Almond Culture and Orchard Management

Final Report June, 2005

Project No.:

Project Leader: Roger Duncan, UC Cooperative Extension, Stanislaus County

Project Cooperators: John Edstrom, UCCE Colusa County; Brent Holtz, UCCE Madera County; Franz Niederholzer, UCCE Sutter and Yuba Counties & Mario Viveros, UCCE Kern County

1) Yield Comparisons for Differing Almond Orchard Planting Arrangements

Roger Duncan, UCCE Farm Advisor, Stanislaus County

It is generally believed that fertilization will be improved if three or more varieties are present in an almond orchard. While three varieties offers the advantage of potentially increased yields in some years over orchards that have only two varieties, this planting arrangement also requires a third harvest operation. In Stanislaus County, most almond growers farm twenty or fewer acres. These growers feel they must choose between the potentially lower yields of planting only two varieties or the added difficulty and expense of hiring custom operators to harvest their small acreage three times.

A University of California field trial in the Sacramento Valley has demonstrated that alternating two varieties down the same row can increase yields over a standard planting arrangement of alternating rows of two varieties. However, it is not known whether alternating two varieties down the row can produce yields comparable to orchards where three varieties are planted in a standard arrangement. If so, growers of small acreage could grow just two varieties without having to settle for lower yields.

In 2000, an 8.5 acre almond orchard was planted on the Modesto Junior College student training farm to compare yields of the following three planting arrangements:

1. Alternating rows of Nonpareil (50%) & Carmel (50%) varieties.
2. Alternating rows of Carmel (25%), Nonpareil (50%) and Monterey (25%).
3. Nonpareil (50%) and Carmel (50%) trees alternating down the same row.

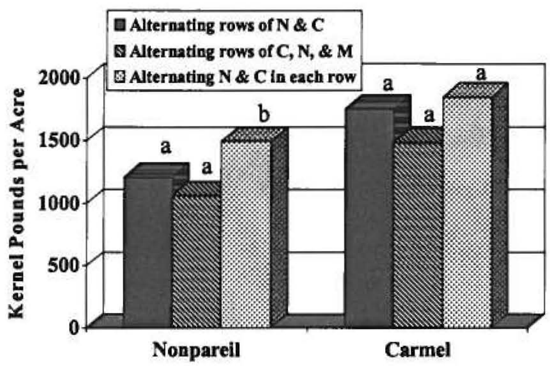
Trees are planted in an 18' x 22' spacing (110 trees per acre) and microsprinkler irrigated. Each planting configuration is five rows wide and 14 or 15 trees long.

Results:

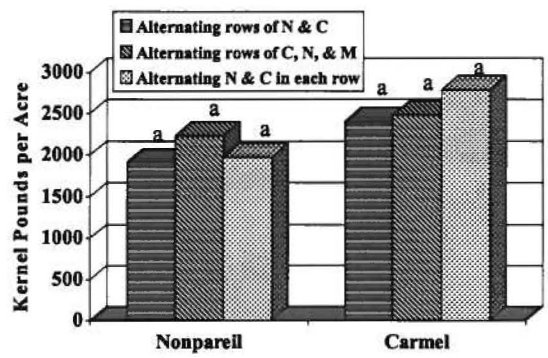
Yields in this plot were recorded in 2003 (fourth-leaf) and 2004 (fifth-leaf). In 2003, weather conditions were generally very good through most of the bloom period for all three varieties. In 2004, a cool rain storm occurred during the early Nonpareil bloom period but weather was very favorable for the second half of Nonpareil bloom and most of the Carmel and Monterey bloom period.

In 2003, Nonpareil yield was significantly higher where Nonpareil & Carmel trees were alternated down the same row. There were no differences in Nonpareil yield between the other two planting arrangements. Carmel yield was statistically similar for all three planting arrangements. In 2004, there was no clear yield advantage to any of the three planting arrangements for Nonpareil or Carmel.

Yield Comparison of Three Planting Configurations for Nonpareil and Carmel Almonds, 4th leaf



Yield Comparison of Three Planting Configurations for Nonpareil and Carmel Almonds, 5th leaf



If growers choose to alternate varieties down the same row, they must either plant varieties that can be harvested together or care must be taken to plant varieties with harvest periods that are sufficiently different from each other. Mixing varieties at harvest can result in severe pricing penalties.

