pistachio trees grown in California.

Alternaria late blight, caused by *Alternaria alternata*, is also a devastating disease which occurs annually in California pistachio orchards. This disease has caused significant losses to the industry in the last decade. Losses occur mainly because of early defoliation, which is often severe enough to cause difficulties during harvest as well as undesirable staining of fruit (Michailides & Morgan, 1991). According to pistachio growers, estimated losses up to $1,000 per acre have been reported in some orchards because of inferior nut quality caused by Alternaria late blight. Besides early defoliation and shell staining, invasion of kernels by *A. alternata* can result in moldy nuts (Doster & Michailides, 1999; Michailides & Morgan, 1991).

Pistachio growers use different amounts of fertilizers and follow various practices when they fertilize their orchards, and we raised the question, how do these different fertilization rates affect diseases in pistachios grown in California. In other words, we wanted to investigate the relationship between fertilization levels of the macronutrients (N, P, and K) and Ca and diseases in pistachios. Thus we investigated the effect of various nutrient elements and their levels on the susceptibility of pistachio to Botryosphaeria panicle and shoot blight and Alternaria late blight in greenhouse studies.

Objective:

Determine the effects of fertilization on pistachio diseases such as Botryosphaeria and Alternaria blights in greenhouse experiments.

Procedures:

Botryosphaeria panicle and shoot blight. The susceptible pistachio cultivar Kerman to Botryosphaeria blight was selected for greenhouse experiments. Potted, 2-year-old trees were obtained from a pistachio nursery for experiments in 1999 and experiment I in 2000. One-year-old trees were used in experiment II in 2000. Three levels of nitrogen (N), phosphorous (P), and potassium (K) elements were established by feeding 4-replicated potted trees with modified Hoagland solution (Hoagland, 1950) once per 2 weeks (1.0 liter per tree). Three levels of calcium were established by spraying 4-replicated trees with 0.1%, 0.2% and 0.4% $CaCl_2$ and $Ca(NO_3)_2$ (50ml per tree) for experiment I and II in 2000, respectively. After fertilizing the trees for 2 months, all trees were sprayed with 20,000 of spores /ml suspension of *B. dothidea*. To create conditions favorable for infection, the inoculated trees were covered with a plastic bag for 12 hours. The disease severity was assessed 15 days after inoculation. The following system was used for severity assessment: 0 = leaves without lesions, 1= lesion area less than one quarter of the leaf area, 2 = lesion area between one quarter and half of the leaf area, 3 = lesion area between half and three quarters of the leaf area, and 4 = lesion area greater than three quarters of the leaf area. The disease index (DI) for each tree was calculated using the formula:

$$DI = \left(\sum_{i=0}^{4} N_i * i \right) / \sum_{i=0}^{4} N_i$$

Where i is severity (0 to 4) and N_i is the number of leaves with the severity of i. Analysis of variance for DIs of pistachio trees affected by the different levels of fertilization was conducted using ANOVA of SAS.

Alternaria late blight. Similar to the Botryosphaeria blight experiments (1999/00 and 2000/01), the susceptible pistachio cultivar Kerman was selected for a greenhouse experiment to study the effect of fertilization on Alternaria late blight. Because Alternaria late blight requires senescing leaves in order to infect, this experiment was performed in August to October 2001 when leaves were fully mature and started senescing. Potted, 1-year-old Kerman pistachio trees were obtained from a nursery for the greenhouse experiments. Two levels of nitrogen (N) (25 and 100 mM), potassium (K) (25 and 100 mM), and Calcium (Ca) (12.5 and 50 mM) were established by spraying six replicated potted trees with NH_4NO_3, KCl, KNO_3, $CaCl_2$, or $Ca(NO_3)_2$. After fertilizing the trees once a week for 2 months, all trees were sprayed with 20,000 of spores /ml suspension of *Alternaria alternata*. To create conditions of high humidity favorable for infection, the inoculated trees were covered with a plastic bag for 12 hours. Two weeks after inoculation, leaf samples were collected from each tree and analyzed for latent infections using the OverNight Freezing Incubation Technique (ONFIT). Analysis

of variance for latent infections (number of lesions per leaf) by *A. alternata* on pistachio leaves among various treatments was conducted using ANOVA of SAS.

