HortScience 24(5):803–805. 1989.

Highbush Blueberry Firmness Following Insecticide Applications

R.L. Meagher, Jr.[1] and J.R. Meyer[2]
Department of Entomology, Box 7626, Grinnells Lab, North Carolina State University, Raleigh, NC 27695-7626

Additional index words. *Vaccinium corymbosum*, fruit quality, malathion, carbaryl, blueberry stunt

Abstract. **Grower reports of increased fruit softening following insecticide use prompted this 2-year study to determine if insecticides commonly used against arthropod pests in blueberries (*Vaccinium corymbosum* L.) caused significant fruit softening. Following applications of malathion or carbaryl, firmness (mean chord stiffness) of the fruit was determined with a blueberry compression instrument. No significant decreases in firmness were found due to post-bloom insecticide applications, but berries became softer with time after harvest. Chemical names used: 1-naphthyl methylcarbamate (carbaryl); diethyl mercaptosuccinate, *S*-ester with O,O-dimethyl phosphorodithioate (malathion).**

Insecticides are used in production of high-quality blueberries in North Carolina. In southeastern North Carolina, control of the blueberry maggot (*Rhagoletis mendax* Curran) is necessary. Sprays are usually applied during June at 7- to 10-day intervals, and two or three applications may be made. Growers have reported that berries sprayed with preharvest insecticides soften faster after harvest than unsprayed berries. The objective of this study was to determine if insecticides are responsible for the reported increased fruit softening.

Previous research on the effects of pesticides on quality factors have shown that some insecticides, such as phosmet, had no association with off-flavors or flavor impairment when applied to lowbush blueberries (9). In apples, positive effects from fungicide and insecticide applications were shown in quality and gustative factors and in biochemical composition (5, 6). Factors influencing firmness in blueberries, such as ripeness stage, size, cultivar, bruising, decay (1), and hand- vs. machine-harvesting have been studied (2).

In 1987, 'Bluecrop' highbush blueberry plants located at University Research Unit 4, Raleigh, were sprayed with dilute solutions of two commercially formulated insecticides using a FCX Unico stainless steel hand sprayer. No other pesticides were applied to these plants either before or during the study. The treatments were: 1) malathion 57% EC applied at the recommended rate of 539 ml a.i. in 378 liters, 2) carbaryl 50WP applied at the recommended rate of 227 g a.i. in 378 liters, and 3) water control. Two applications to each plant were made on 14 and 23 June, when fruit was ripe. Each treatment consisted of three or four plants in a random design. The plants were sampled by harvesting the ripest fruit on the spray date, and 1, 3, and 6 days after the first application, and 1 and 3 days after the second application.

Fruit was held in open pint (473 cm^3) containers in a laboratory at 20 ± 0.7C and 16 RH. Blueberry firmness was tested 0, 24, 48, and 96 hr after harvest. Berries were pooled from the plants and three replications per treatment were tested for firmness by a blueberry compression instrument (BCI) modified from Slaughter and Rohrbach (8). The BCI compresses 10 berries simultaneously between two plates in a nearly parallel arrangement. The compression deformation was measured with a transformer and time was measured with a real time clock. The plates stopped if either the transformer reached its maximum stroke length (1 mm) (MSL) or 60 sec elapsed. Firmer berries increased the time the transformer took to reach the MSL. Time data were converted to mean chord stiffness (MCS), a measure of force/distance ($N \cdot m^{-1}$) using a linear regression formula from Slaughter and Rohrbach (8). Analysis of variance [Proc ANOVA, SAS Institute (7)] was used to separate the main effects of treatment and Proc REG was used to analyze harvest date and testing hour trends.

In 1988, six highbush blueberry cultivars (Wolcott, Murphy, Bluecrop, Croatan, Blueray, and Harrison) growing in a 1.6-ha field at the Horticultural Crops Research Station at Castle Hayne, N.C. were tested. The field was arranged in two randomized blocks of three cultivars each with five rows per cultivar, 15 plants per row. Preharvest fungicides (benomyl, triforine, and captafol) were applied in March and April, and two applications of malathion 57% EC (1079 ml a.i. in 378 liters) were applied in May to the entire field. Treatment insecticide sprays were applied to two rows (with two guard rows) using a Tifone airblast sprayer. The treatments were: 1) malathion 25WP (227 g a.i. in 378 liters), 2) malathion 57% EC (237 ml a.i. in 378 liters), 3) carbaryl 50WP (227 g a.i. in 378 liters), and 4) water control. Sprays were applied to 'Wolcott' on 31 May and 14 June; 'Bluechip', 'Croatan', and 'Murphy' on 7 and 21 June; and 'Blueray' and 'Harrison' on 14 and 28 June.

