

## VI. Biology/Phenology

### Bt's Change the Leafroller Time Clock in Apple

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Bt products (containing endotoxins of *Bacillus thuringiensis*) have been adopted by nearly 25% of Washington's apple growers to combat leafroller pests. The basic program is a two sprays timed between pink and petal fall. Growers can expect to get 50-98% control with this type of program. Several types of studies have been conducted to optimize grower's use of Bts. These include: 1) determining which are the most active Bt toxins against leafrollers, 2) determining the interaction of Bt concentration and larval stage on the sublethal effects expressed through the rate of larval development and pupal size; 3) determining the importance of parasitism of leafroller larval populations delayed by Bt; 4) developing a new predictive model to time summer control actions more effectively in orchards treated with Bt in the spring; and 5) optimizing the use of Bt in the spring.

Laboratory assays were run with eight toxins against both obliquebanded (OBLR) and Pandemis (PLR) leafroller larvae. The most active toxins were the Cry1A's which are the primary toxins found in the various commercial products used in tree fruits.

The delay in larval development achieved following ingestion of Bt appears to be dose related and affects newly hatched, medium, and large larvae similarly. Pupal size was reduced especially when larger larvae fed on Bt. The effects on pupal size were lower when newly hatched larvae were exposed, apparently larvae recovered prior to pupation. Smaller pupae will produce smaller adults and this could affect mating success, fecundity, and dispersal of adult females. Further exploration of these effects are planned by Dr. Lerry Lacey, an insect pathologist at the Yakima Laboratory.

Preliminary data collected in 1994 indicated that a number of parasites attacked the delayed larvae during May and early June. Further studies are planned to assess the timing of these parasites and their importance in orchards treated with and without Bt.

In 1994 our preliminary data with Pandemis showed that the current phenology model was 2-3 weeks early in predicting summer egg hatch if the orchard was treated with Bt in the spring. Using our laboratory data and three years of field data of OBLR in the Brewster area a new model has been developed for this species. During 1997 this model will be validated in 8 orchards.

Current programs using Bt in the spring recommend that two applications be applied between pink and petal fall when the weather is warm. Two types of studies were

conducted to optimize these recommendations. First in environmental chambers programmed to replicate spring days where the high temperature reached 55, 65 or 75°F bioassays were conducted with third and fifth instar OBLR on leaf disks treated with six rates of Bt. Results from this study showed that there was little difference in the susceptibility of the two larval stages but a tremendous difference in the results at each temperature. Bts were approximately 2-3 times more effective between each temperature jump. This suggests that Bt applications should be delayed until weather is warm despite the presence of larger larvae. The second study tested the hypothesis that the larvae that survive the first spray will be more difficult to kill due to their cessation of feeding. Survivors of 0.25 lb Dipel per 100 gal were only 30% as susceptible in laboratory tests. This result suggests that the first application needs to be applied at a high rate, during warm weather, and using optimal spray coverage to minimize the sublethal effect. Also, the second application should likely be delayed for two weeks to allow the population to recover. This approach will be tested in both laboratory and field trials during 1997.