

## Implementation Programs

### Apple Production Without Broad-Spectrum Insecticides

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This was the second year of a 3-5 year SARE (Sustainable Agriculture Research and Education) project investigating the economics and ecology of Delicious apple orchards managed without using broad-spectrum insecticides (NBSI). Conventional (CONV) and NBSI management programs were directly compared at six locations, five in Washington (Bridgeport, Chelan, Orondo, Yakima, Wapato) and one in Oregon (The Dalles). In addition, a no class I (NOC1) management program was evaluated in a third 10-acre block at the Bridgeport, Orondo and Wapato sites.

**Arthropod pests and natural enemies.** Control of codling moth (CM) and leafrollers (LRs) in NBSI blocks was substantially better in 1996 than in 1995. Isomate C+ was the primary control for CM in both years. The pheromone treatment was supplemented with applications of the insect growth regulator, tebufenozide (Confirm®), in three NBSI blocks in 1996. Tebufenozide also replaced *Bacillus thuringiensis* (*Bt*) as the primary control for LR in four of the NBSI blocks in 1996. This material was added to the control program following the granting of a fresh fruit experimental use permit for 50 acres in Washington and Oregon. CM fruit injury in NBSI orchards was kept in check in five of six sites in 1996, but in only three of six sites in 1995 (Fig. 1). Improved control of this pest at the Bridgeport site was especially impressive with a 10-fold reduction in fruit injury from 1995 to 1996. The Orondo site (W2) provided the major challenge for controlling CM in 1996. Greater CM pressure at this site than at other sites resulted in unacceptable levels of control in NNAI and conventional (CONV) blocks. Six applications of the organophosphate insecticide, azinphosmethyl (Guthion®), did not prevent CM from infesting 1% of the fruit in the CONV block. Very poor control of CM occurred in the NBSI block at this site, with 6.1% fruit injury recorded for the season. Only a single Confirm spray was applied for control of second generation larvae because very low moth catches indicated this would be sufficient. Most of the infestation occurred late in the summer, when Confirm residues were probably very low. One acre on the upslope edge sustained close to 50% fruit injury. Fruit in this area was picked and destroyed prior to larvae leaving the fruit in an effort to reduce potential CM pressure for next season. Fruit injury dropped to 5.8% in the four acres directly below the area of very high infestation. Excellent CM control was achieved in the lower five acres of the NBSI block, with no fruit injury observed at harvest.

Improvement in control of LR in 1996 compared to 1995 was quite dramatic (Fig. 1).

Greater than 1% fruit injury was recorded in four of six NBSI orchards in 1995, while very low, nearly undetectable, levels of damage were recorded in all NBSI orchards in 1996. Control of this pest at The Dalles site (D1) was especially impressive, with a reduction in fruit injury from 9% in 1995 to 0.3% in 1996. Much of the success of the 1996 management program can be attributed to the availability of tebufenozide. Overall, leafroller control was better in tebufenozide treated than in *Bt* treated areas.

