EFFECT OF MINERAL NUTRITION ON THE OCCURRENCE OF BITTER PIT IN NORTHERN SPY APPLES

By

GENE HERMAN OBERLY

AN ABSTRACT

Submitted to the School for Advanced Graduate Studies of Michigan
State University of Agriculture and Applied Science
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GENE HERMAN OBERLY ABSTRACT

Leaf, twig and fruit samples were collected from 15 Northern Spy trees in each of 18 orchards located in the major apple producing areas of Michigan.

Twig samples consisting of the 1957 shoot growth were collected in March 1958. The average length of terminal growth was measured and the average dry weight per centimeter of growth was calculated as a basis of twig vigor. The percent of nitrogen and potassium in the twig samples was determined.

Leaf samples were collected in July 1958 and analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, copper and boron.

Fruit samples were collected at harvest and stored at room temperature for two weeks. The samples were weighed and then evaluated for external and internal pitting. A section was removed from the center slice of each apple. The fruit sample was analyzed for the same nine elements as the leaves.

The 15 tree plots in each of 16 commercial orchards were divided into three blocks of five trees each. Five trees received one pound of boric acid per 100 gallons of spray six weeks following full bloom. Five trees received two applications of calcium nitrate at one pound per 100 gallons of spray at four and six weeks prior to harvest. Five trees were not treated.

Analysis of variance on the percentage of fruit free of bitter pit found in the 16 commercial orchards showed there were no significant differences due to treatments. A significant difference at the one percent level did exist between orchards. The interaction between treatments and locations was not significant.

Correlation coefficients were calculated by orchards for 23 measured variables on each of 17 orchards, and 20 variables on one orchard against the percentage of bitter pit free fruit. All variables showed a significant correlation in at least one or more orchards with the exception of the percent of manganese in the leaf samples.

Correlation coefficients were calculated for 23 observations on 250 trees against the percent of bitter pit free fruit. The results showed that the percent of bitter pit increased as the weight of the fruit increased, as the percentages of boron and potassium in the leaves increased and as the percentages of boron, potassium, nitrogen and phosphorus in the fruits increased.

The percent of fruits with bitter pit decreased as the percentages of magnesium and manganese in the leaves increased and as the percentages of calcium and manganese in the fruits increased.

Information obtained in relation to recent changes in cultural practices indicates that widespread use of potassium fertilizers increased nitrogen applications and inadequate use of lime may be responsible for the increased occurrence of bitter pit in recent years. The relationships found for other nutrients are probably interactions between nutrients found in the different orchards.

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INTRODUCTION

Michigan's most important processing apple is Northern Spy (*Malus domestica* *Bork.*). However, this variety, along with many others, has been afflicted with a physiological disorder known as bitter pit. Apple fruits affected with this disorder have created much additional expense and wastage during the processing and marketing of the fruits.

Michigan produces from one to two million bushels of Northern Spy apples each year. According to data obtained from Cherry Growers Incorporated (13), who purchase a large volume of Northern Spy apples for processing, the percentage of apples with some form of bitter pit varies from about one percent for some growers to about thirty-three percent for other growers. The average percentage of apples showing bitter pit for all growers was about 8.5 percent. It has been estimated that when Michigan produces a crop of 900,000 bushels of Northern Spy apples, about 76,500 bushels are lost each year due to bitter pit.

The purpose of this study was to determine the relationship of mineral nutrition to the development of bitter pit in Northern Spy apples.

LITERATURE REVIEW

According to Carne (9) the first unmistakable reference in the literature to bitter pit was made by Jaeger in 1869.

Cobb (14) stated in 1895, "I would suggest that the name bitter pit is one very suitable for the disease. It has received no common name up to this date so far as I know." Cobb (14) reported that he had known and observed the disorder for about 20 years prior to his publication.

Bitter pit is known by many different common names. In Germany the disorder is referred to as Stippen, Stippenflecke, Stippfleck, Stippigheit, Stippigwerden and Stippigfleckigheit. Throughout the United States, Great Britian, Canada, Australia, South Africa and New Zealand, the disorder is called bitter pit, Baldwin spot, tree pit or fruit spot. A Latin name has not been given to the disorder.

Cobb (14) and Gourley and Howlett (24) reported that the pits were bitter to taste. Heinicke (27) observed that it was only the old pits which were bitter and that the newly formed pits did not have the characteristic bitterness.

Bitter pit should not be confused with other corky diseases of apples. Hill (29) and Smock (42) described the histological characteristics of the disorder. The first external symptom appears as slightly discolored spots on the epidermis of the fruit. On yellow apples the spots are a darker green than the surrounding color and on red apples the spots are a deeper red. The external symptoms may or may not appear on the fruits which are affected with the disorder. It is necessary to slice through the apple to detect the presence of the disorder when the pits occur below the hypodermal layer of the fruit.

According to Smock (42) the disorder may be characterized by small brown spots or streaks in the flesh of the fruit. The early stages of development may be detected by a collapse of the cell wall of a group of cells beneath the hypodermal layers of the fruit. As the disorder develops, the cell walls not only continue to collapse, but may become torn. Between the cell walls may be observed starch grains which remain for the life of the fruit. As the pits develop, the cells may become dry in appearance. Smith (40) considered the drying out of the cells to be the result and not the cause of the disorder.

Rose et al. (38) listed the varieties which were most susceptible to bitter pit as Baldwin, Northern Spy, Rhode Island Greening, Yellow Newtown, York Imperial, Rome Beauty, Winter Banana, Stayman, Arkansas (Mammoth Black Twig), Arkansas Black, Delicious and Gravenstein.

Cobb (14) reported that the late varieties were more susceptible to bitter pit than the early or mid-season varieties. The late season varieties which were more acid appeared more susceptible.

Many theories have been proposed as to the cause of bitter pit. McAlpin (34) proposed the theory that the disorder was due to a rupturing of the vascular net work.

Herbert (28) in his investigations proposed the crushed cell theory. The crushed cell theory was based on the following observations:

> "A. Sunken spots constitute the first external symptom.
> B. The skin is intact over the pitted area.
> C. The vascular bundles frequently extend through a pit spot and supply normal tissue beyond.
> D. Starch is present in the pit cells.
> E. The tensile strength of cellulose is sufficient to eliminate the possibility of bursting."

Herbert (28) also reported that individual cells of the flesh of an apple would not burst when placed in water. Also, if the disorder was caused by rupturing of the vascular system, the epidermis should burst or at least form a bump instead of a depression.

Smock (43) could show no indication that the pits were associated with the vascular bundles in the flesh of the apple. A vascular bundle was always close to a pit in the apple. However, the presence of numerous vascular bundles in the periphery of the fruit would make it very difficult to find a pit which would not be adjacent to a vascular bundle.

Many persons have advanced theories, in one way or another, that the collapse of the cells was caused by a water stress. Darnel-Smith (19) submitted the theory that pitting may be due to a water stress as a result of either a loss of water which could increase the cell sap concentration of acids and kill the cells, or a rupturing of the cells due to an excess of water.

Chandler (12) reports that under drought conditions the cell sap of the leaves had a higher concentration than the cells of green fruits. Under these conditions the osmotic flow would be from the fruits to the leaves. Smock (43) found that by ringing limbs, the osmotic value of the leaves could be increased proportionally more than the osmotic value of the fruit. By partial girdling of the fruit stem, Smock (43) found the fruits were more susceptible to bitter pit. This technique presumably increased the osmotic value of the leaves to more than that of the fruits.

Güssow (25) reported that Wortman in 1892 concluded the malady to be due to a superabundance of an acid in the apple, which was caused by a shortage of water during the dry years. The susceptibility for apples to form bitter pit appeared to increase, according to Carne (8) when the acid distribution within the fruit became uneven.