2) Yield Benefits of Machine Hedging Almonds in a Marianna 2624 Hedgerow

John Edstrom, UC Farm Advisor and Stan Cutter, Nickels Estate

Marianna 2624 plum rootstock is the most useful rootstock for Oak Root Fungus sites, but it also shows good resistance to crown gall and has become increasingly important in the expansion of almonds onto the heavier soils. Tree size is reduced significantly with M2624 when compared to all other almond rootstocks, so maintaining vigor and productivity has been a concern. Union Mild Etch, graft union disorder with M2624 has been a problem in some orchards. Mission, Ruby and Padre varieties have shown excellent compatibility with M2624, but field performance of Butte has been erratic. Evaluating the commercial potential of M2624 plantings requires closer spacings than typically used in almonds, resulting in more trees and higher investment expenses.

A test planting was established to check the productivity of four varieties in a close-planted hedgerow on M2624 rootstock. All trees were obtained as certified virus free (scion and root) to remove the virus affects. Commercially harvestable replications were designed into the test to collect yield data. Butte, Mission, Ruby and Padre almonds were planted March, 1989, under drip irrigation, in single north south rows with a 10' x 20' spacing for 218 trees/acre.

A mechanical hedging program was initiated 6 years ago (1999) to stimulate growth and fill in the canopies between rows. Alternate sides of alternate rows were cut each winter. A rotary saw topper made an angled cut on the shoulder of the canopy, positioned 2 feet from tree top center and angled 30 degrees down into the row middles. One side of all Ruby and Butte rows were cut the first time. The next winter all Padre and Mission rows were cut. Four winters were required to complete the hedging plan in 2002-03.

All varieties responded well to this operation. Of special interest were Ruby and Butte, the weakest trees in this test. Ruby trees produced 2-5 shoots at each saw cut, which grew 24-36 inches in length during the season. Buttes grew 3-6 shoots at each cut, which grew 24-48 inches. Invigoration of the Padre and Mission was somewhat greater.

Results

Yields last year were extraordinary and likely reduced production for 2004. Yields this year were 1574 lbs/acre for Butte, 1942 for Mission, 1673 for Ruby and 2381 lbs. per acre for Padre. The planting has averaged about 2000 lbs per acre per year during the duration of the test.

Of importance to note in this six acre planting is the 100% tree survival rate spanning 16 years of this test. An adjacent orchard of the same age/same variety on Lovell peach rootstock has lost 5-10% of the trees to various maladies, while this M2624 rooted block remains solid. In this respect, under these conditions, Marianna 2624 rootstock exhibits a very desirable trait. Even though all Butte trees have survived on M2624, this variety continues to produce less than when grafted to Lovell as found in the adjacent block.

Tree size measurements show that Padre trunks are the largest, at 76 cm circumference followed by Butte at 75 cm, Mission at 66 cm and Ruby at 57 cm. Union mild etch has not afflicted this planting but persistent root suckers have been some what difficult to manage.

Tree canopies in the unhedged rows filled in the 20-foot row spacing in 2002. Hedging actually delayed the canopy extension by stimulating more up-right growth that required two years of cropping to bend and touch in the middles. The hedging program stimulated growth, which formed more fruitwood. Hopefully this will result in increased production. However, so far, no difference in yield has been found between hedged and unhedged trees.

Variety	Yield Lbs/ac	Kernel Size gms/K
Padre	2,344	0.79
Butte	1,574	0.79
Mission	1,942	1.02
Ruby	1,673	0.87

3) Processed-Kaolin Particle film on almond

Brent A. Holtz[1] and Eric W. Hoffman[2]
Pomology Farm Advisor[1] and Staff Research Associate[2]
University of California, 328 Madera Avenue, Madera CA 93637, USA

Surround, a white clay like processed-Kaolin particle film, can easily be dissolved into suspension and sprayed onto trees. Several research reports have been published in the Journal American Society Horticultural Science and HortTechnology describing how this reflective film can reduce heat stress, reduce solar injury, increase leaf carbon assimilation, and reduce canopy temperatures on a number of crops in several countries (1, 2, 3). In 2001 processed-Kaolin particle film was applied to 15 year old Nonpareil, Sonora, and Carmel almond trees in a preliminary experiment. Three in-season applications of Kaolin appeared to result in more return bloom, nut set, and yield on Carmel trees in 2002 when compared to non-sprayed Carmel trees (4). The Carmel trees in this orchard were showing symptoms of severe bud failure. The Sonora and Nonpareil varieties appeared unaffected by the Kaolin. Record hot temperatures were experienced in the San Joaquin Valley in May 2001 and above normal temperatures at this time have been shown to worsen the severity of bud-failure on Carmel (Dale Kester).

