DESCRIPTION:	**Management of Frost Injury, Fireblight and Fruit Russetting of Pear Using Biological and Cultural Methods**
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Management of Frost Injury, Fire blight, and Fruit Russetting of Pear Using Biological and Cultural Methods.

Principal Investigator: Steven E. Lindow, Department of Plant and Microbial Biology, University of California, Berkeley, CA 94720-3102.
email - icelab@socrates.berkeley.edu.
Telephone (510) 642-4174. Fax (510) 642-4995.

Cooperators: Rachel Elkins, Cooperative Extension, Lake County, 883 Lakeport Blvd. Lakeport, CA 95453

Chuck Ingels, Cooperative Extension, Sacramento County, 4145 Branch Center Road, Sacramento, CA 95827-3898

ABSTRACT

The process of colonization of pear buds and flowers was monitored in 5 commercial pear orchards. Both the total number of indigenous bacteria in buds as well as the proportion of those bacteria that were "internal" to pear tissue varied greatly between orchards. Total indigenous bacterial populations associated with pear in the early spring in 2001 were generally intermediate in number compared to higher and lower numbers observed in previous years, with mean populations in individual buds ranging from about 10,000 to 100,000. Generally a majority of the bacteria associated with buds were external, while the proportion that was internal to pear tissue increased in developing flower and tissues after bud break. The fraction of the total bacterial population associated with pear buds that was "internal" was generally less than 10% in all orchards, and highest populations were observed in Lake and Yuba county orchards. Bacterial populations generally increased rapidly after bud enlargement, and a progressively larger proportion of the bacteria on such green tissues were internal to pear. The applications of erradicant bactericides before bloom enhanced the colonization of flowers with the biological control bacterium *Pseudomonas fluorescens* strain A506 early in the growing season compared to control trees to which the bacterium was applied without erradicant pre-treatment. Application of strain A506 with the organo-silicon surfactant Breakthru resulted in populations on trees that were as much as 2-fold higher early in the growing season than when the bacterium was applied in water alone. The population size of strain A506 in pear flowers throughout the spring generally increased with increasing concentrations of surfactant in which the bacteria were applied in a single application at the time of first bloom. Importantly, the population size of strain A506 on flowers on trees that were inoculated only a single time at "first bloom" with Blightban A506 in 0.2% or 0.5% Breakthru were as high as or higher throughout the spring than that on trees that received weekly applications of the same amount of Blightban A506. Blightban A506 was also applied with high rates of surfactant in 2 large replicated trials in commercial orchards in 2001. Because of warm weather that accelerated bloom, the bacteria were applied a single time at from 20 to nearly 100% bloom in a single application with surfactant instead of at first bloom and were compared to three applications of Blightban at about weekly intervals

without added surfactant. At one site the fraction of flowers that were colonized by A506 were as high as on flowers in trees sprayed repeatedly throughout the spring. Some phytotoxicity was observed on trees when high rates of surfactant was applied at full bloom, while no russetting was observed when surfactant was applied before substantial bloom had occurred. These results suggest strongly that we should be able to greatly reduce the number of applications of the bacterium by applying it early in the season with a penetrating surfactant. In addition, by applying the bacterium only once early in the early spring before applications of Dithane and Terramycin and other pesticides are subsequently made to trees, we can avoid potential problems with compatibilities of the bacterium with these other pesticides. Frost injury was extensive in the various plot areas in 2001, and the incidence of frost injury was reduced about 50% on trees that had been treated with Blightban A506, irrespective of the method of application.

Colonization of pear buds and flowers with indigenous bacteria in the early spring

Work during 2001 addressed important issues in the microbial ecology of pear trees that relate to the management of fruit russet, frost injury and fire blight disease of pear. One major objective was to monitor populations of indigenous bacteria in pear buds and emerging florets during winter/early spring and relate them to weather parameters such as spring rainfall. An earlier analysis of data in which we had measured indigenous bacterial populations on the flowers of pear at the beginning of bloom revealed large variations in population size from year to year. In some years such as 1995 and 1998 there were large populations of bacteria of all types in flowers shortly after they open in the spring, while in other years flowers emerged nearly sterile and become colonized by bacteria that apparently immigrated to the open flower via the air or insect vectoring from nearby plant sources such as orchard cover crop and weed species. We had found that the number of bacteria in emerging flowers is generally correlated with rainfall abundance during the winter and early spring months before bud opening. We presumed that winter rains allow colonization of the buds and/or the emerging florets as the buds begin to open. Importantly, we had found that the incidence of early season fire blight infection is generally inversely proportional to the population size of the indigenous bacteria in the emerging flowers on control trees (eg. there is less disease in years when there are a lot of indigenous bacteria - "natural biological control" of fire blight seems to be operating). We also noted that the colonization of flowers by antagonistic bacteria such as *Pseudomonas fluorescens* strain A506 is less efficient in years when there are large indigenous bacterial populations. Fortunately, the presence of large numbers of indigenous bacteria can apparently confer some degree of "natural biological control" in those years when A506 itself is inhibited in its growth on pear by the presence of indigenous bacteria. The presence of large numbers of indigenous bacteria on emerging pear flowers is also associated with a relatively high incidence of frost injury during mild frost events compared to orchards and years when indigenous bacteria populations were low. We therefore undertook a detailed temporal analysis of the processes that allow bacteria to develop in emerging pear flowers to better understand how to manage biological control agents of fire blight disease as well as frost injury and fruit russet and to better predict when indigenous bacteria will be sufficiently numerous to present a high hazard of fruit russet and frost injury. Beginning about 3 weeks before bud break in 2001 we monitored the process of colonization of pear buds and the flowers that emerged from these buds on a frequent basis to determine how

rapidly bacterial populations changed and what weather factors were associated with the development of bacterial populations in buds and flowers. Bacterial populations were monitored on buds and flowers in two commercial pear orchards in Lake County, one orchard in Yuba County, as well as in two orchards in Sacramento County. In addition to measuring the total bacterial population on buds and flowers we also measured the "internal" populations. At each sampling time the 40 bud or flower samples for each orchard were divided into two separate pools of 20 samples each. Total bacterial populations were determined by macerating the bud or flower samples from one pool individually in a small amount of buffer and plating appropriate dilutions onto non-selective media. In contrast, "internal" populations were determined as before on the other 20 samples in a given pool after the buds or flowers were surface sterilized by treatment with 0.5% sodium hypochlorite.