Carne (8) concluded that the cause of bitter pit was due to excessive transpiration from the surface of the fruit. The loss of water from the surface of the fruit caused an osmotic gradient to be established which pulled water from the starch filled cells, causing the cells to become plasmolized. Rigg and Tiller (37) also found that bitter pit was more severe under conditions of excessive transpiration. Heinicke (27) noted that the affected fruits were ones which would also be first affected if the water supply was to become limited.

Britton et al. (4) concluded that the seasonal weather conditions exerted an important influence on the development of bitter pit. The climatic conditions were also noted by Hutton (31) as being an important factor in the development of the disorder. This was particularly true if high temperatures, low humidity and a fluxuating soil moisture occurred at the time the fruit commenced to mature.

Hill (29) noted bitter pit to be more severe on shallow soils during years of low rainfall. Brooks and Fisher (5) reported the disorder varied with the water holding capacity of the soil, particularly the sub-soil. The disorder was most severe when the soil moisture was limited.

Cummings (16) found bitter pit to be just as prevalent on irrigated soils as non-irrigated soils. Hill (29) could not associate bitter pit with soil moisture. Several workers (16, 18, 38, 40) reported that heavy rainfall during the growing season increased bitter pit more than when the season was dry.

The maturity and sugar content of apple fruits were affected by temperature treatments according to Smock (41). Limbs of individual trees and not whole trees were used for this study. Under these conditions there were no differences in the percentage of bitter pit due to the different temperature treatments.

Cummings (17) concluded that bitter pit was a climatic and water loss disease for which there was no control.

Cobb (14) in 1895 could show no evidence that bitter pit was due to a fungus. However, he recommended removal of the tree if the disorder persisted for two years.

According to Carne *et al.* (10), Attanasoff's virus theory was based on preliminary work done by McAlpine in 1913. McAlpine had taken bud wood from a tree which had been producing bitter pit apples and from a tree supposedly free of bitter pit. The scions were then grafted on trees free of bitter pit. The tree which had been used for bitter pit free scion wood in 1913 had 67 percent pitted fruits in 1914. Other workers (7, 26, 38) have confirmed Carne's report that bitter pit was non-parasitic.

Darnell-Smith (19) concluded, from studies with different apple varieties and rootstock combinations, that the stock had no effect on the expression of bitter pit, and that it was the nature of the scion which became the determining factor.

Young trees bearing a light crop of apples may create conditions which favor the development of bitter pit (4, 24, 31, 34). Palmer (36) reported that a light crop appeared to be very susceptible to pitting if it had been preceded by a heavy crop. However, Palmer (36) elucidated further by stating that the susceptability to pitting could be reduced by allowing the fruit to mature for a longer period on the tree before it was harvested.

A crop of large apples, according to several workers (8, 19, 24, 35) have a greater percentage of the fruits pitted than a crop of small apples. This was true, particularly in the case of fruits which had been growing rapidly because of excessive pruning or fruit thinning.

The position of the apple on the fruiting spur has been reported by Heinicke (27) and confirmed by others (8, 24) to be an important factor in the development of bitter pit. Heinicke (27) observed four conditions regarding the position of the apple on the spur and position of the spur to the limb in the development of bitter pit.

1. On adjacent spurs, terminal fruits without lateral fruits showed less bitter pit than terminal fruits with lateral fruits.

2. On adjacent spurs, single terminal fruits without lateral fruits showed less bitter pit than single lateral fruits without terminal fruits.

3. Basal spurs showed more bitter pit than spurs towards the terminal portion of the limb.

4. Vigorous spurs originating on the upper surface of the limb had less bitter pit than weak hanging spurs.

Heinicke (27) substantiated his observations on the basis of the percentage of good seed in the apples. He reported that lateral apples required a larger percentage of good seeds than a terminal apple if they were both on the same spur. Heinicke (27) found that apples with a low percentage of good seeds were more inclined to be pitted than apples with a high percentage of good seeds.

Smock (42) found somewhat different results. On unthinned limbs, the lateral fruits of a cluster were more likely to show bitter pit than terminal fruits.

According to Smock (42) when limbs were shaded during the growing season, the percentage of pitted apples was less than on limbs exposed to sunlight.

Cobb (14) noted the presence of starch grains in the pitted area and wrote:

> "The cells of the spongy brown mass still contains starch grains, and if the apple ripens as well as it can under the circumstances, it will be found that the cells adjacent to the bitter pit, and which are not turned brown, ripen, i.e., their starch is converted into other substances as is usual in ripening fruit."

Carne (9, 11) observed the starch grains in the pitted area and theorized that they must have an important bearing on bitter pit development. He reported that the more irregularly the starch was hydrolyzed in an apple the more susceptible it was to bitter pit.

Darnell-Smith (19) concluded that the susceptibility of an apple to pitting, was determined while the apples were still on the tree and before the starch had been hydrolyzed to sugar.

Smock (43) detected starch grains in both the healthy tissue and the necrotic tissue. Starch grains were also found between the collapsed cell walls. Smock (43) suggested that perhaps the starch grains were the result of the disorder, and not the causal agent.

Most persons who have studied the bitter pit problem appear to be in agreement as to the stage of maturity at which the apples should be harvested. Apples harvested at an immature state are more likely to develop bitter pit than fully mature fruits (1, 4, 5, 7, 8, 11, 24, 31, 35, 36, 38, 40).

Attempts have been made to differentiate between the pits which occur on the tree and those which occurred after the fruit had been placed in storage.

Bünemann (6) detected starch grains in the preharvest pits with an iodine test, but could not detect the starch grains in the pits which had developed while the fruit was in storage. Smock (43) could show no differences between the pits which developed in storage and those which developed prior to storage.

Prompt storage at 32°F after harvest (4, 24, 31, 40) reduced the percentage of post-harvest bitter pit. However, according to Gourley and Howlett (24), placing the apples in cold storage only delayed the expression of bitter pit, because bitter pit developed after the fruit had been removed from the storage.

Smock (42) reported that controlled atmospheric storage may delay the appearance of bitter pit, however it did not reduce the percentage of affected fruits. Smock (42) also found that a high relative humidity in the storage helped to retard the rate of development of bitter pit in apples.

Allen (1) added ethylene gas to a cold storage room in order to increase the rate of respiration of the apples. It was reported that the increased rate of respiration may have reduced the percentage of bitter pit, but that the results were not conclusive.

Smock (42) reported that California Gravenstein, Northern Spy and Baldwin apples which had been dipped in certain wax emulsions did not develop bitter pit as rapidly as untreated fruits. When shredded oiled paper was added to the containers with the apples, there appeared to be an increase in the percentage of fruits which became pitted. Smock (41) explained this increase as being an indirect effect caused by a lowering of the relative humidity surrounding the apples.

Mulching with hay increased the yield of apples, according to Butler and Dunn (7), but had no effect upon the percentage of fruits which had bitter pit.

The theory that bitter pit may be caused by an unbalanced nutritional condition is shared by many persons (7, 16, 18, 20, 22, 23, 24, 29, 38, 42, 46, 47).

Hill (29) associated bitter pit with high vigor, particularly when high nitrogen symptoms existed. Heinicke (27) found contradictory results. When one-half of a tree was fertilized with sodium nitrate, the side of the tree receiving the fertilizer had less bitter pit than the side of the tree which received no fertilizer.

Butler and Dunn (10) reported that nitrogen and potassium increased bitter pit, while phosphate decreased bitter pit. It was reported also that sulfur and phosphorus tend to counteract the effects brought about by nitrogen and potassium.

Van Schreven (44) reported that apples with bitter pit contained a higher content of nitrogen, phosphorus and potassium than apples without the disorder.

