FINAL REPORT

PROJECT NO: 3748

TITLE: Management of Micronutrients in Washington Orchards

YEAR INITIATED: 1996-97 **CURRENT YEAR:** 2000-01
TERMINATING YEAR: 2000-01

PRINCIPAL INVESTIGATOR: F. J. Peryea, Assoc. Soil Scientist/Assoc. Horticulturist, WSU Wenatchee

CO-INVESTIGATORS: (fruit chemical analyses)
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JUSTIFICATION:
See Proposal for 2000-2001.

OBJECTIVES:
The objective of the research was to update and improve guidelines for use of micronutrients in Washington orchards.

PROGRESS (2000-2001):
NOTE: The early date for submission of this proposal/report regrettably does not allow for a complete report on research results for 2000-01 funding year. I am awaiting the results of 225 plant tissue samples sent to the University of Wisconsin for chemical analysis. Comprehensive research results should be available by the time of the Research Commission review.

1. I continued a field study initiated in 1996 to compare the effectiveness of different foliar B fertilizers, including some new ones designed to have improved handling characteristics over the existing standard Solubor. The test trees are Fuji/M.26 grown on a Cashmont gravelly sandy loam soil. No sprays were applied in 2000 in order to evaluate residual effects of the last four years of B sprays applied at pink timing. Treatments in 1996-1999 were (1) water control; (2) Mor-Bor 17 (powder, 17.3% B); (3) Solubor (powder, 20.5% B); (4) Solubor DF (dry flowable, 17.4% B, more easily dissolved polyborate form now marketed in the USA); (5) Spraybor (powder, 16.5% B, less alkaline polyborate form from South Africa); (6) Borosol (liquid, 10% B, boric acid stabilized by amino compound); (7) Liquibor (liquid, 2.5% B, liquid boric acid); (8) N-Boron (5.4% B, boric acid plus urea to enhance B uptake); (9) Solubor plus Coron (polymeric urea compound to enhance B uptake); and (10) Solubor applied only to the ground. Flower cluster and leaf samples were collected for mineral element analysis (flower cluster analyses are completed), and fruit samples were collected and assessed for quality attributes.

   Flower cluster B in all of the B treatments dropped almost to the Water Control concentration of 26.4 ppm (Fig. 1), confirming the WSU recommendation to apply B annually. None of the B products differed in residual effect on flower cluster B or in any of the other 12 elements analyzed. There was a slight effect on machine color values L, a and b which, when transformed into human visual perception, means that fruit from trees treated in past years with Mor-Bor 17 were slightly redder than fruit from trees treated with the other B products. Firmness, soluble solids concentration, titratable acidity, and fruit weight were not influenced by past differential B treatments.

2. I continued a field study initiated in 1998 to compare the effectiveness of several other foliar B fertilizers and added a new liquid B fertilizer, Boron X-tra. The test trees are Fuji/M.26 grown on a Cashmont gravelly sandy loam soil. The sprays were applied by handgun at first pink. All tested materials were applied at the WSU B deficiency rate (1.0 lb B/acre) instead of the previous year's 0.5 lb B/acre maintenance rate because the 1999 data indicated that the trees were growing into deficiency despite using the B maintenance sprays in 1998. Treatments were water control; Solubor; Mor-Bor 17; B-17 (boric acid powder, 17% B); Albion Liquid Boron (liquid amino acid complex, 5% B); and Boron X-tra (boric acid liquid with biostimulants, 5% B). Flower cluster and leaf samples were collected for mineral element analysis (flower cluster analyses are completed), and fruit samples were collected and assessed for quality attributes.

   All of the B sprays increased flower cluster B. There was no significant difference between the five B products. The 1.0 lb B/acre rate increased flower cluster B about 100 ppm more than did the previous year's 0.5 lb B/acre maintenance rate. The two products made from sodium polyborates, Solubor and Albion Liquid Boron, increased flower cluster sodium. There were no horticulturally significant treatment effects on fruit quality.