Both the total number of indigenous bacteria in buds as well as the proportion of those bacteria that were "internal" to pear tissue varied somewhat between orchards (Figures 1-5). Total indigenous bacterial populations associated with pear in the early spring in 2001 was generally intermediate in numbers between the higher and lower populations observed in previous studies. Average total bacterial populations ranged from about 10,000 to 100,000 cells/sample (bud) in the various orchards. It was noteworthy that populations increased in some orchards throughout the spring (Figures 1 and 2), while in other orchards there was little change in populations from February through March. (Figures 3-5). We are checking the spray history of these orchards to determine if sprays made in the winter might have affected bacterial populations in these orchards since there was no obvious regional, and thus environmental association with those orchards for which bacterial numbers increased. The fraction of the total bacterial population associated with pear samples that was "internal" was generally less than 10% in all of the orchards before bud break (Figures 1-5). Thus it seems that most bacteria on buds are not "inside" the buds and thus might be expected to be influenced strongly by both winter pesticide applications, as well as weather conditions. The moderate weather in the spring of 2001 is consistent with the moderate populations of bacteria seen on buds and developing flowers; these populations are much lower than those seen during wet springs such as1995 and 1998. The results of 2001 confirm our suspicions that bacterial population development in pear occurs rapidly during bud enlargement, and is not associated with large internal populations that developed during winter since the winter months.

In contrast to the relatively stable populations of bacteria that were observed on buds and "fingers" of pear in the early spring, more rapid bacterial multiplication was noted in some orchards upon flower opening (Figures 1-2). For example, total bacterial populations after mid-March on flowers emerging in a Sacramento County orchard increased over 10-fold within a few days (Figure 1). It was interesting to note that the increases in total bacterial populations were associated with increases in "internal" populations, and thus the proportion of the total bacterial population that were within pear tissue increased to more than 50% (Figure 1). The percentage of bacteria inside pear tissue thus seems to be somewhat variable from site to site within a year and between years; the factors affecting such variation are still unclear, but this phenomenon has importance for the control of frost and russet since such bacteria are important inoculum sources. This study is designed to be a relatively long-term study in which we will examine colonization of pear under a variety of weather conditions over a number of years so that the influence of weather conditions on bacterial populations can be better predicted. Predictions of indigenous

bacterial populations before bloom will be useful in future predictions of the severity of fruit russet and of frost injury that are associated with these indigenous bacteria.

Eradication of indigenous bacteria on pear in early spring to reduce fruit russet and enhance colonization of pear by biological control agents.

Since relatively large indigenous bacterial populations had been found on pear tissue at the time of first bloom in some previous years and since these large populations were associated with poor establishment of the biological control agent *Pseudomonas fluorescens* strain A506, we evaluated strategies to reduce such early season populations. Since the severity of fruit russet is proportional to the total population sizes of bacteria on pear tissues in the early spring (due to the contribution of IAA-produced by a subset of these bacterial populations), we were interested to know if we could reduce the population sizes of indigenous bacteria and thereby reduce the severity of fruit russet. *Pseudomonas fluorescens* strain A506, for which extensive field experimentation has been conducted over the last several years in California, has been registered as the product "Blightban A506" and commercial sales began in the 1996 growing season. We therefore conducted additional research to address issues relating to the best methods by which this bacterium can be established in pear trees to achieve biological control of frost injury, fire blight disease, and fruit russet, especially under conditions when pears might already harbor substantial populations of other bacteria in the early spring.

A field trial in which several early-season chemical eradicants were evaluated was established in a commercial pear orchard in Lake County. Both bleach (Sodium hypochlorite - 0.05%) as well as copper hydroxide (Kocide 101) were evaluated as bactericides to eradicate bacterial populations. These eradicants were applied with a high rate of this surfactant (0.5%) to determine if the bactericide could be made more accessible to the bacteria in and on pear tissues. Such eradicant treatments were made at the "finger" stage. At the time of about 10% bloom weekly applications of *P. fluorescens* strain A506 (label rate of Blightban A506) were initiated. The total indigenous bacterial populations on untreated trees and on trees treated only with streptomycin and Terramycin in this Lake county orchard were relatively low (about 10^5 cells/spur) in the early spring of 2001, but increased after mid-April after trees became contaminated with strain A506 from adjacent trees (Figure 6). Like in most other studies, we found that treatment of trees with a mixture of streptomycin and Terramycin did not reduce total bacterial populations during much of the spring (Figure 6). It should be noted that this contamination of trees with bacteria from other treatments in the plot is commonly observed due to the ability of strain A506 to move so efficiently from one tree to another; even the buffer trees used in this study are not enough to completely eliminate the movement of the inoculum via insects and wind. Our results in 2001 thus confirm that bacteria such as *P. fluorescens* strain A506 can move efficiently between closely adjacent trees. Thus differences in population sizes between different A506 treatments in 2001 were probably reduced due to such migration of bacteria from tree to tree. The application of eradicant bactericides increased the establishment of strain A506 early in the growing season (Figure 7). Populations of P. *fluorescens* strain A506 was about 10-fold higher at early sampling dates on trees receiving weekly applications of Blightban A506 on trees treated with eradicant bactericides than on trees without such earlier chemical treatments (Figure 7). In all cases, populations of strain A506 increased within a few

days of initial treatment onto trees to a population of over 10^7 cells/spur and remained at close to this population throughout the rest of the sampling period (Figure 7). We also compared the colonization of pear by strain A506 when it was applied to trees in water without a surfactant and when it was applied in a solution of 0.05% Breakthru (Figure 8). Because the colonization of pear flowers was so efficient even without addition of Breakthru we did not see a consistent increase in populations of his bacterium when applied with the surfactant as we had previously seen; populations of the strain A506 were apparently as high as they could achieve even without the addition of the surfactant. We had found that the bacterium is applied more uniformly to plant surfaces when mixed with this surfactant that has a very low surface tension. Presumably the surfactant allowed the bacterium to more fully colonize parts of the flowers and young fruit by allowing sprayed inoculum to move easily to all parts of the developing tissues. Presumably this also reflects a greater ability of the bacterium to prevent the growth of deleterious bacteria such as ice nucleation active bacteria capable of causing frost injury, of IAA-producing bacteria that cause fruit russet, and of *Erwinia amylovora*, the pathogen that causes fire blight disease.