Berries were harvested from the treated rows by randomly picking the ripest fruit on the spray date, and 1, 3, and 7 days later. Four sets (to correspond to 4 testing hr) of 40 berries each were picked, with a total of 30,720 berries harvested during the study. Fruit was held in open pint (473 cm^3) containers stored in coolers while in the field and in a growth chamber at 30 ± 0.5C, 16 RH in the dark for the storage treatments. Blueberry firmness was tested by means of the BCI at 0, 24, 48, and 72 hr after harvest. Each treatment sample contained three replications and a total of 23,040 berries were tested.

Time data were converted to MCS and analysis of variance [Proc ANOVA, SAS Institute (7)] was used to separate the main effects of treatment, harvest date, testing hour, and all interactions. Additionally Proc REG

Table 1. Firmness (mean chord stiffness, $N \cdot m^{-1}$) of 'Bluecrop' blueberries among insecticide treatments for two application trials (14 and 23 June). Means were not significantly different among treatments (first trial, $P = 0.3031$; second trial, $P = 0.2848$), Raleigh, N.C., 1987.

Insecticide[z]	Firmness (mean ± SE)
First trial	
None	681 ± 14
Malathion	675 ± 15
Carbaryl	666 ± 15
Second trail	
None	631 ± 23
Carbaryl	620 ± 20
Malathion	618 ± 20

[z]Treatments: none, water control; malathion 57% EC (539 ml a.i. in 378 liters); carbaryl 50WP (227 g a.i. in 378 liters).

Table 2. Firmness (mean chord stiffness, $N \cdot m^{-1}$) of highbush blueberries among insecticide treatments for two application trials. Means were not significantly different among treatments (first trials, $P = 0.7931$; second trials, $P = 0.6043$), Castle Hayne, N.C., 1988.

Insecticide[z]	Firmness (mean ± SE)
First trial	
Malathion WP	664 ± 12
Malathion EC	652 ± 11
Carbaryl	646 ± 11
None	646 ± 11
Second trial	
None	630 ± 10
Malathion WP	626 ± 10
Malathion EC	606 ± 9.9
Carbaryl	598 ± 9.2

[z]Treatments: none, water control; malathion 25WP (227 g a.i. in 378 liters); malathion 57% EC (237 ml a.i. in 378 liters); carbaryl 50WP (227 g a.i. in 378 liters).

Received for publication 11 Oct. 1988. Paper no. 11856 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7643. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[1]Assistant Professor. Current address: Texas Agricultural Experiment Station, Weslaco, TX 78596.
[2]Professor.

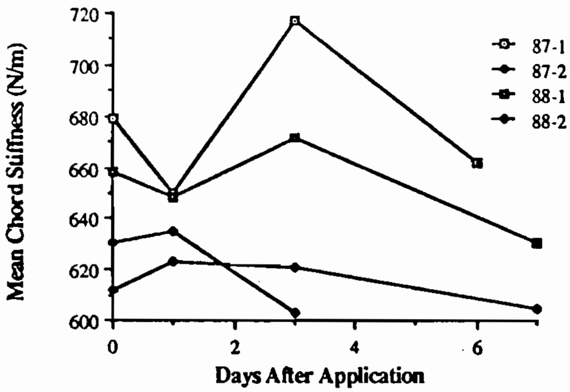

Fig. 1. Blueberry firmness ($N \cdot m^{-1}$) vs. days of harvest after insecticide applications for two applications each in 1987 and 1988.

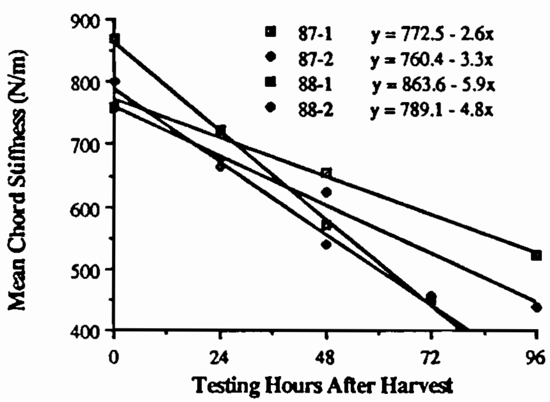

Fig. 2. Linear regression of blueberry firmness ($N \cdot m^{-1}$) vs. testing hours after harvest for two insecticide applications each in 1987 and 1988. All regressions were significant, $P < 0.0001$.

was used to analyze harvest date and testing hour trends. The experiment was designed as a split-plot with insecticide treatment as the whole plot, cultivar as the subplot, harvest date as the sub-subplot, and testing hour as the sub-sub-subplot. The blocking gradient was geographical distance from a pine woods border, a factor important because of a higher incidence of blueberry stunt in bushes closer to the woods. Bushes infected with stunt produced fewer berries and made it difficult to randomly harvest testable fruit. Because of the field design of the blocks and cultivars in the planting, the effects of cultivar were confounded within the variation of blocks. Thus, little statistical inference will be made concerning difference among cultivars.