Ross and others (38) stated that the presence of a high concentration of certain salts in the irrigation water caused pits in apples which resembled bitter pit. They reported that, in the Pacific Northwest, high concentrations of magnesium sulfate may cause a type of pitting to occur.

DeLong (21) found low levels of calcium in the fruit to be associated with an increase in the percentage of fruit which had bitter pit. Garman and Mathis (23) also found that calcium may be the critical element in the development of Baldwin spot in Connecticut. They reported a very definite positive correlation between the ratio of the calcium content of the leaves divided by the calcium content of the fruit and an increase in the percentage of pitted apples.

Several persons (7, 23, 35, 46, 47) could show no relationship between bitter pit and boron. However, boron was effective in all reported studies for the control of drought spot and corky core. Dunlap and Thompson (22) reported that heavy boron applications at blossom time and at petal fall were effective in controlling bitter pit disorders on York Imperial apples in Maryland.

Van Stuivenberg and Pouwar (45) reported effective control of bitter pit in the variety Notaris, in Holland, by applying borax sprays during mid-July. They also found that the same results could be obtained by applying B-indolylacetic acid in July.

Woodbridge (47) reported that the boron content of apple twigs was lower on trees which had the disorder than on trees which were not affected.

MATERIALS AND METHODS

A preliminary study, to test the effectiveness of calcium nitrate sprays for the control of bitter pit, was initiated on 29 Northern Spy apple trees in the Rogers Incorporated orchard located near Honor, Michigan, during the 1957 growing season.

An immature fruit sample was collected from each of 18 trees during July, 1957. The samples were weighed and the weight per apple was calculated to the nearest one-tenth of a gram. A section was removed from each apple in the samples to form a composite fruit sample from each tree for a chemical analysis.

The 18 fruit samples were oven dried at 160°F for two days and then ground in a Wiley mill with a 20 mesh screen. The ground samples were placed in screw cap bottles, stored and later analyzed.

Two applications of calcium nitrate at the rate of one pound per 100 gallons of spray were made by the owner to trees in a block near those from which the green fruit samples had been collected. The applications were made approximately four and six weeks prior to harvest, following the recommendations of Garman and Mathis (23).

Mature fruit samples, consisting of 25 fruits, were collected from each of the 29 trees (18 untreated and 11 treated) on October 10, 1957.

The samples were held in a heated shed at the Horticultural farm in polyethylene lined boxes until November 1, 1957.

The ripe fruit samples were weighed and the average weight per fruit was calculated to the nearest one-tenth gram.

The apples were then examined for external pit symptoms and the number of affected fruits were recorded. The apples were then cut into approximately one-fourth inch slices and examined for internal pitting, the number of affected fruits were recorded.

A section was removed from each of the 25 ripe fruits collected from each tree and composited to form a ripe fruit sample for a chemical analysis.

The composite samples were weighed and then oven dried at 160° C for three days. After drying, the samples were reweighed and the percentages of moisture of the samples were calculated.

The dried fresh fruit samples were then ground in a Wiley mill with a 20 mesh screen and placed in screw cap bottles.

Both the green and ripe fruit samples were analyzed for nine mineral elements. Nitrogen was determined by the Kjeldahl method, using a one gram aliquot of the sample. Potassium was determined by the flame-photometer according to the proceedure outlined by the Association of Official Agricultural Chemists (2). Boron, calcium, copper, iron, magnesium, manganese and phosphorus were determined spectrographically according to the method of the Association of Official Agricultural Chemists (3), with a modification whereby the solution was placed on a flat polished electrode instead of a graphite-filled electrode.

Eighteen orchards were selected for a more comprehensive study during 1958. Ten trees were selected from the variety-fertilizer trial block at the Michigan State University Horticultural farm, East Lansing, Michigan, 20 trees selected from a Northern Spy fertilizer block on the Graham Experiment Station, Grand Rapids, Michigan, and 15 trees in each of 16 commercial orchards located in the major apple producing areas of central and northern Michigan.

The 16 commercial orchards were selected from a grower list furnished by the Cherry Growers Incorporated (13). Three years data had been compiled from the processing records, showing the percentage of bitter pit found in each orchard where fruit had been purchased. By the use of these data it was possible to select orchards which had previous records of high and low percentages of bitter pit. In the selection of the orchrds, age of the trees, vigor of the trees and location within the State were given consideration. The selections were made to provide a wide range in the occurrence of bitter pit between orchards and between major fruit producing areas.

Twig samples, consisting of about 15 to 20 shoots of the preceding year's growth, were collected from all trees, except the 20 trees located at the Graham Station. The twig samples were collected from about shoulder height (5 feet) around the periphery of the tree. The length of each twig was measured to the nearest one-half centimeter and the average length of the twigs for each tree calculated.

The twigs were oven dried at 160°F for three days and weighed on a torsion balance to the nearest one-half gram. The average weight per centimeter of growth was calculated on a dried weight basis as a means of evaluating twig vigor. The twigs were then ground in a Wiley mill with a 20 mesh screen and placed in screw cap bottles.

The twig samples were analyzed chemically for nitrogen by the Kjeldahl method and potassium by the flamephotometer (2).

In cooperation with the Cherry Growers Incorporated (13), a questionnaire (see appendix) was sent to about 200 commercial apple growers in Michigan. The purpose of the questionnaire was to obtain information concerning the orchard management practices, soil management practices, fertilization program and spray program for the years 1956, 1957 and 1958.

Boron spray treatments at the rate of one pound of boric acid per 100 gallons of spray were made to five of the fifteen trees in the commercial orchards. The boron treatments were applied from July 8 to 15, 1958.

Calcium nitrate spray applications were made to five of the fifteen trees in the sixteen commercial orchards, and to ten of the twenty trees located at the Graham Experiment Station. Two applications of one pound of calcium nitrate per 100 gallons of spray were made four and six weeks prior to harvest. The time of application for each major fruit area varied to correspond with the differences in the harvest dates.

Leaf samples were collected from around the periphery of each tree in the 18 orchards. Mature leaves, which were about midway between the base of the shoot and the terminal leaf and free of insect or disease damage, were selected. The leaf samples were collected from July 28 to August 6, 1958.

The apple leaf samples were washed in an aqueous solution, using Dreft as the detergent, rinsed in tap water and in distilled water. The leaves were oven dried at 160°F for two days and ground in a Wiley mill with a 20 mesh screen. The ground samples were placed in two ounce screw cap bottles.

The ground leaf samples were analyzed for the same nine elements and in the same manner as the green fruit samples which were previously described.

Mature fruit samples were collected from October 7 to 16, 1958. Fifty fruits were collected from around the periphery of the tree at about the height of five feet. An attempt was made to select fruits which were representative of the majority of the fruits on the tree. The harvested samples were then taken to East Lansing and stored in one of the food technology laboratories at about 72° F.

Two weeks after harvest, 40 apples were selected from each of the 270 samples. The 40 apples were weighed and the average weight per apple was calculated.

Each apple was then examined for external pitting and scored on the following basis:

0--no observed pits.

1--one to several scattered pits.

2--many pits in a localized area.

3--many pits covering the fruit.

The apples were then sliced with a commercial french fry potato cutter, with the cross blades removed. The apples were individually scored for internal pits on the following basis:

0--no observed pits.

1--pits occurring only beneath the hypodermis.

2--pits occurring beneath the hypodermis and scattered pits in the flesh of the apple.

3--heavily pitted throughout the flesh of the apple.

A wedge was removed from the center slice of each apple and the 40 wedges were composited to form a fruit sample for a chemical analysis.

The ripe apple fruit samples were placed in cheese cloth bags and oven dried for two weeks at 160° F. The dried apple fruit samples were then placed in four ounce screw-cap bottles and stored. At the time the samples were to be analyzed, the bottles containing the samples were placed in a drying oven and re-dried for two days at 160° F. The samples were then emptied into a Wiley mill and ground through a 20 mesh screen. The samples were collected in the same bottles in which they were dried, sealed with Saran wrap and re-capped.