The severity of fruit russet on trees receiving applications of Blightban A506 was often numerically lower than that of untreated trees in most cases, but because of variation in russet severity between trees often did not differ statistically (Table 1). The severity of fruit russet was higher on trees in which early season eradicant bactericides were applied in addition to weekly applications of Blightban as compared to where Blightban alone was applied (Table 1). We presume this was due to phytotoxicity of the copper compounds and bleach to the developing fruit; such phytotoxicity had not been previously seen, and we are not sure what aspects of the weather or flower development in 2001 predisposed them to phytotoxicity. It is also noteworthy that the application of a high rate of Breakthru (0.5%) was not associated with fruit russet (Table 1). Thus this penetrating surfactant apparently does not harm pear tissues even at high rates when applied in the early spring to flowers that were not yet open. Frost injury was also severe in the plot area, and nearly 30% of the fruit from untreated trees had severe ice rings and/or blistering of the calyx end of fruit at harvest. The incidence of frost injury was reduced by over 50% by treatments of Blightban A506 (Table 1). The greatest frost control was associated with the application of strain A506 with 0.05% Breakthru, the treatment that achieved the highest population sizes of the biological control agent.

Establishment of *P. fluorescens* strain A506 in pear flowers by single early season applications with surfactants

Given that we had observed in previous years that rapid colonization of flowers by indigenous bacteria could occur if flowers were inoculated with bacteria, we investigated approaches by which *P. fluorescens* strain A506 could be introduced into pear tissues before bloom so that flowers would be exposed to this antagonistic bacterium as soon as they opened. We evaluated the potential of introducing bacteria into pear tissues using relatively high rates of the penetrating surfactant Breakthru. Just as we had demonstrated in walnut that this surfactant could allow topically applied solutions to penetrate into tissues, we hypothesized that suspensions of *P. fluorescens* strain A506 could be made to enter pear tissues if applied with such surfactants. Organo-silicon surfactants such as Breakthru and related compounds have the

unique ability to allow water solutions to penetrate into plant tissues through natural openings due to the low surface tension of such solutions. Normal sticker-spreaders do not have a sufficiently low surface tension to permit such penetration into plants. Laboratory tests had indicated that strain A506 was tolerant to over 3% Breakthru. Thus this bacterium was compatible with even high rates of surfactant. We inoculated pear trees at the time of the first bloom in an orchard with Blightban A506 with different concentrations of Breakthru and then measured the colonization of flowers by strain A506 after they emerged. Because the bloom of pear was very compact in 2001 (nearly all of the flowers emerged within a few days of each other – much more synchronized than normal) colonization of pear flowers form a single early season spray of strain A506 led to high levels of colonization of pear flowers, largely irrespective of the amount of surfactant that was applied with the bacterium (Figure 9). The early-season (first bloom) applications led to higher populations of strain A506 at early sampling periods than when the bacterium was applied at 20% bloom (Figure 9). Thus it appears that the compact bloom and weather conditions of 2001 were nearly ideal for the colonization of flowers from a single spray of strain A506. The results of previous trials were quite different in that little colonization occurred from early applications unless surfactant was applied. In more normal years, the opening of flowers is staggered over a much longer time period, so inoculum from early applications is apparently unavailable to most of the opening flowers unless it sequestered in the buds of unopened flowers. Thus the work of 2001 again demonstrated that a single early-season application of Blightban A506 is an effective method of applying the bacterium. We must assume that the surfactant should always be used in such early season applications since we cannot assume, and will be unable to know before bloom, whether the bloom will be sufficiently compact and weather conditions conducive for ideal colonization. Thus the surfactant can be considered to aid the colonization process, especially under more normal weather and tree conditions.

Blightban A506 was also applied with high rates of surfactant in 3 large replicated trials in commercial orchards in 2001. Because of warm weather that accelerated bloom, the bacteria ended up being applied a single time at from 20 to nearly 100% bloom in a single application with surfactant instead of at first bloom and were compared to three applications of Blightban at about weekly intervals without added surfactant. The populations of indigenous bacteria of various types that were present on flowers at the time of first bloom were quite low at two of these sites (Figures 13 and 14). While the number of indigenous bacteria on flowers varied from undetectable to nearly 10^6 cells/flower, on average a flower had about 1000 bacteria at the time that Blightban A506 was applied (Figures 13 and 14). The colonization of emerging flowers from early-season applications of bacteria and/or surfactant differed substantially in the different commercial orchards sprayed with airblast sprayers. At the Yuba site the fraction of flowers that were colonized by the biological control organism strain A506 were as high as on flowers in trees sprayed repeatedly throughout the spring (Figure 10). High frequencies of colonization of flowers with either weekly application of Blightban A506 in water or a single early-season application of Blightban A506 in 0.5% Breakthru was observed in the Yuba orchard (Figure 10). Similar patterns, but lower frequencies of colonization of flowers from these two treatments were observed in a trial at Wheatland (Figure 11). Unfortunately, Blightban A506 was omitted from the early-season spray application containing Breakthru at the Sutter location by the cooperator (Figure 12) making evaluation of the single application of Breakthru impossible. However,

regular applications of Blightban A506 at this later location without surfactant led to high frequencies of colonization with strain A506 (Figure 12). As noted above, these initial large-scale tests of early-season applications of Blightban A506 with surfactant are hard to interpret because of the unique combination of weather and delayed application in 2001. The preliminary assessment that can be gained from 2001 is, however, promising, since the results from the Yuba site, which was applied under the most appropriate timing resulted in high levels of colonization of strain A506 (Figure 10). No significant incidence of fire blight was observed in most plots, and the little fire blight that occurred in one plot occurred very late in the summer (long after bloom time applications of protectants would be expected to affect fire blight), which prevented us from assessing the effects of these alternative methods of application of Blightban A506 on fire blight control. The incidence of frost injury was very low in these central valley trials, and no effects from treatments could be inferred (Table 2). The application of an iron chelate (which may increase the efficacy of Blightban to control *Erwinia amylovora*) did not lead to fruit russet, and did not significantly alter the colonization of pear flowers by this bacterium (Table 2). For the first time we observed some russetting associated with high rates of application of the surfactant Breakthru. This russetting was associated with two unusual events 1) the Breakthru sprays were applied to open flowers instead of buds as in past experiments in most cases due to the accelerated bloom which prevented us from applying the sprays at the earlier times that we had targeted, and 2) relatively high temperatures at the time of spray. Even though the sprays were applied on the same day in the various orchards, russet severity was pronounced only in the two orchards that had the most advanced bloom (Table 2). Little or no russetting was observed in the commercial orchard in Yuba in which the sprays were applied at about 20% bloom, nor in the Lake County trial in which sprays were applied at first bloom as targeted (Table 1). Thus we feel that the fully opened flowers are more susceptible to phytotoxicity with high rates of organo-silicon surfactants, especially when applied during warm weather. In contrast, these materials appear safe to apply to trees before substantial bloom has occurred. These large-scale tests will be repeated in 2002 to verify this new strategy of application of the biological control agent.

