# Effect of Calcium, Boron and Naphthalene Acetamide Sprays on Cork Spot and Mineral Content of York Imperial Apple[1]

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*Abstract.* Boron, calcium, and naphthalene acetamide (NAAm) foliar sprays were applied alone or in combination to 'York Imperial' apple trees under Eastern Pennsylvania orchard conditions. Mineral content of the leaves and fruit and number of cork spots in the fruits were determined.

B applications alone or in combination with Ca and/or NAAm increased leaf and fruit B content. All Ca applications increased the leaf Ca content, the fruit P content, and the leaf and fruit K and Fe content, but had no effect on fruit Ca content. NAAm sprays increased the leaf Mg and Al content. NAAm applied in combination with Ca increased the leaf Ca content. The NAAm effects appear to be associated with the valence of the element, having no effect on monovalent elements, some effect on divalent elements, and the strongest effect on the trivalent element, Al.

Th B-Ca and B-Ca-NAAm spray treatments reduced the number of cork spots per fruit. Regression analysis indicated that as the B and Ca content increased in the leaves, and fruit peel and flesh the cork spots decreased. Cork spots increased as the P and K content of the leaves increased. Core data showed that cork spots decreased as the B and Mg content increased and the B × Mg interaction decreased. There was no relation between number of cork spots and the leaf and fruit content of Mn, Fe, Cu, Zn, or Al, despite significant effects of the treatments on these elements.

No completely satisfactory control for cork spot of apple has been devised in spite of extensive studies over many years (1).

Hewetson (2) initiated an experiment in southern Pennsylvania in 1964 in which sprays of calcium, boron, and naphthalene acetamide (NAAm) alone and in various combinations were applied yearly to 'York Imperial' trees in an attempt to control York spot. In some years, cork was reduced appreciably; in other years there was a limited or no effect. In 1966 and 1967, tissue samples were taken periodically during the growing seasons on 5 of the key treatments to investigate the nutrient content of the foliage and fruit and the amount of cork at harvest in 1967.

## Materials and Methods

A randomized block design replicated 6 times was established in 1964 in 2 mature 'York Imperial' orchards near Arendtsville, Pa.: (a) The Keller orchard and (b) the McDannell Bros. orchard. Leaf and fruit samples were taken at weekly intervals from 5 of the 13 treatments in 1967; only leaf samples were taken in 1966. The spray treatments from which samples were taken in 1966 were: (a) check—no spray; (b) NAAm at 10–11 mm diam. of fruit; (c) boron at bloom and 1 and 6 weeks after full bloom (AFB); (d) Ca at 2, 3, 6 and 7 weeks AFB; and (e) boron at bloom and 1 and 6 weeks AFB, calcium at 2, 3, 6 and 7 weeks AFB, and NAAm at 10–11 mm fruit diameter. Tween 20, ½ pt, was added to all sprays. Concentrations in 100 gal of spray were: B—1 lb. Solubor; NAAm—25 ppm; Ca—2½ lb. $CaCl_2$; and Tween 20, ½ pt.

In 1967, the same treatments were used, except treatment (d) above was dropped and replaced with a combined B, Ca and T-20 spray at the 1966 concentrations and timing.

In 1966, only the Keller orchard was used because of a crop failure in the McDannell Bros. orchard. Application dates were May 16 and 23 for B; June 3 for NAAm; and May 31, June 8 and 29 and July 3 for Ca. Weekly leaf samples were taken starting May 19 until the appearance of cork on July 15. A sample consisted of 50 mid-shoot and spur leaves gathered at breast height around a tree. On May 19 and 26, leaf size was so small that one composite sample was made on each date from the 6 replicates in a treatment to obtain adequate tissue for analysis.

In 1967, data were taken only in the McDannell Bros. orchard due to a crop failure in the Keller orchard. Boron application dates were May 8, 9 and 16 and June 20; NAAm on June 8; and Ca on May 23 and 31, and June 21 and 28. Weekly leaf samples were started May 13 and continued until cork appeared on August 4, when they were taken every other week until harvest on September 22. Samples the first week were composited for all 6 replicates as in 1966. Due to a light crop, only 6 fruits per tree were collected on September 22 and divided into 2 replicates of 3 fruits each, which were separated into peel, flesh and core (without the seeds) after recording the number of cork spots in each fruit.

The data were analyzed for significance between treatments. Polynominal regression was performed to determine the relationship between number of cork spots per fruit and mineral content of the leaves, fruit, peel,

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flesh and core. Individual elements, ratios and products of elements (B, Ca, P, K, Mg) were used in regression analysis.