In 2003 and 2004, four applications of Kaolin (25 lbs/100 gallons water) were made each year to Carmel trees planted in January 2002 in order to examine if Kaolin could reduce heat stress and the onset of bud failure. We also examined the effect of Kaolin on tree carbon assimilation, canopy temperatures, tree growth, and yield. An almond orchard in Madera with 16 Carmel rows was divided into a replicated design where 8 rows received four Kaolin applications in each year. Mid-day leaf stem water potential, tree circumference, and current season shoot growth were examined.

In 2003 and 2004 mid day leaf stem water potential measurements were performed once a month from June-September. In 2003, June and July mid day leaf stem water potentials were significantly less on Surround treated trees when compared to non-treated trees. In August and September there was no difference between Surround and non-treated trees (5). In 2004, mid day leaf stem water potentials of Surround treated trees were significantly less when compared to non-treated trees in June, July, and August (figure 1). By September there was no difference between Surround and non-treated trees.

In 2003 and 2004 the Surround treated trees had significantly more current season shoot growth when compared to non-treated trees (figure 2). But there was no difference in truck circumference between the two treatments in either 2003 or 2004. In 2004 we counted fruit on 60 trees that had received Surround and 60 control trees. We found no difference in the numbers of fruit per treatment. We will again repeat the application of Kaolin in 2005 in order to investigate the effect of Surround on heat stress and bud failure in both Carmel and Nonpareil varieties.

Acknowledgement: The project would not have been possible without the cooperation of George Andrews Farms in Madera, CA.

Literature:

1) Glenn, D.M., Prado, E., Erez, A., Mc Ferson, J., and Puterka, G.J. 2002. A reflective, processed-Kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple. J. Amer. Soc. Hort. Sci. 127(2):188-193.
2) Glenn, D.M., Puterka, G.J., Drake, S.R., Unruh, T.R., Knight, A.L., Baherle, P., Prado, E., and Baugher, T.A. 2001. Particle film application influences apple leaf physiology, fruit yield, and fruit quality. J. Amer. Soc. Hort. Sci. 126(2):175-181.
3) Schupp, J.R., Fallahi, E., and Chun, I.J. 2002. Effect of particle film on fruit sunburn, maturity, and quality of "Fuji" and "Honeycrisp" Apples. HortTechnology 12(1):87-90.
4) Holtz, B.A. 2002. Bud failure or crazy top–the curse of the Carmel, the effect of Surround on Carmel return bloom, hull rot on almonds and field meeting, variety update. *The Pomology Post*, Vol. 37, May, 8 pages.
5) Holtz, B.A, and Hoffman, E.W. 2003. Processed-Kaolin particle film on almond. Almond Board of California, 31st Almond Industry Conference Proceedings 35-36.

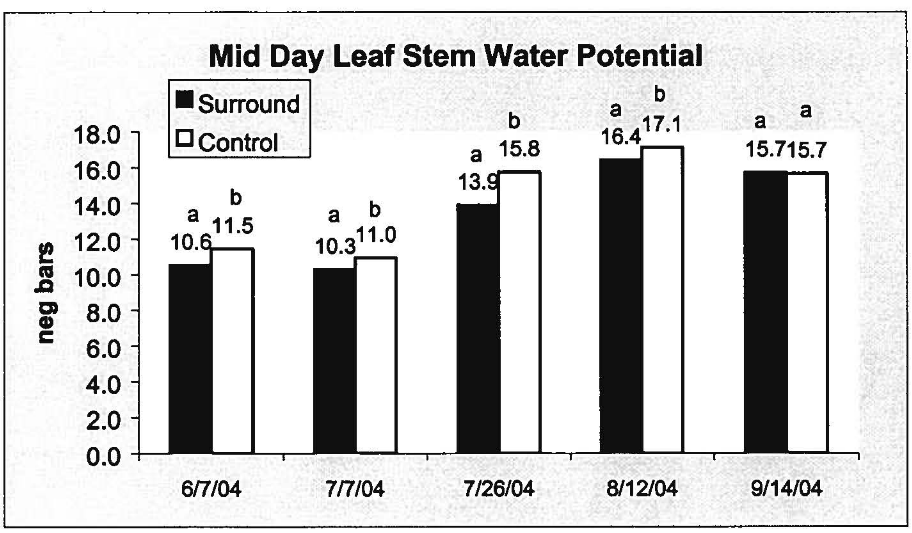


figure 1. Paired columns within the date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