These results are very exciting in that it suggests that early season application of antagonistic bacteria may be a superior means of establishing these biological control organisms on trees. These results confirm that we should be able to greatly reduce the number of applications of the bacterium by applying it early in the presence of the penetrating surfactant. In addition, by applying the bacterium only once early in the early spring before applications of Dithane and Terramycin and other pesticides are subsequently made to trees, we can avoid potential problems with compatibilities of the bacterium with these other pesticides. Since strain A506 can be established on trees before these other pesticides need to be applied, and since we have already shown that the bacterium is quite tolerant of other pesticides such as Dithane and Terramycin if it has established on trees before these pesticides are applied, we can greatly reduce any possibility that they will interfere with the performance of strain A506 in biological control of frost, fire blight and fruit russet. Such an application strategy should thus also help increase the adoption of biological control strategies for fire blight and fruit russet since they will make it easier to integrate into existing management strategies. This approach will be a major focus of our work in the year 2002.

Table 1
Frost Injury and Fruit Russet to Pear Treated at Bloom with *P. fluorescens* Strain A506 With and Without Penetrating Surfactants.

Treatment	Russet Severity (% of surface)	Frost Damage (% of fruit)
Control	0.97 b	0.29 a
Kocide + 0.5% Breakthru (1st bloom) +A506 weekly	4.88 a	0.13 cd
Bleach + 0.5% Breakthru (1st bloom) + A506 weekly	4.28 a	0.10 cd
A506 weekly	1.01 b	0.22 abc
A506 + 0.05% Breakthru weekly	0.55 b	0.07 d
A506 + FeEDDHA (1lb/100gal) weekly	0.35 b	0.10 cd
A506 + 0.5% Breakthru (1st bloom only)	1.44 b	0.10 cd
A506 + 0.2% Breakthru (1st bloom only)	2.03 b	0.19 abcd
A506 + 0.1% Breakthru (1st bloom only)	0.73 b	0.14 bcd
A506 + 0.05% Breakthru (1st bloom only)	0.48 b	0.19 abcd
A506 (1st bloom only)	0.48 b	0.13 bcd
Starner (S-0208 so WP) (0.33lb ai/100 gal) (1.65 lb product/100 gal)	0.57 b	0.19 abcd
Starner (S-0208 so WP) (0.33lb ai/100 gal) (1.65 lb product/100 gal)	0.51 b	0.18 abcd
Streptomycin + Terramycin weekly	0.56 b	0.27 ab

Table 2

Incidence of Frost Damage and Russet Severity on Pears from Commercial Orchards Treated with A506 With and Without a Penetrating Surfactant.

Treatment	Russet Severity (% of surface)			Frost Damage (% of fruit)		
	Sutter	Yuba	Wheatland	Sutter	Yuba	Wheatland
Antibiotic program	4.03b	1.22a	1.56a	0.00a	0.01a	0.10a
A506+Breakthru (1st bloom)	5.26a	1.65a	2.36a	0.01a	0.01a	0.08a
A506 3X (no Breakthru)	2.08c	0.98a	1.46a	0.00a	0.01a	0.12a
A506 3X (no Breakthru)+ Fe chelate			1.52a			0.06a

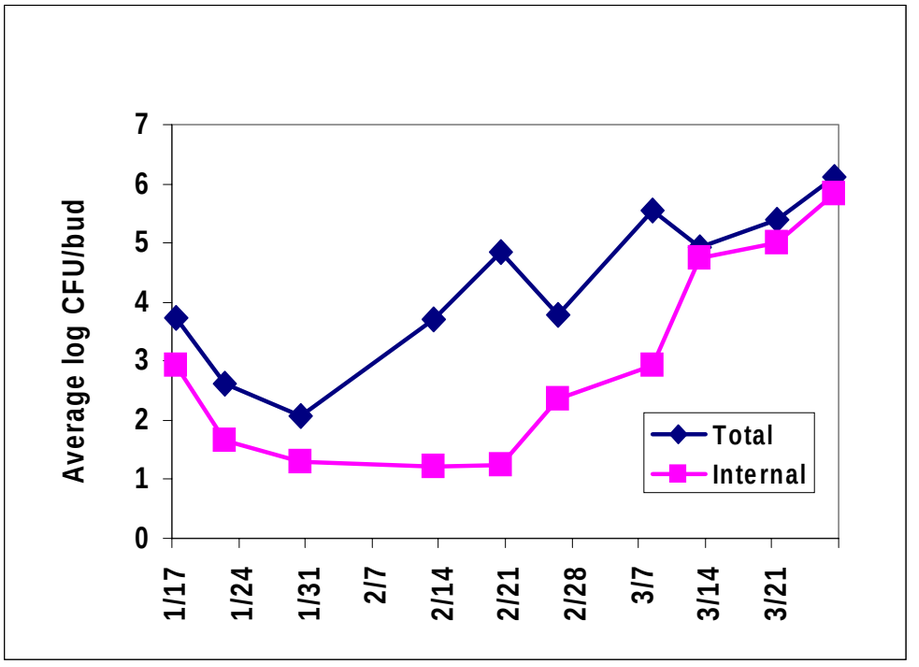

Figure 1. Total bacterial populations (diamonds) and "internal" bacterial populations remaining in buds and clusters of pear that were surface sterilized with bleach (squares) that were collected from commercial Bartlett pear orchard "M" in Sacramento County in the spring of 2001. The vertical bars represent the standard error of the mean of log-transformed bacterial population sizes.