## Results

### leaf analysis

*Boron.* Spray applications of B in both 1966 and 1967 increased the B content of the leaves significantly. Fig. 1 for 1967 is typical. During the early B applications, leaf B exceeded 250 ppm, then gradually dropped to about 50 ppm, which is somewhat above the normal range of 20 to 40 ppm. York spot first was seen in 1966 on July 15. For the 2 seasons as a whole, the average leaf B content from about full bloom to July 15, 1966 and to harvest in 1967 was for the respective treatments (a) 1966: control, 22.8 ppm; NAAm, 22.7 ppm; Ca, 23.5 ppm; B, 48.4 ppm; and B-Ca-NAAm, 50.3 ppm; (b) 1967: control, 26.5 ppm; NAAm, 28 ppm; B, 86 ppm; B-Ca, 90.6 ppm; B-Ca-NAAm, 83.1 ppm.

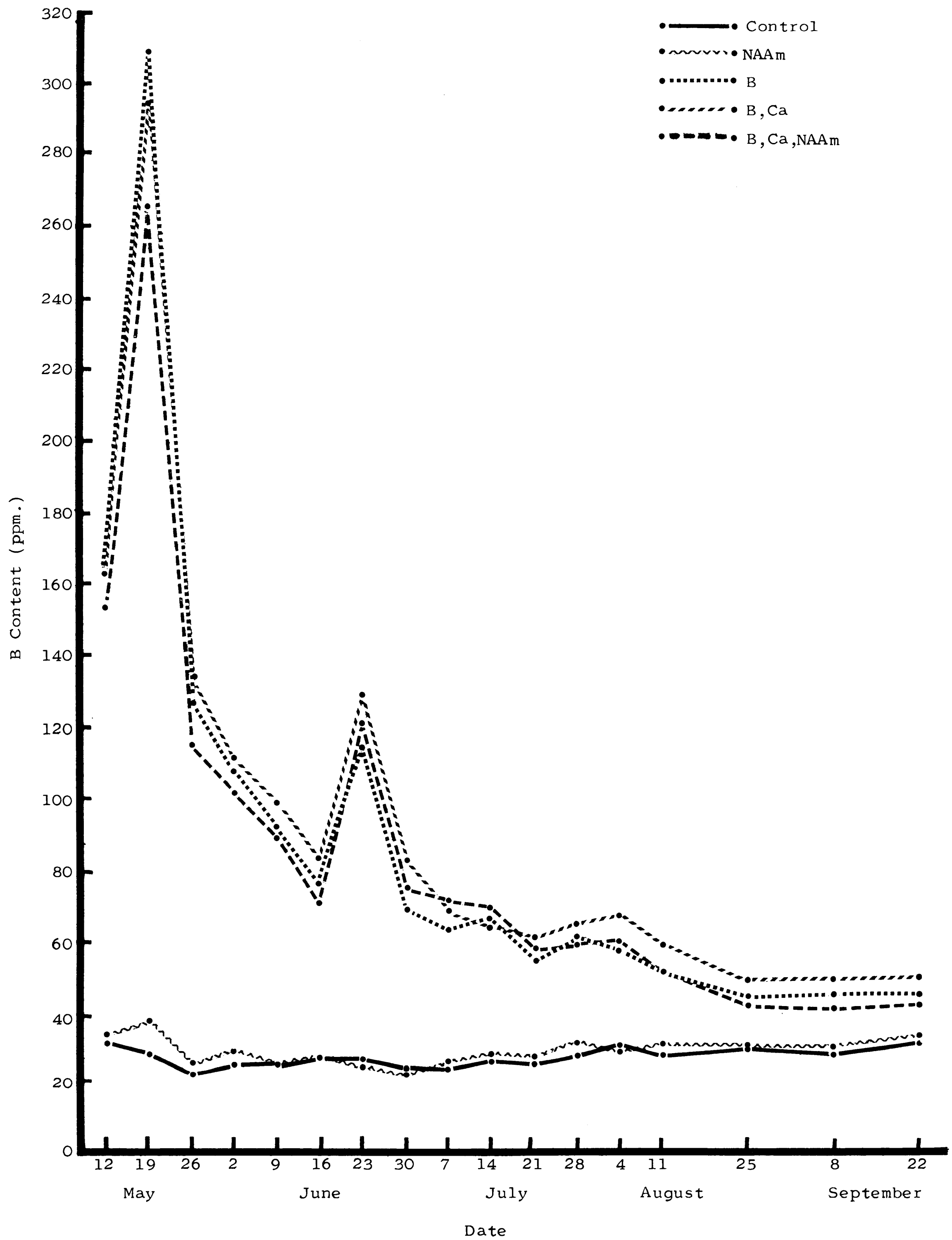


*Fig. 1.* Effect of B, Ca, and NAAm sprays on the weekly B content of York Imperial apple leaves in the McDannell Bros. orchard, Arendtsville, Pa., 1967.