Aliquots were taken from the ground sample for nitrogen, potassium and spectrographic determinations without re-drying the sample. There was no caking of the ground sample. One gram samples were used for nitrogen determinations by the Kjeldahl method, one-half gram samples for potassium by the flame photometer (2) and one-half gram samples for the spectrographic analysis (15) for boron, calcium, copper, iron, magnesium, manganese and phosphorous.

The data obtained from this study were statistically analyzed by using the Michigan State University Electronic Digital Computer. Analysis of variance was calculated for the percent bitter pit, using a split plot design. Correlation coefficients were calculated for 24 observations on each tree on an orchard basis, and then on an overall problem with 250 individual, thus making a total of 5,700 correlation determinations of correlation coefficients.

RESULTS

Preliminary Studies - 1957

It was found that the treated trees had an average of 14. 95 percent internal pitting, while the non-treated trees had 23. 67 percent internal pitting. The analysis of variance, as shown in Table I, for the 1957 data showed no significant difference between the amount of bitter pit on the trees sprayed with calcium nitrate and those which were not sprayed.

TABLE I

Analysis of Variance for Percent Bitter Pit Apples on 11 Trees Sprayed with Calcium Nitrate and 18 Non-treated Trees, 1957*

Source of Variation	d. f.	Sum of Squares	Variance	F
Total	28	9, 841		
Between treatments	1	513	513	1. 50 NS
Within treatments	27	9, 228	342	

*Table 1 of the Appendix presents the data for the above statistical analysis.

Results obtained from the studies (Table II) indicated that the weight of the apples was correlated to the percentage of bitter pit free fruits.

The concentration of calcium in both the green and mature fruits was less than the minimum amount which could be measured spectrographically (3).

TABLE II

Correlation of the Percentage of Bitter Pit Fruit with Weight of Green and Ripe Fruits, Percent Dry Weight of Ripe Fruit and Mineral Composition of Ripe and Green Fruits, 1957

Factors measured		Correlation coefficients	
		29 trees	18 trees
Average weight of ripe fruit		-.493**	-.347
Percent dry weight of sample		+.131	+.179
Composition of ripe fruit....	Boron	+.023	+.400
	Copper	+.018	+.315
	Iron	+.226	+.426
	Potassium	-.349	-.328
	Magnesium	+.291	+.368
	Manganese	+.114	+.114
	Nitrogen	-.273	-.246
	Phosphorus	-.186	-.053
Average weight - green fruit			-.116
Composition of green fruit...	Boron		+.216
	Copper		+.403
	Iron		+.287
	Potassium		-.003
	Magnesium		+.214
	Manganese		+.038
	Nitrogen		-.028
	Phosphorus		-.196

**Significant at the 1 percent level.

Therefore, the values obtained for calcium were often an estimate, rather than being a quantitative determination. Several correlation coefficients approached significance, thus justifying a more intensive study in 1958.

Orchard Survey - 1958

An evaluation of the survey sheets on cultural practices, which were returned by the commercial growers, failed to indicate any particular feature of orchard management practice that was consistently related to high percentage of bitter pit in some orchards and not in others.

The mean for all orchards (Table III) showed that there was 93.7 percent of fruit free from bitter pit. Analysis of variance (Table IV), computed on a split plot design, showed that the boron and calcium nitrate treatments had no significant effect on the percentage of bitter pit free fruits*. A significant difference, in the occurrence of bitter pit, at the one percent level was shown to exist between orchards. The interaction between orchards and treatments was not significant.

Correlation coefficients were calculated to show the relationship between fruit free of bitter pit and 19 observations on each of 20 trees located at the Michigan State University Graham Experiment Station, 23 observations for each of 15 trees in the 16 commercial orchards and 10 trees at the Michigan State University Horticultural farm (Table V).

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*The percentages of fruit free of bitter pit was used for all statistical analysis in order to remove all zero values from the data.

TABLE III

Percent of Fruit Free of Bitter Pit by Treatments and Orchards. Average of Five Single Tree Replicates

Orchard No.	Spray		Check	Average
	Boron	Calcium Nitrate		
1.	91.0	94.5	90.5	92.0
2.	96.5	98.0	98.5	97.7
3.	93.5	97.5	95.5	95.5
4.	95.5	96.5	97.0	96.3
5.	84.4	88.0	91.0	87.8
6.	96.5	98.5	97.5	97.5
7.	97.5	99.5	80.0	92.3
8.	99.5	99.5	99.5	99.5
9.	86.5	79.0	89.0	84.8
10.	94.0	88.5	92.0	91.5
11.	100.0	93.5	100.0	97.8
12.	94.5	95.0	97.5	95.7
13.	97.5	100.0	99.5	99.0
14.	98.0	97.0	99.5	98.2
15.	80.5	80.0	78.7	79.7
16.	89.0	97.5	95.0	93.8
Average	93.4	93.9	93.8	93.7

TABLE IV

Analysis of Variance: Percentage Fruit Free of Bitter Pit; 5 Tree Replicates, 3 Treatments at 16 Locations[1/]

Source Variation	D. f.	Sum of Squares	Variance	F
Replications	4	31, 075		
Treatments	2	1, 089	555	0. 041
Error (A)	8	107, 497	13, 442	
Locations	15	691, 046	46, 069	3. 888**
Treatments x locations	30	210, 783	7 , 030	0. 593
Error (B)	180	2, 131, 989	11, 849	
Total	239	3, 173, 482		

**Significant at the one percent level.

[1/]Table 2 of the Appendix presents all the data for the 1958 statistical analysis.

TABLE V

Average Twig Length, Twig Vigor, Average Weight of Apples, and Mineral Composition of Leaves, Fruit and Twigs with the Percentage of Bitter Pit Free Fruit; by Orchard and Total Orchards. Correlation Coefficients.

Orchard No.	Ave. Twig Length	Twig Vigor	Ave. Wt. Apples	Leaf Composition								
				N	P	K	Ca	Mg	Mn	Fe	Cu	B
1. a	-.084	+.559*	-.097	-.053	-.282	+.090	+.264	+.214	-.215	-.140	+.183	+.046
2. a	+.211	+.105	-.268	+.178	-.398	-.697**	+.236	+.313	+.353	-.037	-.074	-.283
3. a	-.096	-.006	+.118	-.174	-.329	-.470	+.222	-.125	-.167	+.169	+.212	-.400
4. a	+.596*	-.241	-.430	+.013	+.512	-.354	-.267	+.100	-.288	+.324	-.109	-.002
5. a	-.075	-.431	-.163	-.239	-.076	-.095	+.267	+.062	+.395	-.115	-.036	-.334
6. a	-.047	+.098	-.069	-.029	+.480	+.056	+.002	+.244	+.394	+.319	+.261	-.139
7. a	+.127	+.079	-.224	+.375	-.149	-.245	+.229	+.396	-.482	+.081	+.136	-.210
8. a	-.668**	-.194	-.449	-.003	-.418	-.100	+.386	+.083	+.174	-.070	+.380	-.154
9. a	-.174	+.260	+.063	-.191	+.104	+.224	-.003	+.042	+.122	-.222	+.239	+.154
10. a	+.448	+.094	-.441	+.540*	+.433	-.572*	+.404	+.573*	+.246	+.209	+.165	-.593*
11. a	+.432	+.303	+.131	+.626*	+.339	-.382	+.273	+.457	+.210	+.411	+.123	+.504
12. a	-.454	-.211	-.354	-.105	+.433	-.153	+.055	+.286	+.454	+.550*	+.536	+.440
13. a	-.701**	-.511	+.451	-.025	-.009	-.408	+.334	+.345	+.440	+.425	+.378	-.051
14. a	-.103	-.188	-.666**	-.168	+.168	-.229	-.330	-.358	-.279	-.067	+.093	-.100
15. a	+.109	+.051	-.499	-.086	+.318	-.233	+.592*	+.237	+.107	-.046	+.052	-.426
16. a	-.336	-.717**	-.255	-.001	+.515*	-.107	-.097	+.313	-.222	+.370	+.552*	-.011
17.b	-.525	+.053	-.054	-.055	-.012	-.226	+.075	+.301	+.059	+.345	+.498	+.082
18. c			-.309	+.358	+.212	-.380	+.539*	+.487*	-.146	+.165	-.683**	-.166
Total-d	+.083	-.054	-.131*	+.061	+.019	-.284**	+.120	+.249**	+.180**	+.064	+.037	-.160**

a 13 d.f.
b 8 d.f.
c 18 d.f.
d 248 d.f.