Results and conclusions:

Botryosphaeria panicle and shoot blight. In 1999, there were no significant differences among the percentages of infected leaves among the various treatments. However, the 200 % K treatment significantly reduced severity of Botryosphaeria blight on pistachio leaves as compared with the normal fertilization (100% N, P, K) (Table 1). These results showed that nutritional stress did not increase the incidence of Botryosphaeria disease as compared with the normal nutrition level. This could be because of either sufficient amounts of N, P, and K were stored in the potted trees in the first year or probably because of not enough nutritional stress was established by applying these treatments.

For experiment I in 2000, although there were no significant differences ($F = 1.82$, $P = 0.1193$) (Table 2) in disease index (DI) among the various treatments, the DI of 200% K treatment was reduced by almost 30.0% as compared to that of the control treatment (100% each of N, P, and K). In this experiment, 2.0% and 4.0% $CaCl_2$ were phytotoxic to pistachio, thus, $Ca(NO_3)_2$ was used instead of $CaCl_2$ in experiment II in 2000. In experiment II, the disease index (DI) of 200% K treatment was reduced significantly ($P < 0.05$) by 27.3% as compared to that of the control treatment, and the DIs of the trees sprayed with 0.10%, 0.20%, and 0.40% $Ca(NO_3)_2$ were reduced significantly ($P < 0.05$) by 33%, 24%, and 19%, as compared to that of the control treatment, respectively (Table 2).

Alternaria late blight. The results from the greenhouse experiments showed that the severity of Alternaria late blight on pistachio was not affected by applying potassium nitrate or potassium chlorite. However, the disease was reduced significantly by eight sprays of 100 mM of nitrogen, applied either as NH_4NO_3 or $Ca(NO_3)_2$ (Fig. 1). Calcium chlorite at 50 mM or potassium nitrate at 100 mM rates showed trends towards reducing the number of latent infections of *A. alternata* per leaf of pistachio as compared to the control trees. But eight applications of $CaCl_2$ at 50 mM or KCl at 100 mM rates caused phytotoxicity to 1-year-old pistachio trees in these experiments.

The general conclusion from these experiments thus far on the effects of fertilization on Botryosphaeria blight is that fertilizing trees with high levels of potassium or spraying trees with calcium nitrate can reduce the severity of Botryosphaeria panicle and shoot blight. In addition, nitrogen (applied either as NH_4NO_3 or $Ca(NO_3)_2$) fertilization can reduce latent infections of Alternaria late blight and subsequently late blight disease of pistachio. This is in contrast to other studies on other crops where increased nitrogen fertilization increased disease. For instance, increasing nitrogen fertilization of nectarines increased brown rot disease caused by *Monilinia fructicola* (Daane et al. 1995).

A current objective of this study is to analyze plant tissues for disease resistance/susceptibility compounds. Thus frozen leaf samples from each replicated tree in each treatment are being analyzed for disease resistance/susceptibility compounds.

Acknowledgment. We thank Steve Sibbett, UC Cooperative Extension, Tulare County, Brent Holtz, UC Cooperative Extension, Madera County, and Robert Beede, UC Cooperative Extension, Kings County, for their cooperation in this project.

References

Daane, K. M., Johnson, R. S., Michailides, T. J., Crisosto, C. H., Dlott, J. W., Ramirez, H. T., Yokota, G. Y., and Morgan, D. P. 1995. Nitrogen fertilization affects nectarine fruit yield, storage qualities, and susceptibility to brown rot and insect damage. California Agriculture 49(3):13-18.

Doster, M. A., and Michailides, T. J. 1999. Relationship between shell discoloration of pistachio nuts and incidence of fungal decay and insect infestation. Plant Disease 83:259-264.

Huber, D. M. and Watson, R. D. 1974. Nitrogen form and plant disease. Annu. Rev. Phytopathol. 12:139-165.

Michailides, T. J., and Morgan, P. D. 1991. An integrated approach for control of late blight caused by *Alternaria alternata* and management of mycoflora of pistachio through manipulation of irrigation practices. Calif. Pistachio Industry Annual Report, Crop Year 1990-91. pp. 59-65.