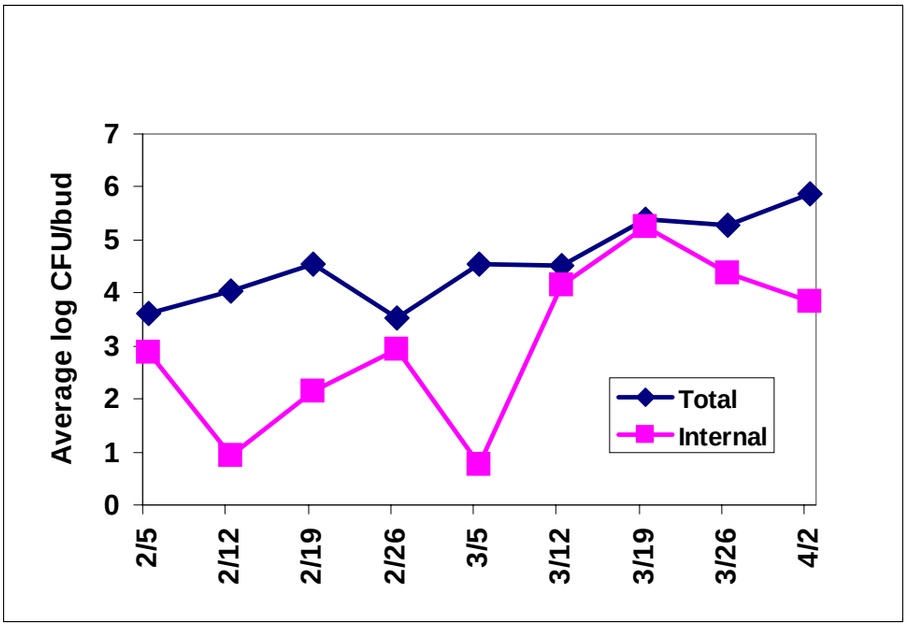

Figure 2. Total bacterial populations (diamonds) and "internal" bacterial populations remaining in buds and clusters of pear surface sterilized with bleach (squares) that were collected from commercial Bartlett pear orchard "R" in Lake County in the spring of 2001. The vertical bars represent the standard error of the mean of log-transformed bacterial population sizes.

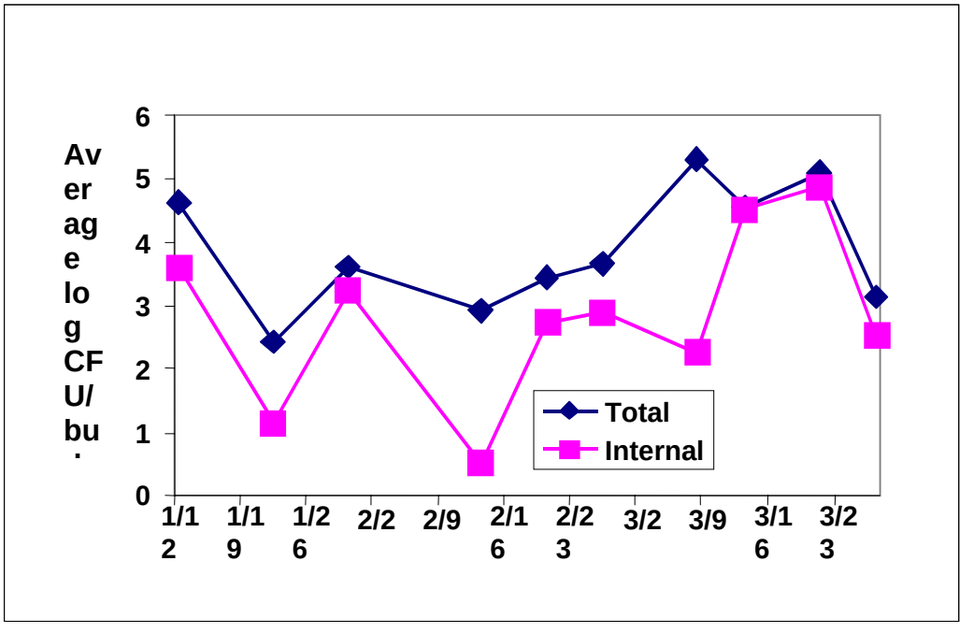

Figure 3. Total bacterial populations (diamonds) and "internal" bacterial populations remaining in buds and clusters of pear that were surface sterilized with bleach (squares) that were collected from commercial Bartlett pear orchard "T" in Lake County in the spring of 2001. The vertical bars represent the standard error of the mean of log-transformed bacterial population sizes.

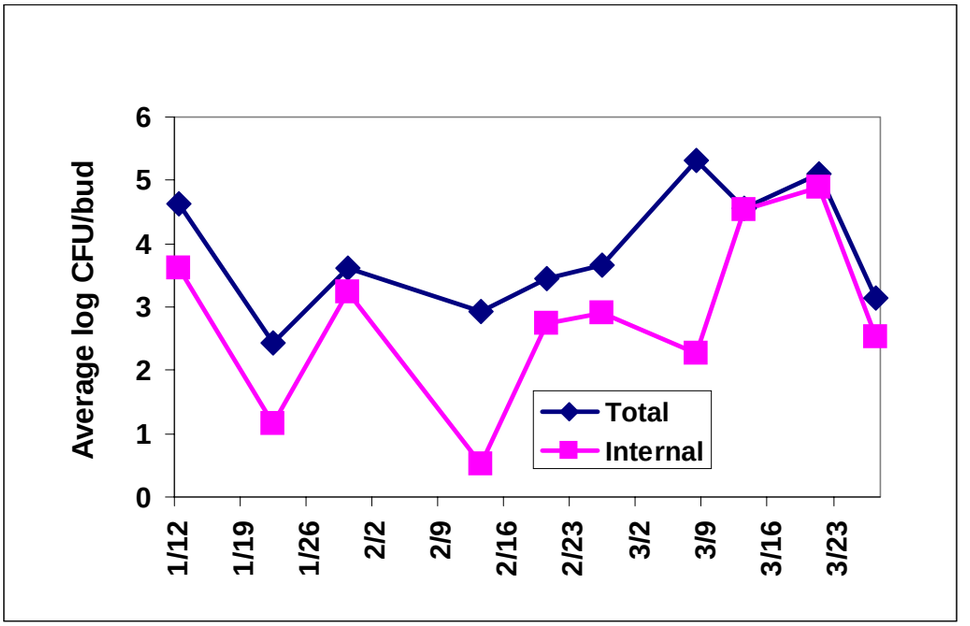

Figure 4. Total bacterial populations (diamonds) and "internal" bacterial populations remaining in buds and clusters of pear surface sterilized with bleach (squares) that were collected from commercial Bartlett pear orchard "T" in Sacramento County in the spring of 2001. The vertical bars represent the standard error of the mean of log-transformed bacterial population sizes.