**Significant at 1 percent level
*Significant at 5 percent level

TABLE V Cont'd

Orchard No.	Fruit Composition N	P	K	Ca	Mg	Mn	Fe	Cu	B	Twig Composition N	K
1.a	+.269	-.356	-.599*	+.650**	+.063	+.140	+.301	-.296	+.016	-.241	+.131
2.a	-.011	-.171	-.326	-.078	-.188	+.234	+.144	-.396	-.238	-.126	-.389
3.a	-.561*	-.158	-.152	-.370	-.653**	-.439	-.072	-.118	-.633*	+.086	-.551*
4.a	+.244	+.005	-.011	+.445	+.270	+.105	+.011	+.031	-.585*	-.200	-.002
5.a	-.343	-.171	+.186	+.513	-.543*	-.372	-.336	-.322	-.188	+.189	-.172
6.a	+.061	+.022	-.119	+.238	-.522*	+.269	-.620*	-.543*	-.357	+.086	+.027
7.a	-.172	-.639*	-.466	+.198	-.007	-.535*	+.021	-.220	-.287	+.034	-.301
8.a	+.159	-.105	-.129	+.190	+.068	+.139	-.181	-.201	-.019	+.437	+.198
9.a	-.569*	-.024	-.309	+.432	+.041	+.341	+.181	+.072	+.260	+.321	-.044
10.a	-.032	+.004	-.436	+.508	-.020	-.321	-.025	+.039	-.357	+.048	-.095
11.a	+.066	-.528*	-.640*	-.114	-.035	+.054	+.278	-.113	+.084	-.516*	+.020
12.a	+.378	-.005	+.249	+.156	+.318	+.609*	-.119	+.187	+.213	+.178	-.195
13.a	-.216	+.413	-.266	-.082	-.461	+.175	-.300	+.181	-.679**	-.082	-.121
14.a	-.120	-.188	-.431	+.439	-.470	-.289	+.255	+.055	-.118	+.159	-.252
15.a	-.015	-.477	-.760**	+.599*	-.078	-.261	-.177	-.352	-.244	+.236	-.024
16.a	-.377	+.546*	+.044	+.310	+.378	+.285	+.015	+.047	-.065	+.218	-.006
17.b	-.077	-.563	-.523	-.167	-.516	-.408	-.132	-.025	-.194	-.063	-.152
18.c	+.031	-.325	-.183	+.694**	+.101	+.393	+.266	+.294			
Total-d	-.193**	-.236**	-.449**	+.371**	-.084	+.170**	-.081	-.104	-.230	+.061	+.070

a 13 d.f.
b 8 d.f.
c 18 d.f.
d 248 d.f.

**Significant at 1 percent level
*Significant at 5 percent level

Correlation coefficients were also calculated for an overall evaluation of the relationship between the percentage of fruit free of bitter pit and the 23 observations taken on 250 trees located in the different orchards (Table V).

The correlation coefficients for individual orchards showed that the percentage of fruit free of bitter pit was related significantly to all of the 23 variables except leaf manganese. The relationship was significant in one, two or three orchards, but not more than three orchards for any one variable. Both positive and negative correlations were found for the average length of twigs, twig vigor and the percentage of magnesium, manganese and phosphorous in the fruit samples, depending upon location.

When all of the locations were used to determine an over-all relationship of bitter pit to the different variables, significant correlation coefficients were found for 11 variables.

Significant negative relationships were found for weight of fruit, leaf potassium, leaf boron, fruit nitrogen, fruit phosphorus, fruit potassium, and fruit boron. These relationships indicated that the percentage of fruit free from bitter pit decreased as the levels of these variables increased. Conversely, as the levels of these variables increased the percent of fruit affected with bitter pit would increase.

Significant positive relationships were found for leaf magnesium, leaf manganese, fruit calcium, and fruit manganese. These relationships indicated that the percentage of fruit free from bitter pit would increase as the levels of these variables increased. Conversely, as the levels of these variables increased, the percent of fruit affected with bitter pit would decrease.

Means for each of the 24 observations were calculated for each orchard. The orchard means were arranged in descending order, from the highest to the lowest mean percentage of fruit free of bitter pit. As shown in Table VI, the orchards were divided according to the percentage of fruit free of bitter pit into three groups of six orchards each. The group averages for the percentage of fruit free of bitter pit were compared to the group averages for each of the 11 factors which were found to be correlated to the percent of fruit free of bitter pit at the one percent level.

The average weight of fruit varied from 167 grams for the high group to 186 grams for the medium group and 185 grams for the low group. The negative relationship of the average fruit weight to the average percentage of fruit free of bitter pit is shown in Figure 1.

The average percent boron in the apple leaves was .0029 for the high group and .0029 for the medium group. However, the low bitter pit free group increased to .0031 percent boron, as shown in Figure 4.

The other nine factors, which were shown by correlation coefficients to be related to bitter pit, followed a general pattern. High levels of calcium in the fruits, magnesium in the leaves, manganese in both leaves and fruits

TABLE VI

Orchard Means, by Groups, of Percent of Fruit Free of Bitter Pit, Average Twig Length, Twig Vigor, Average Weight of Apples and Mineral Composition of Leaves, Fruits and Twigs, 1958