Table 1. Effects of nutrition stress on Botryosphaeria panicle and shoot blight in a greenhouse experiment in 1999.

Treatment	Infected leaves %[x]	Leaf disease index[x]
75% N	64.4 a[y]	0.90 ab[y]
75% P	60.4 a	0.95 a
75% K	62.7 a	0.83 ab
100% N,P,K	58.8 a	0.87 ab
200% N	60.1 a	0.80 abc
200% P	57.3 a	0.71 bc
200% K	54.3 a	0.58 c

[x] Data in columns presented are the average of two experiments since results from these experiments were similar.

[y] Values with common letters are not significantly different at $P = 0.05$ level according to a LSD test.

Table 2. Effects of nutritional stress on Botryosphaeria panicle and shoot blight of pistachio caused by *Botryosphaeria dothidea* in a greenhouse study in 2000.

Treatment	Disease index (DI)
Experiment I	
CK (100% N, P, K)	0.75[x] (±0.28)[y] a[z]
50% N	0.91 (±0.28) a
200% N	0.53 (±0.17) a
50% P	0.89 (±0.42) a
200% P	0.60 (±0.09) a
50% K	0.73 (±0.15) a
200% K	0.52 (±0.10) a
0.1% $CaCl_2$	0.57 (±0.15) a
0.2% $CaCl_2$	0.53 (±0.18) a
Experiment II	
CK (100% N, P, K)	0.47 (±0.11) abc
50% N	0.49 (±0.05) ab
200% N	0.44 (±0.10) abcd
50% P	0.53 (±0.10) a
200% P	0.40 (±0.06) bcde
50% K	0.48 (±0.09) abc
200% K	0.34 (±0.03) de
0.1% $Ca(NO_3)_2$	0.32 (±0.06) e
0.2% $Ca(NO_3)_2$	0.36 (±0.05) de
0.4% $Ca(NO_3)_2$	0.38 (±0.06) cde

[x] The data presented are the average of four replicated trees.

[y] Numbers in (±) denote standard errors.

[z] Values in columns for each experiment followed by the same letter are not significantly different according to LSD of SAS test at $P = 0.05$.

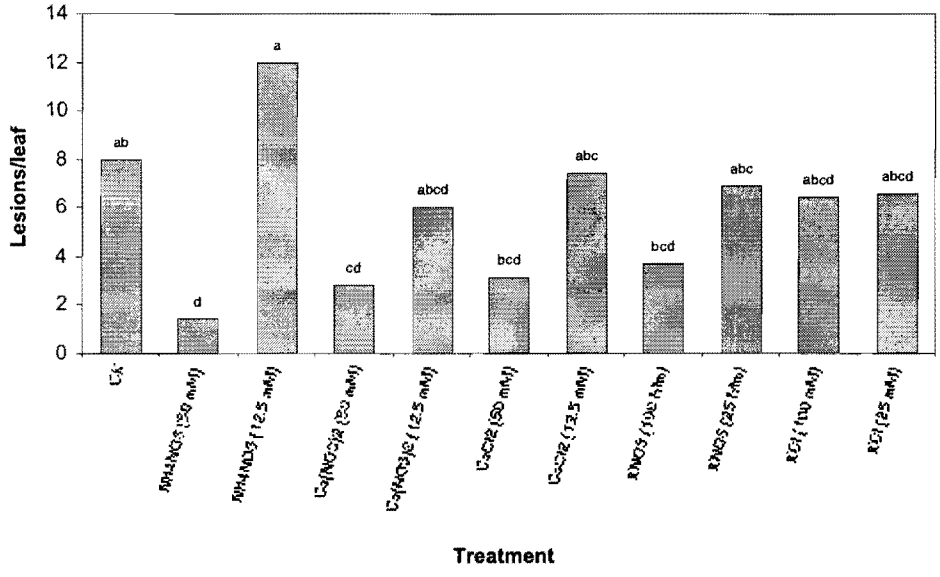

Figure 1. Effects of nutrition on Alternaria late blight of pistachio caused by *Alternaria alternata* in greenhouse experiments. Bars topped with different letters are significantly different at $P = 0.05$ level according to LSD test.