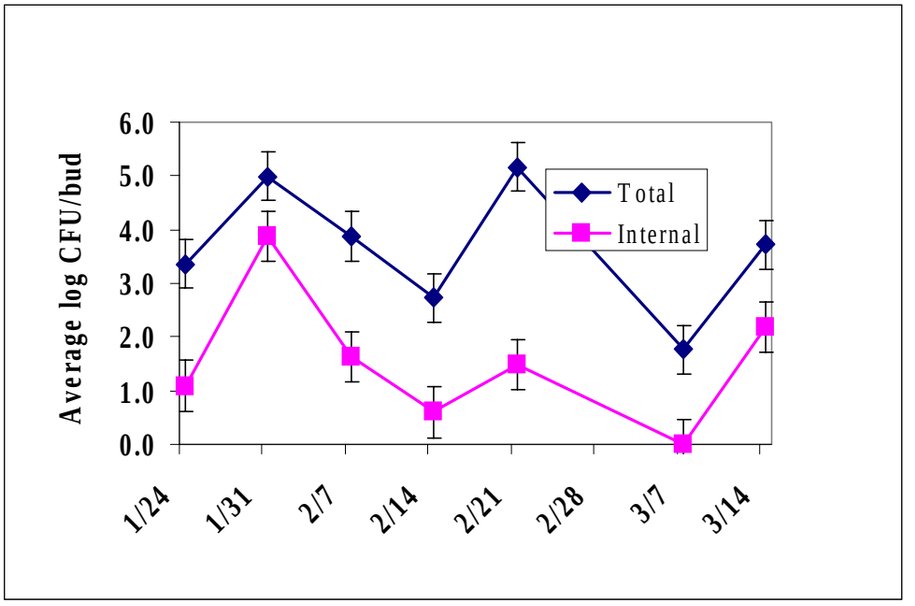

Figure 5. Total bacterial populations (diamonds) and "internal" bacterial populations remaining in buds and clusters of pear surface sterilized with bleach (squares) that were collected from a commercial Bartlett pear orchard Yuba County in the spring of 2001. The vertical bars represent the standard error of the mean of log-transformed bacterial population sizes.

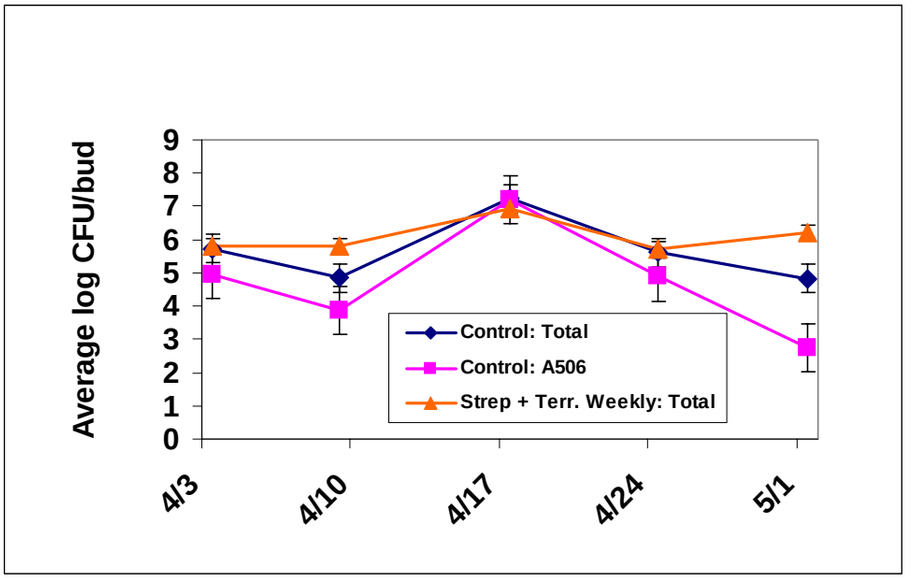

Figure 6. Total bacterial populations (diamonds and triangles), and populations of *Pseudomonas fluorescens* strain A506 (squares) on untreated Bartlett pear trees (diamonds and squares) or on trees treated weekly with a mixture of streptomycin or Terramycin (triangles) in a Lake County plot in 2001. The vertical bars represent the standard error of the mean of log-transformed bacterial population sizes.

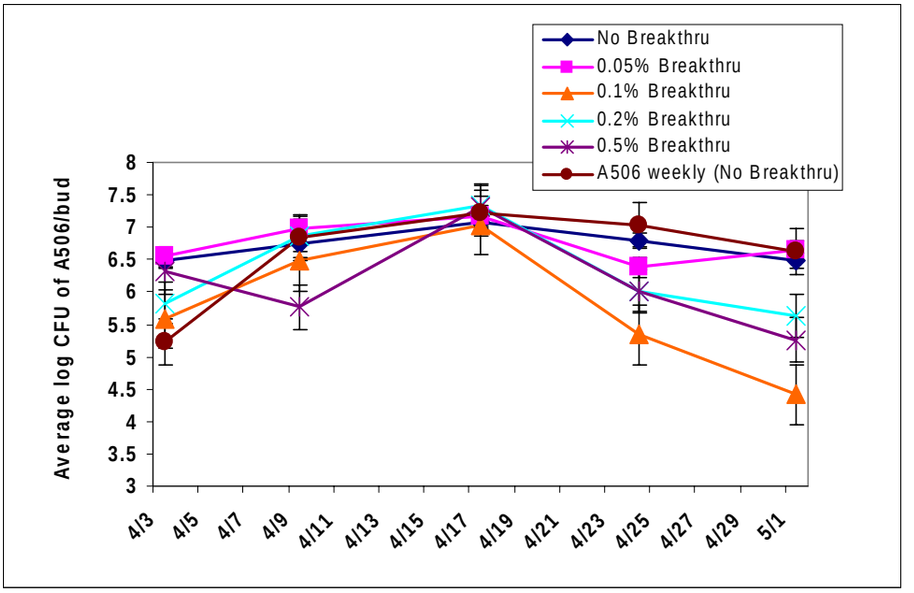

Figure 9. Populations of *Pseudomonas fluorescens* strain A506 on Bartlett pear trees treated once only at the "first bloom" stage of growth [when only a few flowers were observed in an orchard] with a label rate of Blightban A506 in water alone (diamonds) or in 0.05% Breakthru (squares), 0.1% Breakthru (triangles), 0.2% Breakthru (x's) or 0.5% Breakthru (stars) compared with weekly applications of Blightban A506 in water (circles) in a Lake County plot in 2001. The vertical bars represent the standard error of the mean of log-transformed bacterial population sizes.