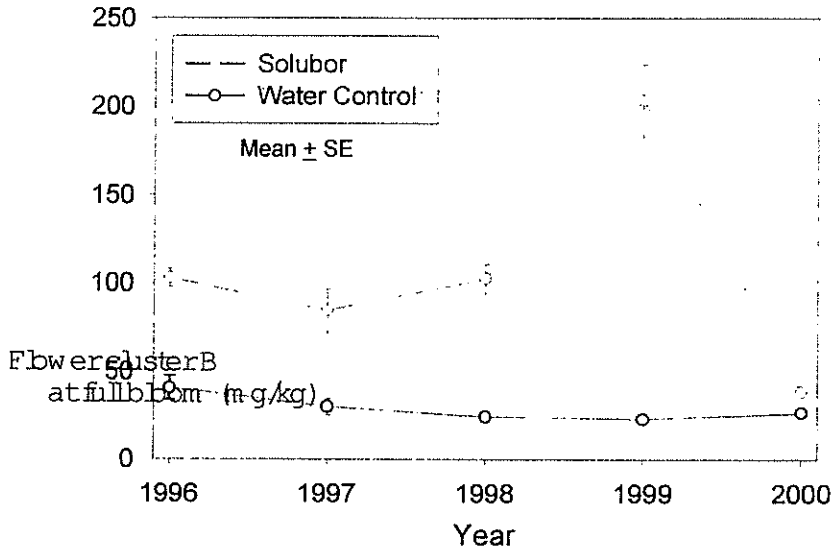

Fig. 1. Effect of B spray program on flower cluster B of Fuji apple:
0.5 lb B per acre, sprayed at pink timing (1996-98);
1.0 lb B per acre, sprayed at pink timing (1999);
no sprays in 2000. All B products performed similar to Solubor.

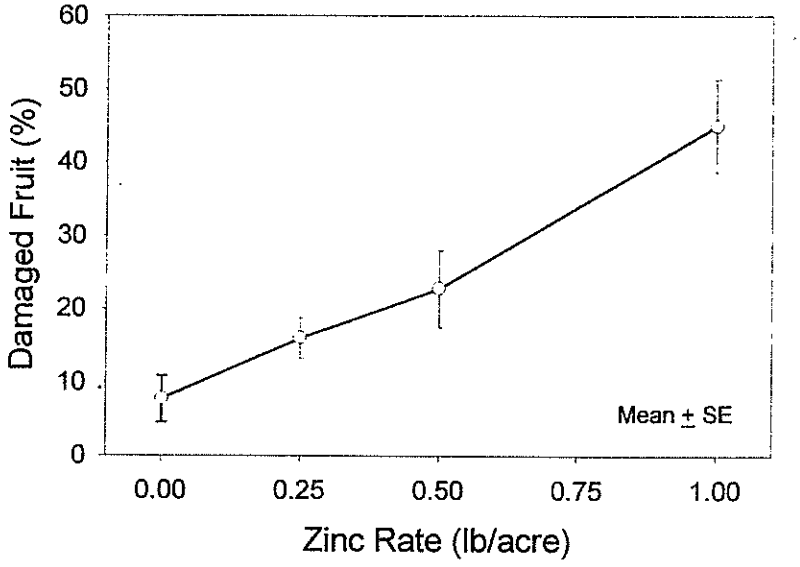

Fig. 2. Fruit damage resulting from multiple postbloom sprays of zinc nitrate tank-mixed with calcium nitrate (6 lb/acre) applied to bearing 'Golden Delicious' apple trees.