Orchard No.	% Bitter Pit Free Fruit	Ave. Wt. Twigs (gr.)	Twig Vigor	Ave. Wt. Fruit (gr.)	%[1] Composition - Leaves								
					N	P	K	Ca	Mg	Mn	Fe	Cu	B
8. a	99. 5	16. 2	65. 3	179	2. 45	. 21	1. 71	1. 37	. 48	. 0049	. 0153	. 0013	. 0029
18. c	99. 3			180	2. 05	. 20	1. 83	1. 18	. 40	. 0119	. 0531	. 0029	. 0032
7. a	99. 0	12. 3	52. 6	168	1. 85	. 18	2. 11	1. 10	. 32	. 0079	. 0224	. 0014	. 0030
13. a	99. 2	19. 8	66. 1	154	2. 36	. 18	1. 86	1. 06	. 35	. 0172	. 0105	. 0011	. 0023
14. a	98. 2	21. 4	71. 1	147	2. 16	. 21	1. 97	. 95	. 37	. 0040	. 0202	. 0015	. 0033
11. a	97. 8	21. 5	57. 8	178	2. 59	. 18	1. 32	1. 52	. 47	. 0167	. 0330	. 0014	. 0027
Ave.	98. 8	18. 2	62. 6	168	2. 24	. 19	1. 80	1. 20	. 40	. 0104	. 0258	. 0016	. 0029
2. a	97. 6	17. 1	76. 0	178	2. 13	. 20	3. 00	. 89	. 30	. 0051	. 0406	. 0014	. 0033
6. a	97. 5	15. 7	51. 8	170	2. 56	. 16	1. 58	1. 18	. 41	. 0089	. 0370	. 0014	. 0026
17. b	97. 5	17. 3	59. 0	184	2. 01	. 22	2. 13	1. 08	. 33	. 0050	. 0206	. 0021	. 0026
4. a	96. 3	19. 6	74. 5	203	2. 48	. 18	1. 72	1. 12	. 42	. 0095	. 0209	. 0013	. 0027
12. a	95. 7	20. 9	56. 8	196	2. 52	. 16	1. 71	1. 50	. 40	. 0127	. 0426	. 0013	. 0029
3. a	95. 5	15. 4	59. 6	187	1. 90	. 19	2. 20	. 89	. 33	. 0041	. 0312	. 0013	. 0031
Ave.	96. 7	17. 7	63. 0	186	2. 24	. 19	1. 89	1. 11	. 36	. 0076	. 0322	. 0015	. 0029
16. a	93. 8	20. 3	67. 1	136	2. 73	. 18	2. 06	. 71	. 31	. 0033	. 0187	. 0015	. 0031
1. a	92. 0	21. 3	74. 3	259	2. 23	. 25	1. 93	1. 46	. 37	. 0132	. 0255	. 0014	. 0033
10. a	91. 7	18. 1	62. 3	178	2. 26	. 16	1. 95	1. 32	. 41	. 0063	. 0138	. 0013	. 0025
5. a	87. 8	18. 8	72. 0	201	2. 42	. 21	2. 04	1. 06	. 38	. 0055	. 0243	. 0014	. 0036
9. a	85. 2	17. 2	57. 5	185	2. 18	. 24	2. 08	1. 01	. 35	. 0045	. 0409	. 0020	. 0033
15. a	80. 0	12. 8	65. 9	153	2. 15	. 15	2. 04	. 81	. 29	. 0052	. 0120	. 0013	. 0029
Ave.	88. 4	18. 1	66. 5	185	2. 33	. 20	2. 02	1. 06	. 35	. 0063	. 0225	. 0015	. 0031

a 15 trees
b 10 trees
c 20 trees

TABLE VI Cont'd

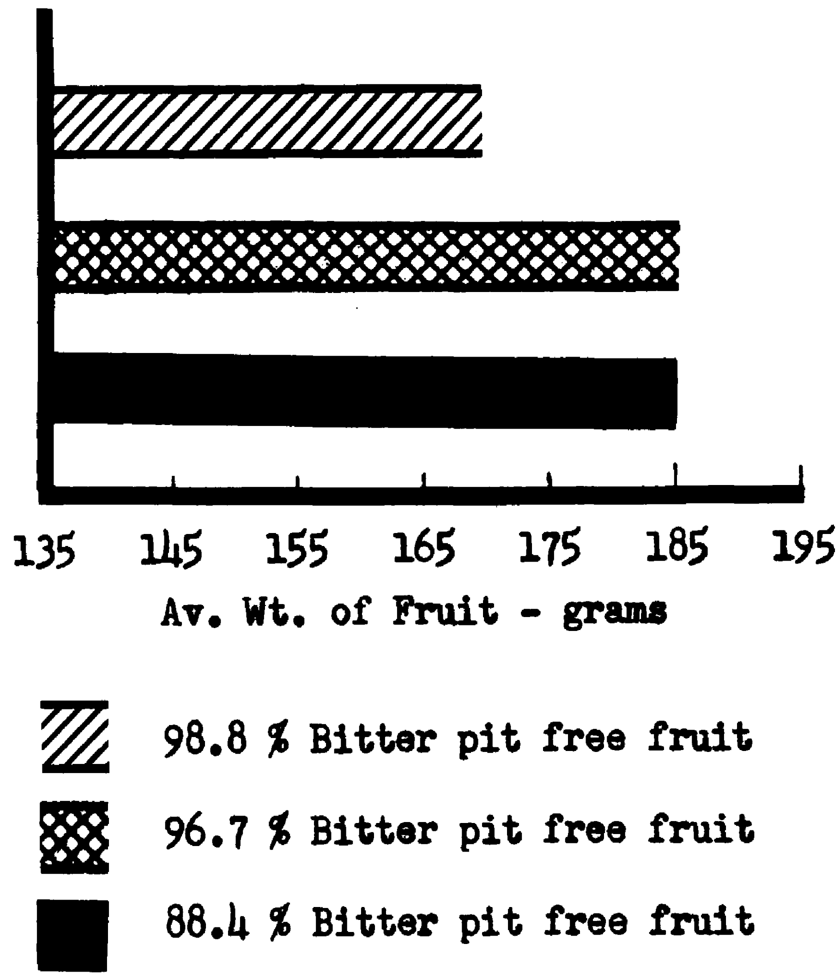
Orchard No.	% [1]/Composition - Fruits									Twigs	
	N	P	K	Ca	Mg	Mn	Fe	Cu	B	N	K
8. a	.199	.24	.61	.13	.05	.0006	.0028	.0007	.0032	.88	.59
18. c	.166	.35	.70	.15	.07	.0011	.0038	.0009	.0040		
7. a	.182	.25	.69	.15	.07	.0010	.0028	.0007	.0036	.84	.58
13. a	.197	.22	.70	.13	.06	.0025	.0029	.0006	.0016	.86	.64
14. a	.192	.33	.72	.13	.06	.0006	.0032	.0008	.0032	.84	.62
11. a	.217	.28	.61	.15	.06	.0015	.0055	.0007	.0026	.90	.60
Ave.	.192	.28	.67	.14	.06	.0012	.0035	.0007	.0030	.86	.61
2. a	.190	.30	.70	.12	.05	.0006	.0027	.0009	.0048	.78	.58
6. a	.239	.24	.62	.14	.06	.0010	.0031	.0007	.0028	1.07	.56
17. b	.210	.49	.77	.15	.08	.0008	.0028	.0012	.0036	.78	.54
4. a	.272	.27	.66	.14	.07	.0012	.0037	.0009	.0029	1.00	.57
12. a	.241	.24	.72	.13	.06	.0010	.0064	.0010	.0027	.85	.62
3. a	.210	.38	.79	.12	.07	.0005	.0032	.0008	.0043	.80	.55
Ave.	.227	.32	.71	.13	.07	.0009	.0037	.0009	.0035	.88	.57
16. a	.277	.31	.80	.13	.07	.0006	.0035	.0008	.0050	.84	.60
1. a	.212	.41	.76	.11	.06	.0007	.0065	.0009	.0044	.87	.56
10. a	.241	.26	.66	.12	.06	.0007	.0034	.0007	.0026	.96	.55
5. a	.308	.34	.75	.12	.06	.0007	.0034	.0009	.0041	.97	.60
9. a	.215	.32	.78	.11	.06	.0006	.0036	.0008	.0037	.90	.55
15. a	.216	.34	.79	.12	.06	.0007	.0034	.0008	.0044	.78	.56
Ave.	.245	.33	.76	.12	.06	.0007	.0040	.0008	.0040	.89	.57

a 15 trees
b 10 trees
c 20 trees

Figure 1

Average percent of fruit free of bitter pit as affected by the average weight of fruit. (Data presented in Table VI. Values are rounded to the nearest whole number)

Figure 1


135
145
155
165
175
185
195
Av. Wt. of Fruit - grams
98.8 % Bitter pit free fruit
96.7 % Bitter pit free fruit
88.4 % Bitter pit free fruit

was correlated to bitter pit free fruit. The relationships of these four elements to bitter pit free fruit are in Figures 2, 3, 8 and 9. With all four factors, the high group of bitter pit free fruit and the highest levels, the medium group had levels approximately midway between the high and low groups, and the low group had the lowest levels.