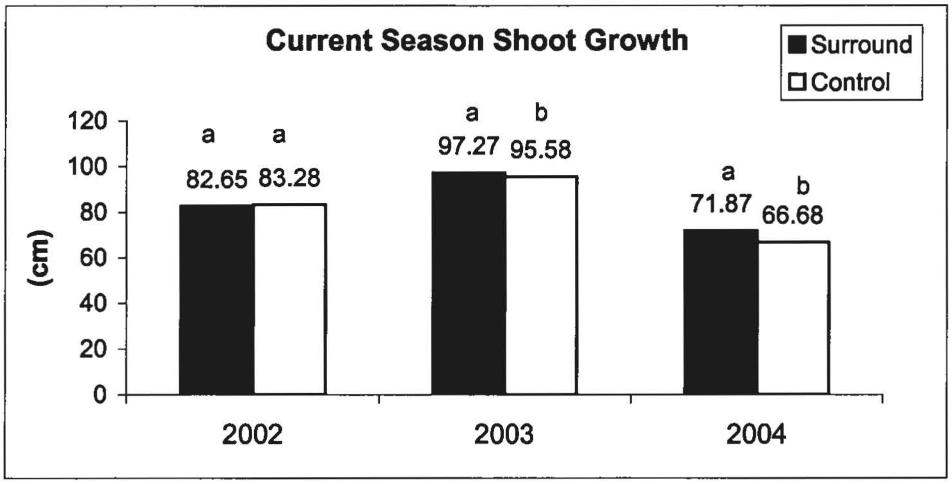


figure 2. Paired columns within the date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

4) Is there a cost effective, alternative to Zn sulfate for fall defoliation?

Franz Niederholzer, UCCE Farm Advisor, Sutter and Yuba Counties

Objective: Evaluate alternatives to high rates of Zn sulfate (36%) for fall almond orchard defoliation.

Introduction: A zinc (Zn) sulfate foliar spray in the fall to treat Zn deficiency has been a common orchard practice for more than half a century. This spray also helps defoliate trees reducing the potential for tree blow-over and facilitating early pruning. However, a fall Zn sulfate spray is relatively expensive – primarily because it is usually applied alone, as other materials are not compatible with 20-30 pounds of Zn sulfate per 100 gallons of water that are commonly applied.

Recent production research results, food quality challenges, advances in fertilizer formulation, and possible review of fertilizer Zn use by regulatory agencies point to the need to evaluate postharvest spray options for almond orchards. Less phytotoxic foliar Zn materials have been developed, and can be tank-mixed with early season fungicides. Foliar boron (B) applications can, where needed, consistently improve almond yield, but several B spray formulations are not compatible with even 20 pounds of Zn sulfate/100 gallons of water. Food quality is now a major concern for the almond industry, and the postharvest/prebloom window is a good timing for "clean up" sprays if needed and/or beneficial. Finally, Zn is toxic to fish, and its agricultural uses, especially at high rates, may soon be reviewed by regulatory agencies. However, since tree blow-over can be a problem in some almond growing areas, it could be beneficial to find a cost-effective, environmentally "soft" alternative defoliant that can be tank-mixed with boron and may have activity on microorganisms.

Materials and methods: Two rates of sodium chlorate or pyraflufen ethyl, commercial cotton defoliants with low environmental impact potential, along with differing rates of Zn sulfate and/or urea solutions, were applied to almond nursery stock ('Price' on 'Lovell") on November 17-18, 2003 using a backpack sprayer. Spray was applied to runoff. Defoliation was visually assessed 20 days after spray application, and digital photos of each treated tree were taken.