3. I initiated a field study examining the safety and effectiveness of postbloom applications of 12 Zn products to bearing Golden Delicious/M.9 apple trees in Wenatchee. The products were selected on the bases of popularity or type of ligand accompanying the Zn ion. The Zn products were Biomin Zinc (liquid, Zn glycine); CM Liquid 9% Zinc (liquid, Zn lignosulfonate); Keylate Zinc (liquid, Zn EHPC chelate); Nutra-phos 0-24-0 (powder, Zn sulfate and Zn phosphate); Nutra-phos Zn-K (powder, Zn phosphate); Nutra-spray Zinc (powder, basic Zn sulfate); Tech-flo Zeta Zinc

22 (liquid, basic Zn sulfate); Zinc Metallosate (liquid, amino acid-complexed Zn); zinc nitrate (powder, reagent grade); Zinc X-tra (liquid, Zn sulfate with biostimulants); ZincMax (liquid, Zn organic complex); and Zinc polyamine (liquid, Zn glucosamine). The products were applied three times on a triweekly basis starting in June at a rate of 0.5 lb actual Zn per acre. Leaf samples were collected and processed three ways (unwashed, normal detergent wash, and detergent plus acid wash) to evaluate the effectiveness of the routine leaf washing procedure and to estimate the amount of total leaf Zn that actually has penetrated into the leaf. Winter bud samples will be collected in January and analyzed for Zn and 12 other elements to provide an estimate of tree Zn status unbiased by spray residues. Fruit samples were inspected for spray damage after each spray application.
There was NO fruit injury caused by any of the Zn spray treatments, suggesting that all of these products have promise as postbloom spray materials. The leaf analyses are ongoing and will be available for the Research Commission meeting.

4. I initiated a field study examining the possibility of tank-mixing Zn with calcium sprays for bitter pit control. Because of the known incompatibility between Zn and calcium chloride, I chose to use calcium nitrate as the calcium source and Zn nitrate as the Zn source. This assumes that use of the same accompanying anion, nitrate, would preclude incompatibilities. Treatments were three triweekly sprays starting in June of 6 lb calcium nitrate per acre in combination with 0, 0.25, 0.5, and 1.0 lb Zn as Zn nitrate per acre. The test trees were bearing Golden Delicious/EMLA.7 in Wenatchee. Leaf samples were collected, processed and analyzed as described in Expt. 3. Winter bud samples will be collected in January and analyzed for Zn and 12 other elements to provide an estimate of tree Zn status unbiased by spray residues. Fruit samples were inspected for spray damage after each spray application. All fruits were harvested in September, and a subsample was evaluated for spray damage.
   Spray damage was linearly related to Zn application rate (Fig. 2). These results indicate that an incompatibility between Zn and calcium also exists for calcium nitrate, supporting the need to evaluate other calcium sources if postbloom Zn treatments are to be safely applied.

5. I tested a portable professional root feeding system to evaluate its possible utility for studies of soil injection of Zn solutions. It quickly became apparent that the system would have to be modified to work properly with the compacted soils often found in orchards. Given the lack of interest in soil injection shown at the 1999 Research Commission meeting, I decided that my time would be better spent focusing on foliar Zn spray research rather than on soil Zn injection.

SUMMARY CONCLUSIONS (1996-2001):
Copper (Cu) in Kocide is not phytoavailable, making Kocide unsuitable as a Cu fertilizer source.

Prebloom Cu sprays applied at rates up to 0.2 lb actual Cu per 100 gal have no effect on apple leaf Cu status.

Prebloom Cu sprays applied at rates up to 0.2 lb actual Cu per 100 gal do not influence typiness of Delicious apples.

Three midsummer Cu sprays applied at rates up to 0.3 lb actual Cu per 100 gal (0.7 lb per acre) substantially increase leaf Cu concentrations but do not influence red color or typiness of Delicious apples.

Most of the leaf Cu derived from foliar sprays appears to occur as non-phytoavailable residue on the leaf surfaces. Very little leaf Cu is resorbed into the tree before defoliation in the fall. As a result, foliar Cu sprays have no or a very small residual effect on tree Cu status, creating a requirement for

annual maintenance sprays to maintain high tree Cu status. That said, there is little evidence of Cu deficiency in Washington apple trees even though leaf Cu concentrations are lower than they have been in the past. Part of the reason may be that use of Cu fungicide sprays was much more common than in recent times and may have caused leaf Cu levels to be artificially high.

