Characterization and Management of Almond Dormant Bud Drop

Final report to the Almond Board - May, 2001

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Objective: To test several fertilizers, nematicides, copper sprays, and organic, inorganic and microbiological soil amendments for reduction in almond dormant bud drop.

Introduction.

Dormant bud drop has emerged as a serious problem in some Northern San Joaquin Valley almond orchards. In years when bud drop is severe, up to 100% of the fruitful and vegetative buds fail to swell on severely affected trees. Although buds appear healthy in the fall, they remain tightly closed through the winter and often begin falling from the tree by normal bloom time. Terminal leaf buds grow normally which results in willowy shoots with blind wood in these chronically affected trees. Dormant bud drop not only reduces the current season's yield, but also results in long term losses due to lack of spur and lateral shoot development. Carmel appears to be the variety most severely affected, but bud drop can also be severe in Wood Colony, Price, Butte, Mission, Fritz, and Nonpareil.

The cause of bud drop is still unclear. A preliminary survey of leaf and soil analyses of affected orchards showed no clear trend of nutrient deficiencies. Most orchards had high counts of ring nematodes but a few orchards did not. Many conditions in bud drop affected orchards are very similar to areas with bacterial canker. In fact, it is common to find trees dying from bacterial canker in areas of an orchard most seriously affected by dormant bud drop. Bud drop is associated with young trees (generally fourth through ninth leaf) growing in sandy soil. All trees observed with dormant bud drop are in second or third generation orchards that were planted after the removal of old almond or stonefruit orchards or grape vineyards. Affected buds are colonized by *Pseudomonas syringae*, the bacterium associated with bacterial canker. It is unclear if bud drop is a previously unreported symptom of bacterial canker or if both problems coincidentally occur in similar orchard conditions.

Several field experiments have been conducted in Stanislaus County since 1997. The first field trials used "shotgun" approaches to find potential treatment avenues to explore. Initial trials included soil-applied fertilizers, foliar nutrient sprays, nematicides, microbiological soil inoculants, and organic and inorganic soil amendments.

Trial #1 – Keyes Orchard.
This trial was conducted from 1997 – 1999 in a severely affected fifth-leaf orchard. Treatments included the following:

1) Untreated
2) Enzone (a nematicide) applied at 400-700 ppm in the fall
3) Potassium sulfate @ 1200 lb / acre
4) Boron @ 50 lb 21% soluble boron / acre
5) Slow release NPK fertilizer + micronutrients @ 150 lb N / acre
6) Four applications of foliar calcium chloride @ 4 qts Stopit® + monthly CAN-17 @ 30 lb. N
7) Combination of Enzone, potassium, boron, slow release N, foliar calcium, CAN-17 treatments
8) Combination treatment plus Bordeaux sprays

At bloom time in 1998 & 1999, trees were evaluated for bud drop by examining three lower limbs (250-300) bud positions on each tree. The average percent of closed and fallen buds in untreated trees for the three tested varieties are shown in Figure 1 below. Although 1999 was not considered a bad year for bud drop, seventy-three percent of the buds on the Carmel trees had fallen or remained closed compared to forty-eight percent on the Price and thirteen percent on the Nonpareil trees.

Keyes, CA Almond Bud Drop Trial.

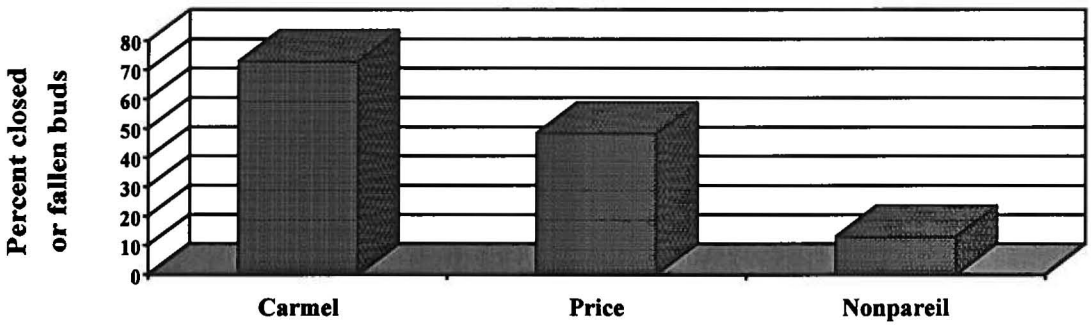

Fig. 1. Varietal differences in bud drop expression. February 26, 1999.

Trees treated with potassium, boron, slow release nitrogen plus micronutrients, or Bordeaux had bud drop severity similar to untreated trees (Figure 2). Although bud drop was still higher than desirable, monthly applications of CAN-17 (30 units of N) + foliar applications of calcium chloride (StopIt®) significantly reduced bud drop severity. One spring application and two fall applications of Enzone drastically reduced ring nematode numbers and also reduced bud drop. However, the concentrated, multiple Enzone applications resulted in severe root damage leading to collapse of some trees in the second year of the experiment. The best treatment included a combination of all treatments, including a fall and winter application of Bordeaux mix. Although Bordeaux by itself did not significantly reduce bud drop, it appeared to be an important part of a successful program. We assumed trees with low bud drop would have better yields.