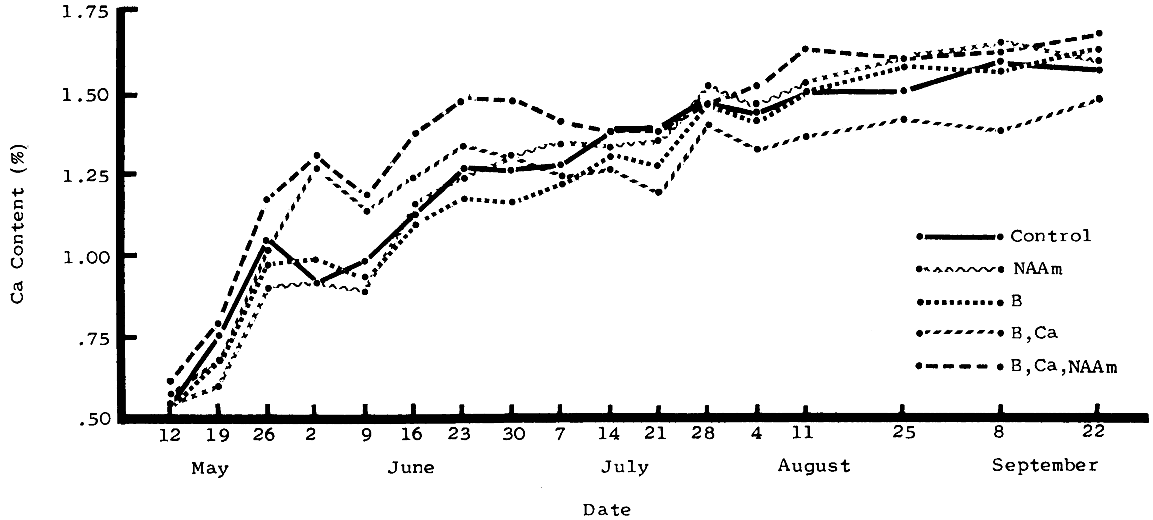


*Fig. 2.* Effect of B, Ca, and NAAm sprays on the weekly Ca content of York Imperial apple leaves in the McDannell Bros. orchard, 1967.

*Calcium.* In 1966, applications of 4 $CaCl_2$ sprays increased significantly the average leaf Ca content to 1.33% over the control level of 1.16%. In fact, the Ca content of leaves from both Ca treatments was consistently higher than in leaves of other treatments from June 3 to July 15, the last sampling date. The B-Ca-NAAm treatment induced an average leaf Ca content of 1.46% which was significantly different from the control and the Ca alone treatments. Other treatments did not show significant differences. These data indicate that NAAm apparently enhanced movement of Ca into the leaf. An increase in leaf Ca could be detected within 3 days after the first spray application.

In 1967, for the season as a whole, the Ca sprays did not significantly increase the average leaf Ca content. However, on a weekly basis, Fig. 2 shows that the B-Ca treated leaves had a higher Ca content from June 2 to 23 after spray treatments. The Ca-B-NAAm leaves also had more Ca than leaves not receiving Ca from May 26 to July 7 and from August 4 to 25.

*Phosphorus.* Only in 1966 were there differences in P content due to treatments and this was on a weekly basis, not a seasonal average. There was more P in the leaves treated with: (a) B from May 26 to June 24 and on July 15; (b) with Ca from May 19 to June 3; and (c) with B-Ca-NAAm from May 26 to June 18. In both 1966 and 1967, there was a normal dilution curve for P from 0.33 and 0.36% at bloom, respectively, to 0.14% on July 15, 1966 and to 0.17% at harvest, 1967.

*Potassium.* In 1966, there was little or no effect of the spray treatments on K content to July 15 when the sampling terminated. In 1967, however, as shown in Fig. 3, the K content of the foliage was increased significantly over the control by the B, B-Ca and B-Ca-NAAm sprays.