Delayed-dormant sprays of basic Zn sulfate applied at rates up to 1.0 lb actual Zn per 100 gal have no effect on apple leaf Zn status.

Tank mixes of Zn nitrate and calcium nitrate can damage apple fruit finish, causing small black lesions and slight fruit deformation.

There are some Zn spray products that appear to be safe for postbloom applications to bearing apple trees.

All tested B spray products performed the same in terms of providing B to apple trees. This means B in the cheapest B product is just as phytoavailable as B in the most expensive B product. Special additives or formulations have no enhancing effect on B uptake. The choice of B product therefore can be determined on the basis of effect on spray water pH, organic certification compliance, cost, and handling characteristics, which are summarized in Peryea (1998) and Peryea (1999).

The amount of sodium supplied by sodium polyborate-based B sprays applied at nutritional rates is too low to influence fruit tree performance or fruit quality.

Claims by some B fertilizer manufacturers about product chemistry and agricultural performance may be incorrect.

Timing of B maintenance sprays to apple is not critical as long as the trees are not B-deficient.

The annual maintenance B requirement can be safely and effectively applied in split applications tank-mixed in the early season calcium chloride sprays.

The standard B maintenance rate of 0.5 lb actual B per acre may be inadequate for trees grown on coarse-textured soils. A maintenance rate between 0.5 and 1.0 lb per acre may be more appropriate.

Leaf B concentration appears to be a suitable measure for assessing apple tree B status.

INFORMATION TRANSFER:

Publications (as of 11/8/00):

Peryea, F.J. 2000. Midsummer copper sprays have no effect on 'Delicious' apple fruit color grade or typiness. J. Plant Nutr. 23:507-515.

Peryea, F.J. 2000. Recommended prebloom copper spray has no effect on 'Delicious' apple tree copper status or fruit typiness. J. Plant Nutr. 23:517-258.

Peryea, F.J., and J.M. Lageschulte. 2000. Boron fertilizer product and concentration influence spray water pH. HortTechnol. 10:350-353.

Peryea, F.J. 1999. Boron products for foliar sprays: 1999 update. Good Fruit Grower 50(8):48.

Peryea, F.J., R. Kammereck, and G.F. Fairchild. 1999. Effect of copper spray chemistry on apple fruit russetting and leaf tissue copper status. p.438-439. Proc. 5th Int. Conf. Biogeochem. of Trace Elements, vol. I, Vienna, Austria. 11-15 July 1999.

Peryea, F.J., K. Lorentz, and J.M. Lageschulte. 1999. Comparison of Solubor versus Albion Liquid Boron sprays at pink timing. p.18. Poster Session Abstr. 37, 95th Annu. Mtg. Washington State Hort. Assoc. 6-8 Dec. 1999.

Peryea, F.J., and J.M. Lageschulte. 1998. Effect of boron fertilizer source and concentration on spray water pH. *In* 1998 Proc. 94rd Ann. Mtg. Washington State Hort. Assoc. 7-9 Dec. 1998.
Peryea, F.J. 1998. Boron products for foliar spray applications. Good Fruit Grower 49(8):41,43-44.
Peryea, F.J. 1996. Boron products for spray applications evaluated. p.47-48. *In* 1996 Proc. 92nd Ann. Mtg. Washington State Hort. Assoc. 2-4 Dec. 1996.

Presentations:

Results of this research project were presented as posters at the 1997-2000 annual meetings of the Washington State Horticultural Association (although for some reason my the abstract for my poster *Effect of boron products and acidifiers on spray tank pH* was not published in the proceedings of the 1997 meeting). The results also were presented at a variety of grower and agricultural consultant meetings from 1996-2001.

Other:

The results of this research project were used to update the B and Cu spray recommendations in the Nutrient Spray section of the WSU Crop Protection Guide for Tree Fruits in Washington, Coop. Extension Bulletin EB0419.

REQUEST FOR FY 2001-02:

Amount allocated by the Commission in FY 2000-01:	$17,300
Amount requested for 2001-02:	None