However, yield data were highly variable between trees and it was difficult to draw conclusions. Many of the trees with the lowest levels of bud drop were the combination treatments that included Enzone but these trees had drastically reduced yields due to their root damage.

Almond Bud Drop Trial, Keyes, CA.
February, 1999

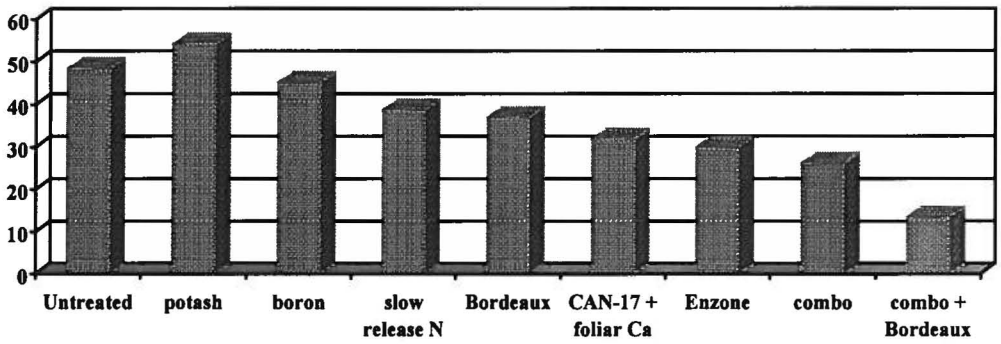

Fig. 2. Summary of percent of fallen or unopened buds on Nonpareil, Carmel, and Price almond trees. Combination treatment included potassium + boron + slow release N and several micronutrients + CAN-17 + foliar calcium + Enzone.

Trial #2 – Modesto Orchard

A second trial was established in 1998 in a severely affected Nonpareil and Wood Colony orchard north of Modesto. In this trial we included the most promising treatments from the first trial. Also included were several microbiological soil amendments locally promoted to improve plant health and increase yields. Ridomil and NutriPhite were included to determine if *Pythium* or *Phytophthora* play a role in bud drop. From our results of the first trial, we learned that Bordeaux mix (possibly any copper spray) was an important component of a bud drop management program. Therefore all experimentally treated trees were also sprayed with Bordeaux mix in the fall and winter in this trial. Liquid soil amendments were tanked around trees in 50 gallons of water just prior to the grower's flood irrigation. Foliar sprays were applied with an Echo brand, motorized, backpack mister/sprayer. Specifically, treatments included:

- Untreated
- Bordeaux solution (10 lb copper sulfate + 10 lb lime in 100 gal water) applied in November and January.
- CAN 17 applied monthly from May – September @ 30 units of N per application + monthly foliar applications of Stopit (calcium chloride - 12% Ca) @ 4 quarts.
- Meister® slow release N-P-K fertilizer plus micronutrients (17-6-12 + Mg, S, Mo, Cu, Fe, Mn, & Zn) @ 150 lb nitrogen per acre.
- Bio A (1 qt \ acre) and Bio B (1 qt \ acre) + Synergy (5 gal \ acre) applied monthly April through September. Bio A & B are aqueous suspensions containing *Bacillus*

subtilis and *Pseudomonas fluorescence* bacteria. Synergy is a complex carbohydrate material similar to molasses intended as a food source for the bacteria in the soil.

- Ceres (3 gpa) followed by Liquicomp (3 gpa) applied monthly May through September. Ceres and Liquicomp are aqueous suspensions containing a wide range of microorganisms produced by Biologically Integrated Organics.
- Shurcrop @ 20 gpa applied monthly. Treatments also included periodic applications of humic acid, Micro 5000, and Biogenisis. Shurcrop is a kelp-based soil amendment.
- Ascend PA & Ascend DC @ 30 gpa - May, 1998 & 2000. Ascend is a VA Mycorrhizal soil and root inoculant produced by BioScientific, Inc.
- Ridomil Gold, a systemic fungicide labeled to control *Phytophthora.*
- NutriPhite P Foliar (May, June, July, and October).
- Combination of CAN-17, foliar calcium, Ceres + Liquicomp, slow release nitrogen and NutriPhite

As before, treated and untreated trees were examined at bloom-time in 1999 and 2000 for percent dormant bud drop. Bud drop was not severe in Stanislaus County in 1999 and was very low in 2000. Due to the low incidence of bud drop in 2000, treatments were not statistically different. Data shown below (Figure 3) were recorded in 1999. As in the first trial, monthly applications of CAN-17 plus foliar calcium chloride was the single best treatment in reducing bud drop (20.8% drop compared to 50% drop in untreated trees). A combination treatment of CAN-17 + calcium chloride, NutriPhite, slow release nitrogen + micronutrients, and Liquicomp did not reduce bud drop any better than the CAN-17 + calcium chloride alone ($P \leq 0.05$).