In December, 2003, study trees were lifted and placed in commercial cold storage. In April, trees were planted into 5 gallon pots containing commercial potting mix to assess possible growth differences following defoliation treatments. Trees (tops and/or roots) were not pruned at potting. Trees were kept outside, irrigated, but not fertilized, from planting until late July, 2004. Trees were destructively harvested in late July. Trees were cut in half at the bud-union and the rootstock discarded. Scion tissue was separated into leaves, current year shoots, and woody tissue. These materials were dried at 65°C in forced air ovens, and dry weights were then measured. Leaf samples per analyzed for nitrogen (N), sulfur (S), and Zn for representative trees of all treatments except the pyraflufen ethyl treatments.

Results: Sodium chlorate, at either rate, effectively defoliated nursery stock trees. Standard-grade urea did not defoliate study trees, while pyraflufen ethyl did not defoliate trees and caused significant shoot die-back (data not presented).

Treatment with urea, Zn sulfate, or sodium chlorate in the fall, 2003 did not affect growth in spring/summer, 2004, with the exception of the high rate of Zn sulfate (30 pounds of Zn sulfate/100 gallons of water), which caused significantly more die back than the other materials (Table 1).

No significant differences (at 5% or 10% level) in summer leaf N concentrations were measured for all treatments (Table 1), excluding pyraflufen ethyl treatments, which were not measured. Trees sprayed with Zn sulfate treatments in the fall, 2003, showed elevated leaf Zn concentrations the following summer (Table 1). July, 2004 leaf S concentrations were significantly higher ($p>10\%$) for trees treated with high Zn sulfate rate and Zn sulfate plus 1% urea and non-ionic surfactant, but not for those treated with Zn sulfate alone at a rate of 15#/100 gallons of water (Table 1).

Conclusions: The success, using nursery trees, of sodium chlorate as a defoliant of almond trees indicates that further work with this material maybe warranted. Further work with pyraflufen ethyl as a defoliant in almond trees is not planned.

Commercial formulations of sodium chlorate include urea as a fire retardant, and the trend of elevated leaf N concentrations in sodium chlorate treated trees compared with control may indicate some N uptake into almond leaves before defoliation. If this speculation is accurate, then sodium chlorate may prove to be an effective defoliant that can be tank-mixed with key nutrients in almond production (N and B).

Further work using field grown trees is planned, as nursery trees and potted plants may not represent mature trees under field conditions. Finally, the elevated leaf Zn concentrations in July, 2004 leaf samples are consistent with research results indicating that foliar zinc absorption occurs by diffusion and is concentration dependent. The increase in July, 2004 leaf S concentrations appears to suggest that fall Zn sulfate sprays may have an additional benefit to growers in addition to Zn nutrition. However, if these results (Table 1) can be applied to established orchards, there may be a risk of some tissue damage when high rates of Zn sulfate (30#/100 gallons of water) are used.

Table 1. Treatments (materials and rates) applied for chemical defoliation of 'Price' almond on November 17-18, 2003, and treatment performance evaluation and measurements between December, 2004 and July, 2004. Values followed by the same letter are not significantly different based on analysis of variance and Bonferroni's multiple comparison procedure (p>10%).

Treatment	Material rate/100 gallons of water	Effective Leaf Drop?	% Dead wood[1]	% extension growth[2]	% Leaf N July, 2004	% Leaf S, July, 2004[3]	ppm Leaf Zn, July, 2004[4]
Control	Water only	No	0.4 ab	18 a	2.00 a	0.22 a	20 a
Standard grade urea	80 # urea	No	0.2 a	16 a	2.22 a	0.25 ab	20 a
Zinc sulfate (36%)	30 # zinc sulfate	Yes	2.5 b	22 a	1.94 a	0.35 bc	63 c
Zinc sulfate (36%)	15 # zinc sulfate	Yes	0.4 ab	18 a	2.10 a	0.23 a	37 bc
Zinc sulfate (36%) + standard grade urea + NIS*	15 # zinc sulfate + 8 # urea + 1 pint R-11®	Yes	0.2 a	14 a	2.15 a	0.35 c	32 ab
Sodium chlorate – 6# a.i./gallon	1.25 gallons	Yes	0.3 ab	15 a	2.31 a	0.26 abc	23 ab
Sodium chlorate - 6# a.i./gallon	3.75 gallons	Yes	0.3 ab	13 a	2.23 a	0.28 abc	20 a
Pyraflufen ethyl (0.208 # a.i./gallon)	3.33 oz	No	ND	ND	ND	ND	ND
Pyraflufen ethyl (0.208 # a.i./ gallon)	9.16 oz	No	ND	ND	ND	ND	ND

1. (dead wood weight/total live wood weight)*100 -- measured in July, 2004
2. (current year shoot + leaves/living 2nd year wood)*100 -- measured in July, 2004
3 Non-ionic surfactant
4 Data are the back transformed weighted means from the $\log_{10}$ transformed raw data.