*Magnesium.* In 1966, leaf Mg was depressed by Ca sprays from June 17 to July 15, the end of sampling, whereas NAAm and B sprayed leaves contained more

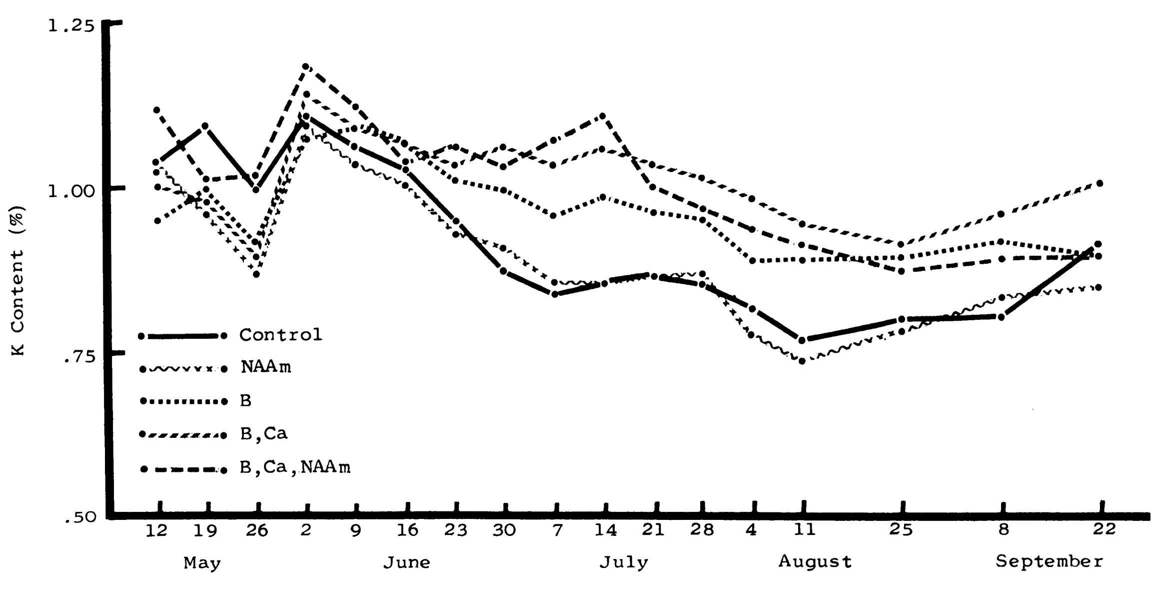


*Fig. 3* Effect of B, Ca, and NAAm sprays on the weekly K content of York Imperial apple leaves in the McDannell Bros. orchard, 1967.

Mg from June 24 to July 15. There were no differences in 1967. Mg increased gradually from 0.36 to 0.41% in 1966 and from 0.26 to 0.39% in 1967.

*Manganese.* In 1966, the NAAm and B sprayed leaves at times showed more Mn, whereas Ca sprayed leaves had less. No differences occurred in 1967. Mn leaf content dropped with season from 133 to 79 ppm in 1966 and from 232 to 57 ppm in 1967.

*Iron.* Fe content was depressed on May 19, 1966, by all sprays with an increase on July 8 by the Ca spray. Fe content in 1967 was significantly increased by Ca sprays but decreased where NAAm was used. Seasonal Fe in the controls showed unrelated ups and downs.

*Copper.* The NAAm, B and Ca sprays tended to reduce leaf Cu content in 1966 with no effect in 1967. Cu dropped with season from 18 to 10 ppm in 1966 and from 14.9 to 8.4 ppm in 1967.

*Zinc.* There were no effects of sprays on leaf Zn in 1966, whereas in 1967 all sprays increased the average Zn content significantly by 1½–2 ppm. There was a downward trend in leaf Zn from the 150's to 37 ppm in 1966 and from 30 to 14 ppm in 1967.

*Aluminum.* No effects of sprays on the Al content occurred in 1966, but in 1967 the NAAm spray gave a seasonal increase in Al; B sprays reduced the Al content. Al in control leaves varied from 95 to 300 ppm in 1966 and from 106 to 169 ppm in 1967 with no seasonal trends.

### FRUIT ANALYSIS

Only in 1967 were fruit analyses made.

*Boron.* Fig. 4 shows that when B was included in a treatment, the B content of peel, flesh and core was significantly increased at the 1% level.