Low levels of boron in the fruits (Figure 5), potassium in leaves and fruits (Figures 6 and 7), nitrogen in the fruits (Figure 10), and phosphate in the fruits (Figure 11) which were shown by correlation coefficients to be associated with a high percentage of bitter pit free fruit, also followed a general pattern. The high group of bitter pit free fruit had the lowest level with all five factors. The low group had the highest levels and the medium group, with the exception of leaf potassium, had levels about midway between the high and low groups. Leaf potassium showed a considerable increase between the medium and low level of bitter pit free fruit.

Shear, Crane and Myers (39) reported that when the proportion of magnesium to boron in the leaves of tung trees (Aleurites fordii Hemsl) became low, boron toxicity occurred.

In the leaf samples, neither the boron content or the ratio of magnesium to boron were such as to suspect boron toxicity. However, in the fruit samples, the ratio between the percentage of magnesium and the percentage of boron decreased as the percentage of bitter pit increased. The ratios obtained by

Figure 2

Average percent of fruit free of bitter pit as affected by the average percent of calcium in the fruits. (Data presented in Table VI. Values are rounded to the nearest second decimal)

Figure 3

Average percent of fruit free of bitter pit as affected by the average percent of magnesium in the leaves. (Data presented in Table VI. Values are rounded to the nearest second decimal)

Figure 2

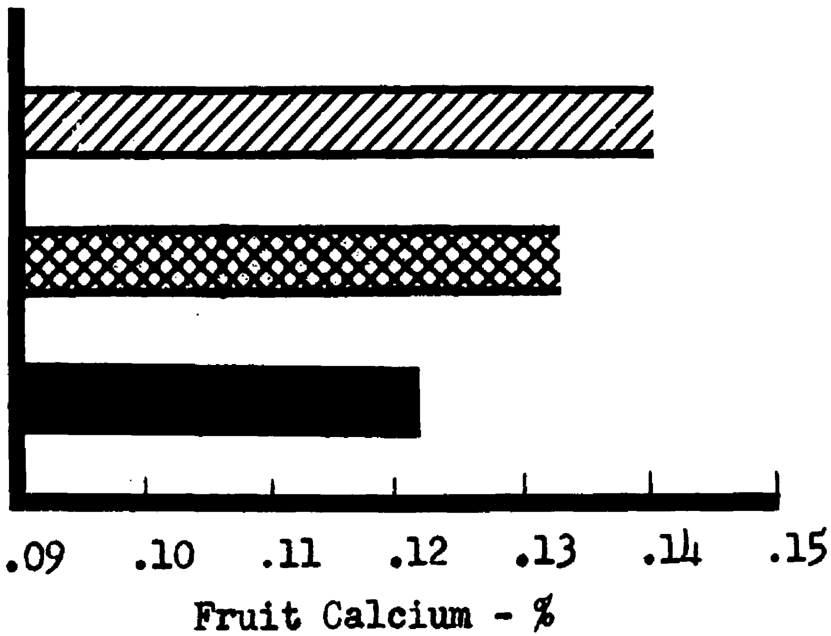
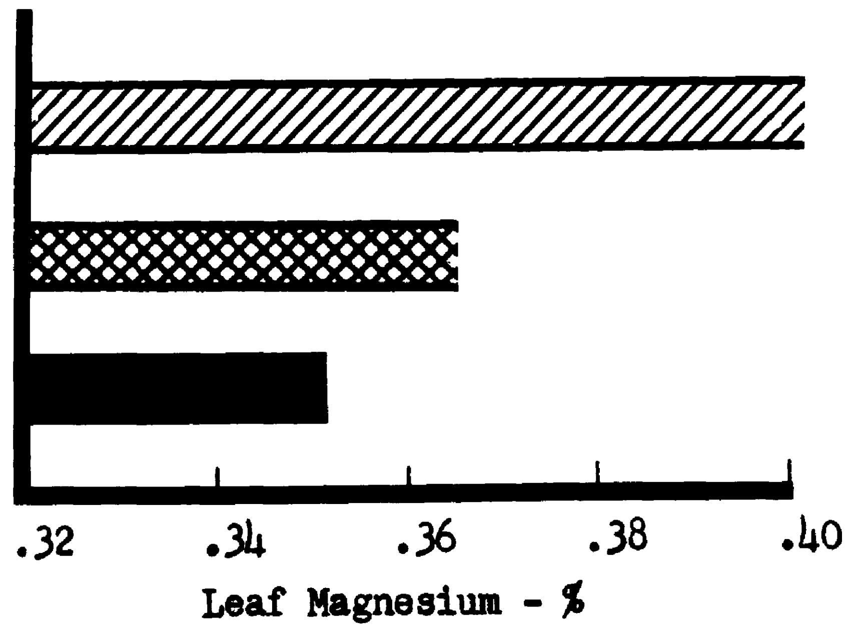


Figure 3



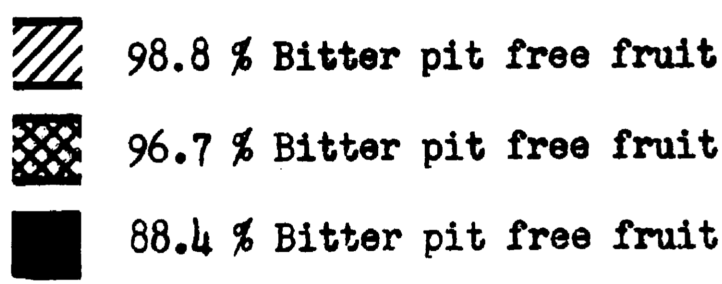


Figure 4

Average percent of fruit free of bitter pit as affected by the average percent of boron in the leaves. (Data presented in Table VI. Values are rounded to the nearest whole number)

Figure 5

Average percent of fruit free of bitter pit as affected by the average percent of boron in the fruits. (Data presented in Table VI. Values are rounded to the nearest whole number)

Figure 4

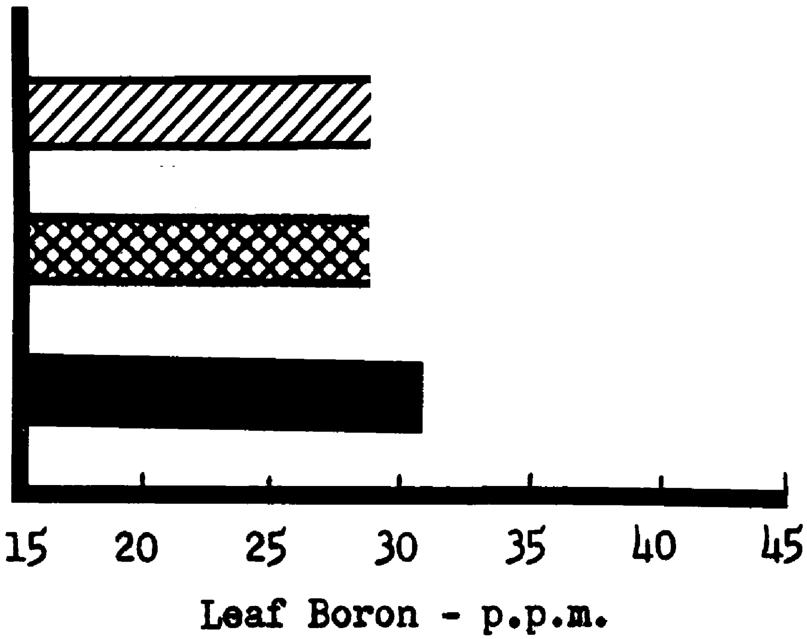
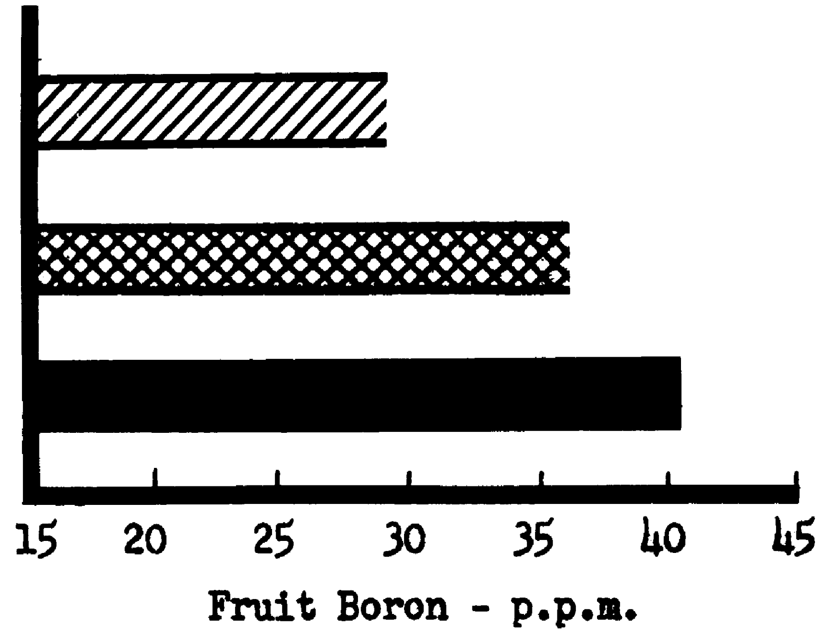