5) Pellicle Ink-Staining

Mario Viveros, UCCE Farm Advisor, Kern County

Inking of the pellicle of the Sonora variety has been a problem in almond orchards in recent years. The inking is only found on the pellicle and not on the endosperm. However, it has been considered as a defect in the Indian and Chinese markets. The staining has been bad enough that some brokers have been forced to sell Sonoras at a discount.

The pellicle ink-staining on Sonoras is widespread in the San Joaquin Valley. At this time, however, the causes are not known. There have been some suggestions that fungal infections may play a part. However, pellicle ink-staining can be found in June before hullsplit takes place.

It has been observed that the worst ink-staining occurs in high temperature years. Therefore, water management may play a role in ink-staining development in susceptible varieties. To determine if irrigation systems play a role in pellicle ink-staining in susceptible and non-susceptible varieties, orchards containing Sonora and Nonpareil under different irrigation systems were selected. Twenty-five nut samples per tree, per variety were taken every week during hullsplit. The irrigation systems selected were flood, single drip hose, subsurface, fan-jet solid set, sprinkler and double drip hose.

Each nut was cut open and placed into three categories. One, small ink-staining nuts were those with one or more dots on the surface of the pellicle. Two, medium ink-staining nuts were those that contained dark areas that covered up to one-quarter of the kernel surface. Three, large ink-staining nuts were those that contained dark areas that covered more than one-quarter of the kernel surface. The results of both Nonpareil and Sonora can be found in tables one and two.

Table 1. Nonpareil nuts (out of 25) showing degrees of ink-staining from different irrigation systems.

Irrigation Systems	Hullsplit	Small	Medium	Large
Flood	10.9 a	10.0 bc	1.0 b	0.0 a
Single Hose Drip	13.1 ab	12.1 c	0.2 a	0.1 a
Sub-surface Drip	15.9 bc	8.5 b	1.0 b	0.1 a
Fan-jet	21.1 cd	3.0 a	0.1 a	0.0 a
Sprinkler	20.6 d	9.0 b	0.0 a	0.0 a
Double Hose Drip	21.8 d	12.4 c	0.5 ab	0.0 a

*Numbers within a column that are followed by the same letter are not significantly different from each other.

Table 2. Sonora nuts (out of 25) showing degrees of ink-staining from different irrigation systems.

Irrigation Systems	Hullsplit	Small	Medium	Large
Flood	5.0 a	5.6 a	3.4 cd	6.6 c
Single Hose Drip	3.4 a	6.5 ab	3.5 cd	6.4 c
Sub-surface Drip	7.1 a	6.8 ab	2.7 bc	5.0 bc
Fan-jet	15.0 b	7.9 b	0.6 a	0.4 a
Sprinkler	17.0 b	11.7 c	1.8 b	3.9 b
Double Hose Drip	17.5 b	12.0 c	4.3 d	5.7 bc

*Numbers within a column that are followed by the same letter are not significantly different from each other.

The data shows that ink-staining can also occur in Nonpareil. The majority occurs in the small category. In this category, the Fan-jet irrigation system has less ink-staining nuts than any of the other irrigation systems. The highest amount of ink-staining took place in flood, single hose drip and double hose irrigation systems. In the case of Sonora, ink-staining occurred in all categories. The Fan-jet irrigation system produced less ink-staining nuts in the medium and large categories. In the small category, this irrigation system produced less ink-staining nuts than sprinkler and double hose drip.

In conclusion, the data shows that ink-staining is related to the orchard's irrigation system. The Fan-jet produced significantly less ink-staining nuts in both Nonpareil and Sonora varieties. In contrast the double hose drip produced significantly more ink-staining nuts than any other irrigation system.