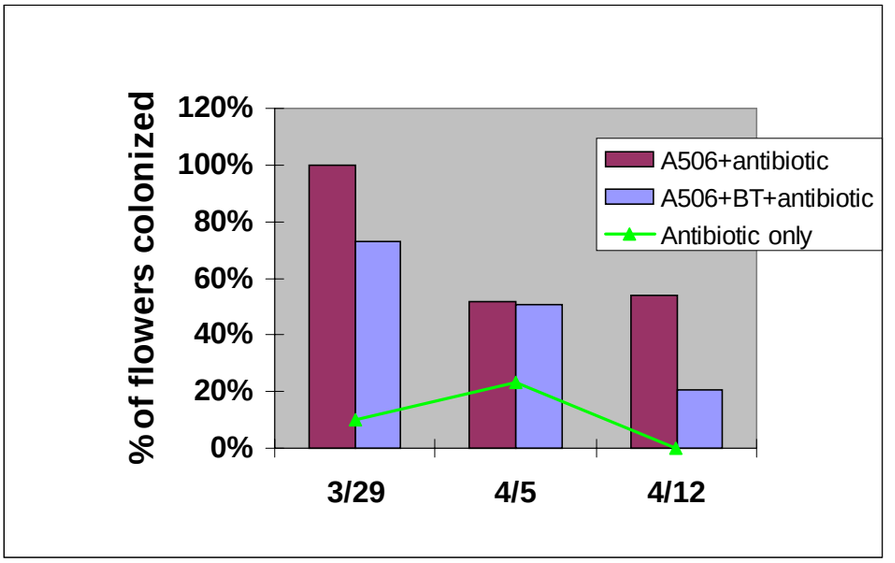

Figure 10. The percent of flowers of Bartlett pear from a commercial orchard in Yuba County that harbored *Pseudomonas fluorescens* strain A506 as measured with a "flower rub" assay at different times during the growing season. Trees received either a normal antibiotic spray program selected by the cooperating grower (triangles) or were treated weekly with Blightban A506 in water alone (dark bars) or were treated a single time at about 20% bloom with Blightban A506 in 0.5% Breakthru (light bars).

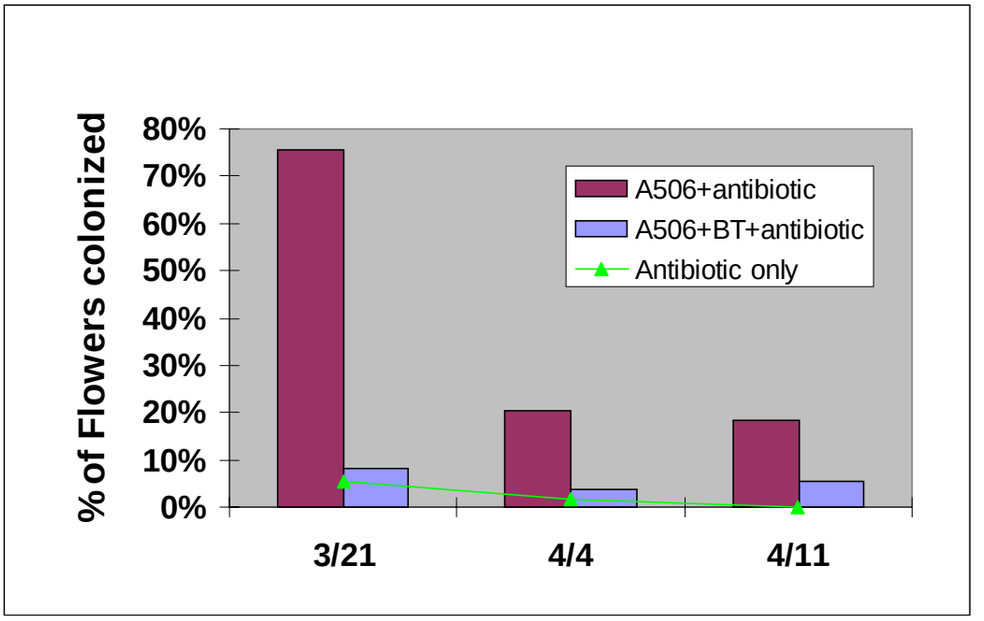

Figure 11. The percent of flowers of Bartlett pear from a commercial orchard near Wheatland that harbored *Pseudomonas fluorescens* strain A506 as measured with a "flower rub" assay at different times during the growing season. Trees received either a normal antibiotic spray program selected by the cooperating grower (triangles) or were treated weekly with Blightban A506 in water alone (dark bars) or were treated a single time at about 20% bloom with Blightban A506 in 0.5% Breakthru (light bars).