Mean chord stiffness means for the 1987 application trials were not significantly different among treatments (first trial, P = 0.3031; second trial, P = 0.2848 (Table 1). Regression analysis was not significant for harvest dates (first trial, P = 0.9666; second trial, P = 0.2924) (Fig. 1), but there was a significant regression for testing hours (both trials, $P < 0.0001$) (Fig. 2). Blueberries held at 20C for >1 day were significantly less firm than more recently picked berries. This was evident not only from the BCI data, but also by fruit inspection. In the first trial, none of the interactions between main effects was significant. In the second trial, the treatment by harvest date interaction was significant and graphical representation showed both changes in the direction and the magnitude of the response. Since treatments were not significantly different and harvest date was not an important factor in this study, no further analysis was completed.

Results for the 1988 trials showed that treatment means were not significantly different (first trial, P = 0.7931; second trial, P = 0.6043), but the order of the means was different between trials (Table 2). During the first trial, the insecticide-treated berries were all slightly firmer than the control berries, but during the second trial, berries sprayed with water were firmer than berries from any of the other treatments. Regression analysis for both trials were significant for testing hours (both trials, P = 0.0001) (Fig. 2) but not for harvest dates (first trial, P = 0.1124, second trial, P = 0.3556) (Fig. 1). As was shown from results in the 1987 study, berries held for longer intervals were significantly softer.

The amount of variation attributed to the combination of blocking and cultivars was important to the nonsignificance of many of the models, since this term was all or part of the error terms (denominator in the F value). Bushes infected with stunt produce lower fruit yields and berries with lower sugar content (4). For example, in some of the rows close to the woods, only two or three bushes produced standard highbush-quality blueberries. The effect of the woods on blueberry stunt is related to the higher incidence and migration of *Scaphytopius* leafhoppers, which transmit the mycoplasma-like organisms (3, 10).

The effect of cultivars cannot be statistically inferred, but there was a wide difference in firmness between 'Bluechip' (739 $N \cdot m^{-1}$ ± 13), 'Blueray' (690 ± 13), and 'Harrison' (656 ± 13) and 'Wolcott' (578 ± 9.5), 'Murphy' (571 ± 11), and 'Croatan' (567 ± 11). Slaughter and Rohrbach (8) found very similar MCS means when they tested an earlier prototype of the BCI. Their results showed 'Bluechip' (720 ± 17) and 'Harrison' (681 ± 38) to be the firmest cultivars tested, while 'Croatan' (565 ± 20) and 'Murphy' (515 ± 22) were the softest.

Little work has been done on the effects of pesticides on physical postharvest parameters such as fruit firmness; however, this work suggests no insecticide effect on fruit firmness by either malathion or carbaryl on several cultivars of highbush blueberries.

Literature Cited

1. Ballinger, W.E., L.J. Kushman, and D.D. Hamann. 1973. Factors affecting the firmness of highbush blueberries. J. Amer. Soc. Hort. Sci. 98:583–587.
2. Mainland, C.M., L.J. Kushman, and W.E. Ballinger. 1975. The effect of mechanical harvesting on yield, quality of fruit, and bush damage of highbush blueberry. J. Amer. Soc. Hort. Sci. 100:129–134.
3. Meyer, J.R. 1984. Life history of the sharpnosed leafhopper [*Scaphytopius magdalensis* (Provancher)] and four related species in southeastern North Carolina. J. Ga. Entomol. Soc. 19:72–87.
4. Milholland, R.D. and J.R. Meyer. 1984. Diseases and arthropod pests of blueberries. N.C. Agr. Expt. Sta. Tech. Bul. 468.
5. Rouchaud, J., C. Moons, and J.A. Meyer. 1984. Cultivar differences in the effects of fungicide and insecticide treatment of apples. Scientia Hort. 23:67–74.
6. Rouchaud, J., C. Moons, and J.A. Meyer. 1986. Effects of fungicide treatments on the gustative quality and the biochemcial composition of apples. HortScience 21:1056–1058.
7. SAS Institute, Inc. 1982. SAS user's guide: Statistics. SAS Institute, Inc., Cary, N.C.
8. Slaughter, D.C. and R.P. Rohrbach. 1985. Developing a blueberry firmness standard. Trans. Amer. Soc. Agr. Eng. 28:986–992.
9. True, R.H., H.Y. Forsythe, Jr., and E.S. Barden. 1978. No off-flavor associated with imidan-treated blueberries. HortScience 13:154–155.
10. Whitney, S.P. and J.R. Meyer. 1988. Movement between wild and cultivated blueberry by two species of sharpnosed leafhoppers (Homoptera: Cicadellidae) in North Carolina. J. Entomol. Sci. 23:88–95.