*Calcium.* Treatments caused no differences in the Ca content of the entire fruit or its parts. In the control fruits, the Ca content was higher in the peel (0.064%) than the core (0.032%); Ca content in the flesh was lower (0.011%) than either.

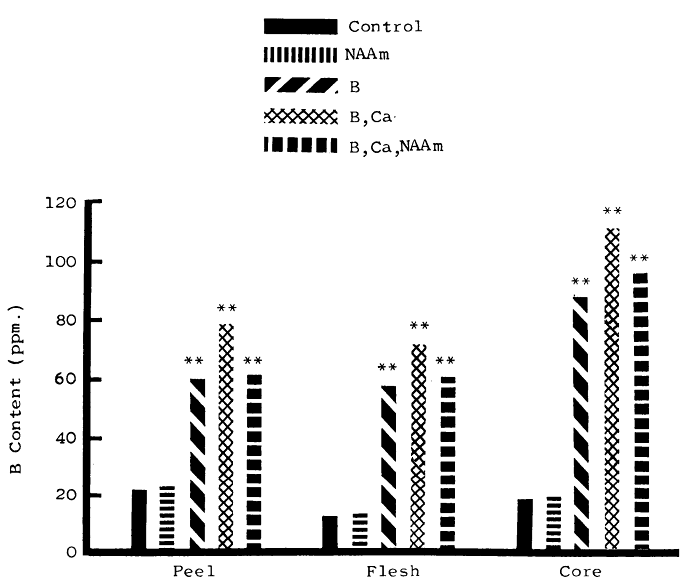


*Fig. 4.* Effect of B, Ca, and NAAm sprays on the B content of the peel, flesh, and core of York Imperial apples in the McDannell Bros. orchard, 1967. Double asterisk(**) indicates significance at the 0.01 level.

*Phosphorus.* The sprays had no effect on the average P content of the entire fruit. The core, however, averaged more P (0.099%) than the peel (0.055) or flesh (0.064). The B-Ca treatment increased the peel P over the control. Flesh P was increased by the NAAm and B-Ca treatments, but decreased by the B spray. Core P was increased by the B sprays.

*Potassium.* The spray treatments had no effect on the average fruit K content. K in the peel (0.84%) and core (0.99) were higher than the flesh (0.59). The peel K was increased by the B and B-Ca treatments while the core K was increased by the B-Ca-NAAm treatment.

*Magnesium.* The control peel contained more Mg (0.078%) than the flesh (0.022) or the core (0.028), the only significant difference in Mg content.

*Manganese.* Mn of the entire fruit was increased significantly (by 0.5 ppm) by the B-Ca treatment, the only apparent difference. Peel Mn (3.3 ppm) of the control was greater than core Mn (1.8 ppm), while flesh Mn (1.0 ppm) was less than either. Peel of the B-Ca treated trees contained 1.25 ppm more Mn than the control.

*Iron.* Only the B-Ca treatment increased Fe content of the entire fruit. Peel of the control contained more Fe (25.9 ppm) than the flesh (9.5) or core (8.8). Peel Fe was increased by about 4 ppm by the B-Ca treatment and 3 ppm by the B-Ca-NAAm treatment.

*Copper.* There were no differences among treatments in the Cu content of the entire fruit or its parts. Peel of the control contained 4.5 ppm, significantly more than the flesh (2.4 ppm) or core (2.9 ppm).

*Aluminum.* No treatment altered the Al content of the entire fruit. The B-Ca sprays increased peel Al by about 2 ppm; the B-Ca-NAAm treatment increased Al by about 3 ppm in the peel. Peel of the control (13.9 ppm) had more Al than the flesh (1.5 ppm) or core (1.1 ppm).

*Cork Spot.* Fig. 5 shows that where B alone or B and Ca were sprayed on the trees, cork spots were reduced significantly.