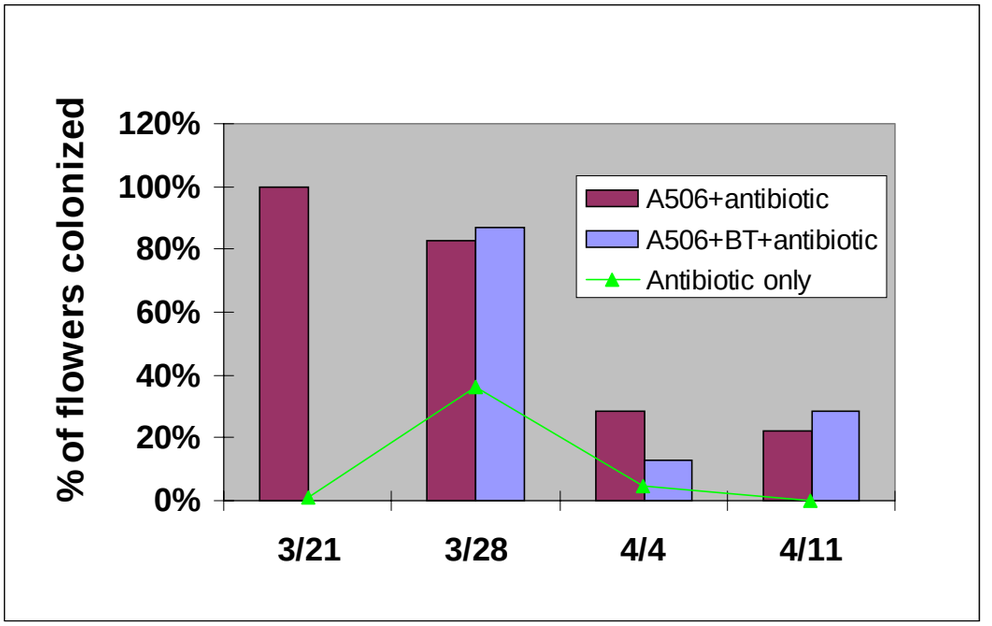

Figure 12. The percent of flowers of Bartlett pear from a commercial orchard in Sutter county that harbored *Pseudomonas fluorescens* strain A506 as measured with a "flower rub" assay at different times during the growing season. Trees received either a normal antibiotic spray program selected by the cooperating grower (triangles) or were treated weekly with Blightban A506 in water alone (dark bars) or were treated a single time at about 100% bloom with Blightban A506 in water alone (light bars).

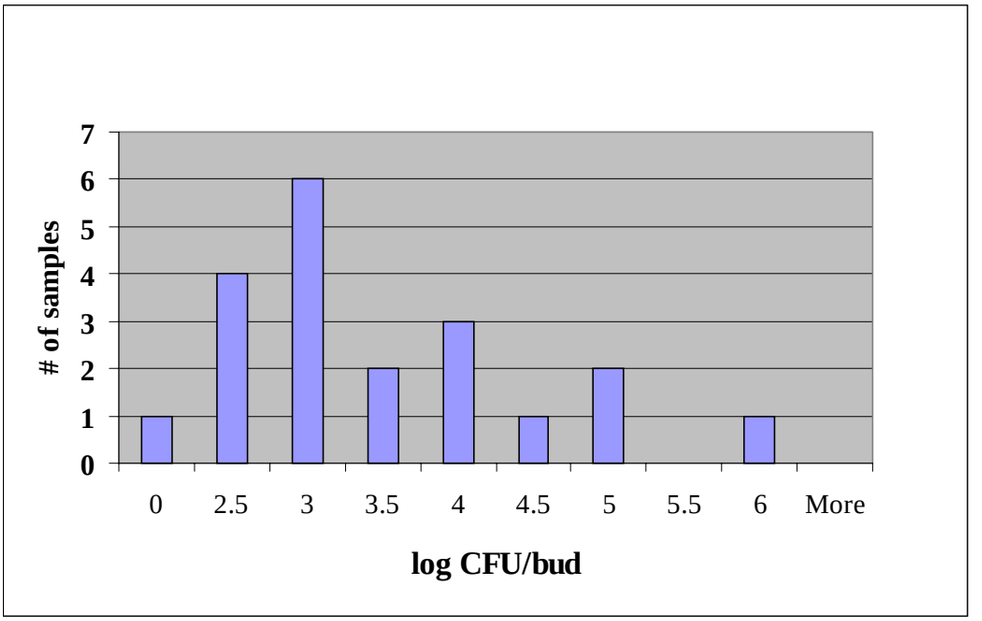

Figure 13. Numbers of indigenous bacteria of various types in recently opened Bartlett pear flowers at a Yuba County commercial pear orchard on March 14, 2001, prior to application of Blightban A506. The number of flowers having the number of bacteria shown on the x-axis is shown.

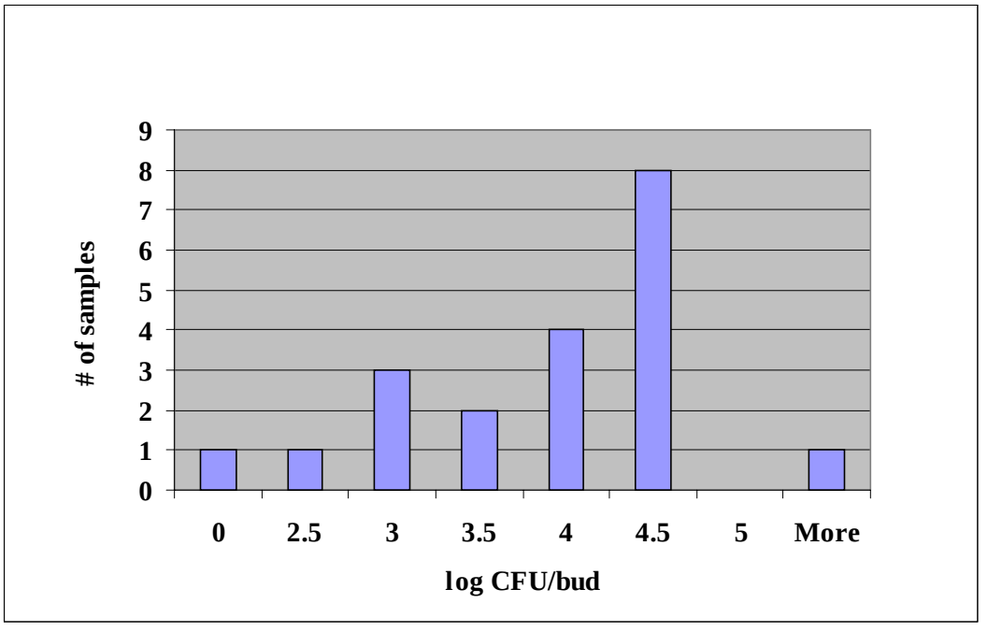

Figure 14. Numbers of indigenous bacteria of various types in recently opened Bartlett pear flowers at a Sutter County commercial pear orchard on March 14, 2001, prior to application of Blightban A506. The number of flowers having the number of bacteria shown on the x-axis is shown.