Almond Bud Drop Trial, Modesto, CA
February, 1999

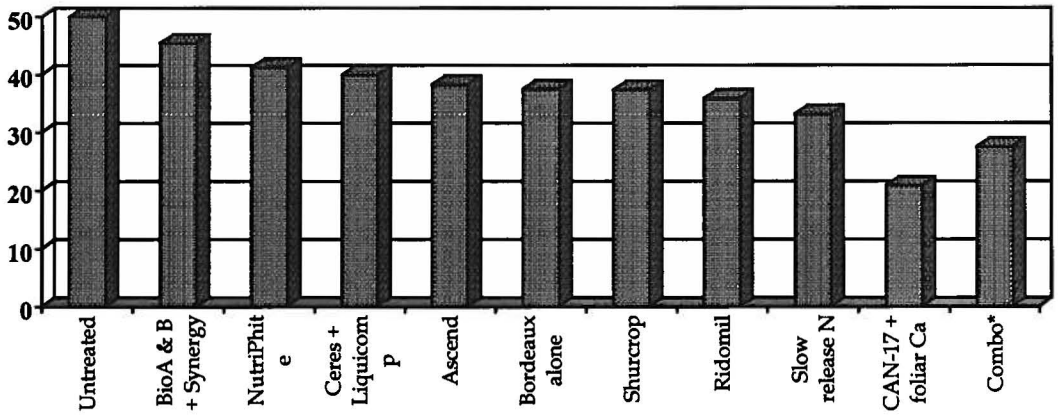

*Figure 3. Percent fallen or unopened Nonpareil and Wood Colony buds. All treatments except untreated were sprayed with Bordeaux in November 1998. *Combination treatment includes monthly applications of CAN-17, foliar calcium, Ceres & Liquicomp, slow release nitrogen fertilizer and NutriPhite foliar sprays.*

Yield data were similar to bud drop data (Table 1). Treatment differences were greater in 1999 than 2000, presumably due to less bud drop in 2000. Untreated trees (no Bordeaux) had the lowest numerical yields while treatments containing CAN-17 and foliar calcium tended to have the highest yields. All treatments (also treated with Bordeaux) except the combination treatment had yields similar to Bordeaux alone.

Table 1. Yields of Nonpareil and Wood Colony Almond Trees Treated with Various Fertilizers and Amendments.
Modesto Bud Drop Trial, Single Tree Plots

	1999		2000	
Treatment[1]	**Meat Pounds per Tree**	**Calculated Meat Pounds/Acre**	**Meat Pounds per Tree**	**Calculated Meat Pounds/Acre**
CAN-17 + $CaCl_2$, Slow release N, Ridomil, Liquicomp	22.4 A	2464	24.3 A	2673
CAN-17 + $CaCl_2$	20.4 AB	2244	22.1 AB	2431
Slow release N + micronutrients	20.2 AB	2222	18.1 ABC	1991
Ridomil	18.6 ABC	2046	21.0 AB	2310
Ceres & Liquicomp	18.0 ABC	1980	21.5 AB	2365
Ascend	18.0 ABC	1980	17.6 ABC	1936
Bordeaux mix	16.2 BC	1782	17.6 ABC	1936
Shurcrop	15.1 BCD	1661	17.5 ABC	1925
NutriPhite	14.1 CD	1551	18.5 ABC	2035
Bio A + Bio B & Synergy	13.5 CD	1485	14.5 BC	1595
No Bordeaux	10.1 D	1111	12.5 C	1375

[1]All treatments except where noted were also treated with Bordeaux mix in November and January.
[2]Values followed by the same letters are not statistically different ($P<0.05$)

Discussion.
Despite "adequate" levels of nitrogen and calcium in leaf samples, these treatments appear to decrease the severity of bud drop. It is unknown whether it is the nitrogen, the calcium, or the combination of the two that is the most important. Questions also remain whether other nitrogen sources could be substituted for the relatively costly CAN-17 or if monthly applications are necessary. New trials have been established to answer these questions. In our first trial, the nematicide Enzone appeared to reduce bud drop. In the same trial, Bordeaux by itself did not appear to decrease dormant bud drop. However when Bordeaux was applied in combination with an effective treatment, bud drop was reduced even further. It is possible buds enter into dormancy in a weakened state, possibly as a result of a compromised root system from nematodes or other "root pruning" organisms. *Pseudomonas syringae* bacteria may then colonize these weak buds which advances the disorder into a disease. We can speculate that copper sprays in November may be able to adequately reduce *Pseudomonas* colonization in healthier buds but may not help sufficiently weak buds. In years when bud drop is severe, buds already begin falling when touched as early as December. Therefore the typical dormant spray timing of January is not early enough to prevent bud drop. This project will continue for one more year.