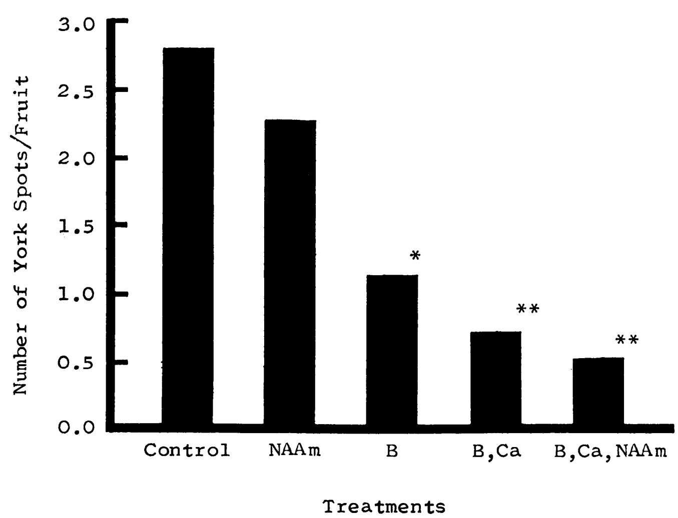


*Fig. 5.* Effect of B, Ca, and NAAm sprays on the number of cork spots per fruit in the McDannell Bros. orchard, 1967. Asterisk indicates significance at 0.05 level; double asterisk, significance at 0.01 level.

### Regression analysis

Stepwise polynomial regression analysis of the fruit cork spots and the minerals in the leaves and fruit in 1967 gave the following relationships.

*Leaves.* Three dates were selected for regression analysis: (a) June 30, six weeks before appearance of cork spot; (b) August 11, when spots first appeared; and (c) September 22 at harvest.

On June 30, leaf B content was highly and negatively correlated (1%) with cork spot, accounting for 65% of the spotting. Ca ranked next accounting negatively for an additional 2%.

On August 11, B accounted for 56% of the spots and Ca for an additional 6%, the correlation again being negative. Leaf P, however, was positively correlated with fruit spotting at the 10% significance level, accounting for 3% more of the spotting.

On September 22, B accounted for 48% of the spotting, Ca for an additional 13%, both negatively correlated. K and P were positively correlated at the 10% level and accounted for an additional 5% and 4% of the spotting, respectively.

*Fruit peel.* At harvest, the peel B accounted negatively for 21% of the cork spots, or as B increased spotting decreased. Ca × P cross-product accounted negatively for an additional 29%. Ca alone accounted negatively for an added 16%. B × Ca and P alone accounted positively for 6% and 4% more spots, respectively. Totally, 76% of the spotting was due to the elements B, Ca and P and to Ca × P and B × Ca interactions. There were no other correlations.

*Fruit flesh.* B, Ca, and the Ca × K cross-product were related negatively to 26, 10 and 4% of the cork spots, respectively. B × Ca positively accounted for 4% of the spots. A total of about 45% of the spots were attributed to the above mineral contents and interactions, with no other correlations.

*Fruit core.* B and Mg inversely accounted for 27 and 14% of the spots, respectively. The only other variable correlated was the B × Mg interaction which was positive at 9%. These variables accounted for 50% of the spotting.

## Discussion

In this study and previous work (2), no foliar spray or combination of B, Ca and/or NAAm sprays completely eliminated fruit corking. Regression analysis of the data collected here, however, showed less fruit corking with the higher B in both the leaves and the fruit. There is considerable literature, as reviewed by Faust and Shear (1) that agrees with this finding. A somewhat higher Ca level in the leaves but not the fruit was associated with less fruit corking and was in the second order of importance. Ca sprays have been shown rather clearly to reduce bitter pit in apple and limited work has shown them to reduce cork spot (1) which also confirms our results.

B moved into the tissues readily from B sprays, lifting the leaf B to 148 to 266 ppm early in the season, followed by a dropping of the leaf B to 20 and 50 ppm later. Ca, however, moved into the leaves and particularly the fruit with difficulty as Martin et al. (3) have found. Earliest leaf sampling on May 19, 1966 showed Ca content to be around 1.00% whereas on May 12, 1967 it was quite low, 0.5 to 0.6%. By mid July, at which time corking first was noted, the Ca content of all plots ranged from 1.2 to 1.4%, which still may not be an adequate supply of Ca for normal functioning and development of the fruit.[3] More work is needed to find a Ca material or a technique to move a greater quantity of Ca into the foliage and fruit, particularly early in the season. Perhaps a more dilute spray than we used (2½ lb. $CaCl_2$/100 gal) in early season may be needed to move a greater quantity of Ca into these younger, more absorptive leaves and avoid burning them.

It would appear that under the conditions of this experiment B, Ca, NAAm, and to a lesser degree certain nutrient interactions were involved in one way or another in the amount of fruit corking that occurred.

[3]Faust, Miklos and C. B. Shear. 1969. Personal communication at conference on controlled Ca nutrition studies with York Imperial on dwarfing stock. U.S.D.A., Beltsville, Md.

### Literature Cited

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