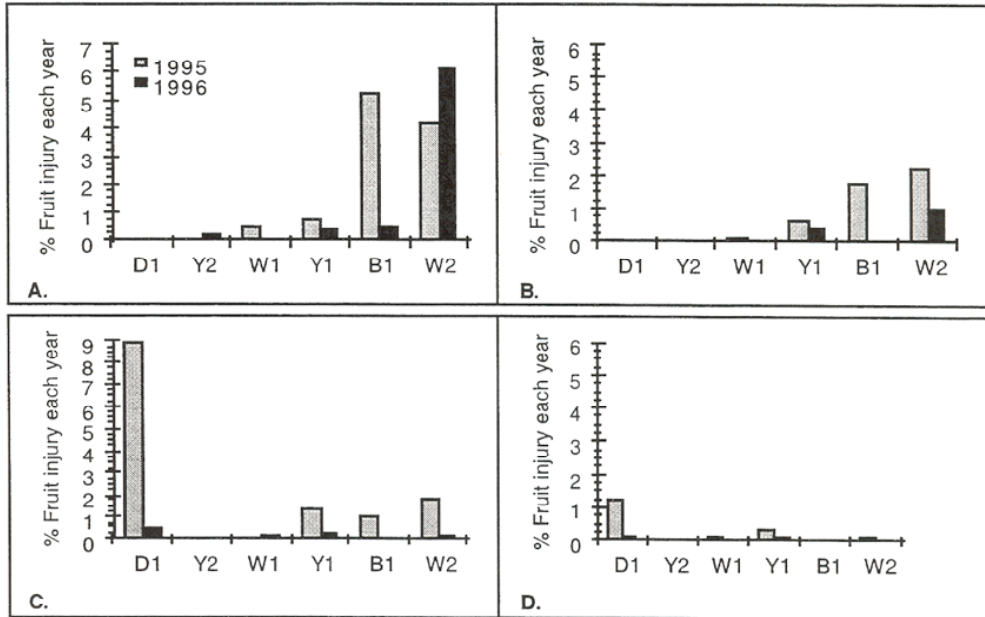
Other arthropod pests were generally at low levels in the NBSI orchards. Substantial numbers of campyloomma nymphs were detected at the Yakima site (2.5 nymphs per tray at bloom). The orchard was treated with a botanical insecticide, Neemix 4.5®. Post-treatment beating tray samples indicated no reduction in campyloomma densities, and by petal fall they had actually increased to 5.1 nymphs/tray. Natural enemies contributed to the suppression of several potential pests. Mite and aphid predators, and the leafminer parasitoid, *Pnigalio flavipes*, were especially abundant in NNAI blocks. Three pest species, white apple leafhopper, green apple aphid and tentiform leafminer, reached population densities that required intervention with insecticides in at least one of the CONV orchards. White apple leafhopper densities were high in two of the NNAI blocks. A substantial level of leafhopper mortality was observed at the Wapato site following a late summer application of Vaporgard for control of this pest.

**Parasitoid releases.** Several parasitoids were released in NBSI orchards. Augmentative releases of two parasitoids of cocooned CM larvae, *Liotryphon caudatus* and *Mastrus ridibundus*, were made late in the summer at the Orondo and Bridgeport sites. Approximately 1000 females of each species were released in two acres of the NBSI blocks at the two sites. Trap cardboard bands and sentinel hosts in bands were placed in the orchards prior to the release. Over 50% of the CM larvae collected in trap bands were parasitized. *Colpoclypeus florus*, a larval ecto-parasitoid of LRs, was released in the spring in four NBSI blocks and again in the summer in two of the blocks. Two thousand females were released each time in two-acre sections of the blocks. Parasitized larvae were recovered at all sites, but levels of parasitism by *C. florus* were fairly low, averaging less than 20%.

**Arthropod biodiversity.** Three methods were used to document broader changes in arthropod biodiversity. Sweep net samples of the orchard ground cover and soil samples were taken once in August of 1994 and three times during the 1995 and 1996 seasons. A majority of the 2500 samples have been processed, with over 100 families, mostly representing eight orders of insects and mites, identified to date. For both soil and sweep net samples, no clear patterns of change in biodiversity are evident. Pit fall traps were used to sample biodiversity for the first time in 1996. Results of pit fall trapping have revealed some consistent differences in biodiversity in NBSI and CONV orchards. Of greatest interest is the significantly higher numbers of predatory ground beetles in the NBSI orchards compared to the CONV orchards.

**Comparison of control programs.** Spray records for the six paired orchards indicated some consistent patterns of insecticide use. An average of four azinphosmethyl applications was made in CONV blocks in 1995 and 1996. In NBSI blocks, codling moth control was provided by one application of pheromone and an average of about 1.5 applications of oil (1995) or tebufenozide (1996). Leafrollers required nearly two insecticide applications in both CONV and NBSI blocks. More insecticides were applied in CONV than in NBSI blocks for control of

secondary or minor pests. No sprays for aphids or leafminers were applied to NBSI blocks. In contrast, half of the CONV blocks were treated with an aphicide each year and at least one block was treated with oxamyl for leafminer control each year.



**Figure 1.** A) codling moth fruit injury in NBSI blocks, B) codling moth fruit injury in CONV blocks, C) leafroller fruit injury in NBSI blocks, and D) leafroller fruit injury in CONV blocks.