Figure 5



98.8 % Bitter pit free fruit

96.7 % Bitter pit free fruit

88.4 % Bitter pit free fruit

Figure 6

Average percent of fruit free of bitter pit as affected by the percent of potassium in the leaves. (Data presented in Table VI. Values rounded to the nearest second decimal)

Figure 7

Average percent of fruit free of bitter pit as affected by the percent of potassium in the fruits. (Data presented in Table VI. Values rounded to the nearest second decimal)

Figure 6

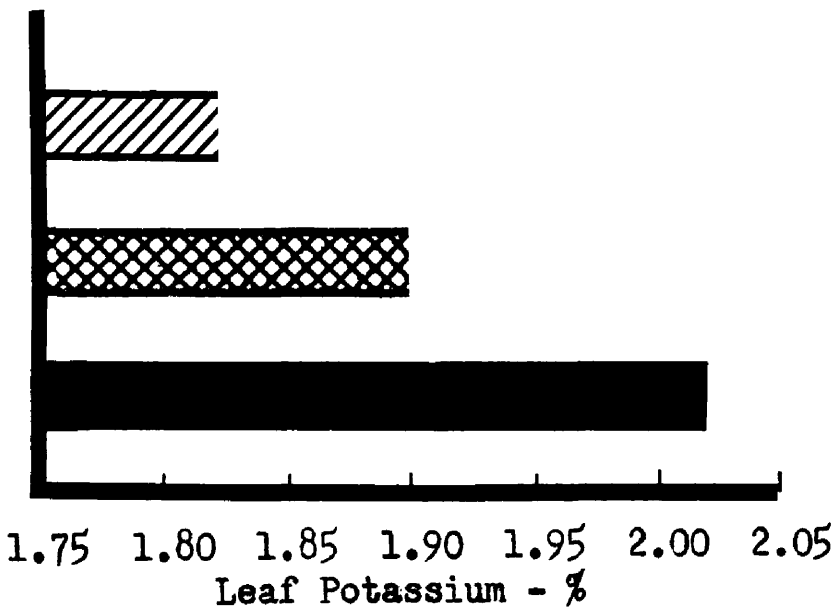
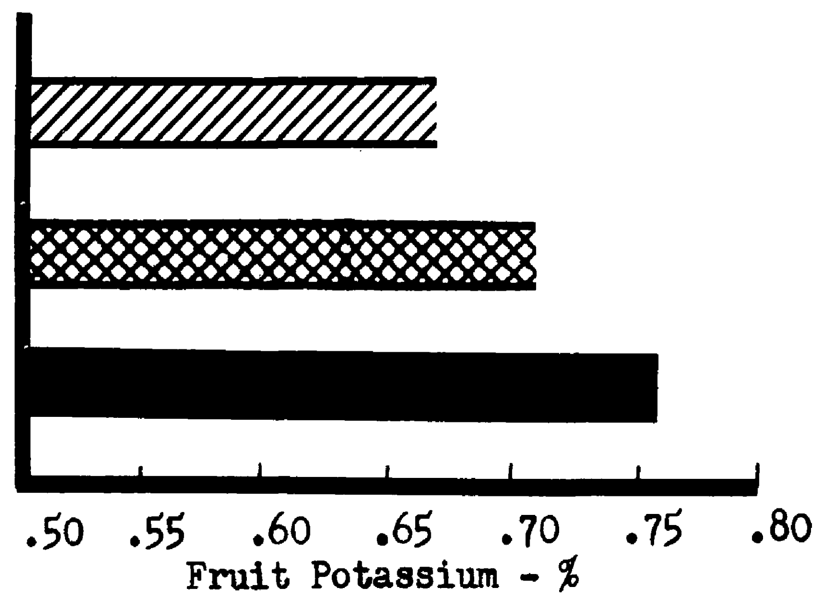


Figure 7



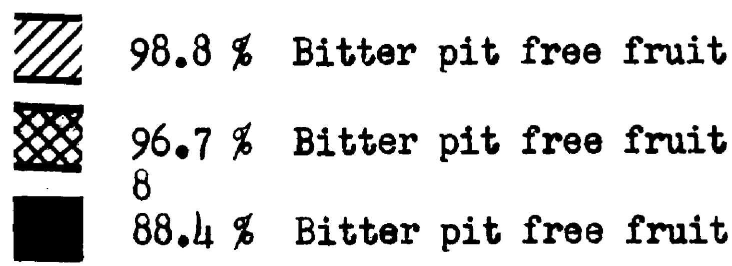


Figure 8

Average percent of fruit free of bitter pit as affected by the average percent of manganese in the leaves. (Data presented in Table VI. Values are rounded to the nearest whole number)

Figure 9

Average percent of fruit free of bitter pit as affected by the average percent of manganese in the fruits. Data presented in Table VI. Values are rounded to the nearest whole number)

Figure 8

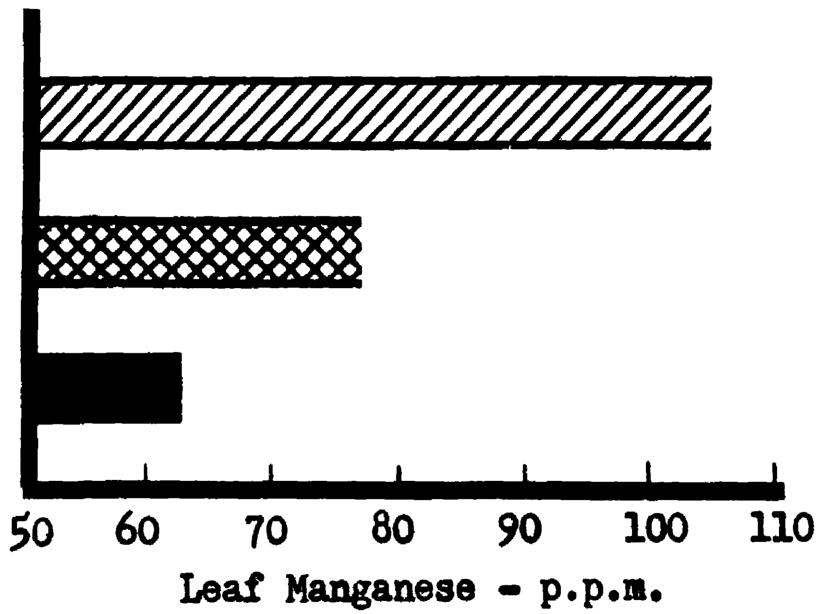
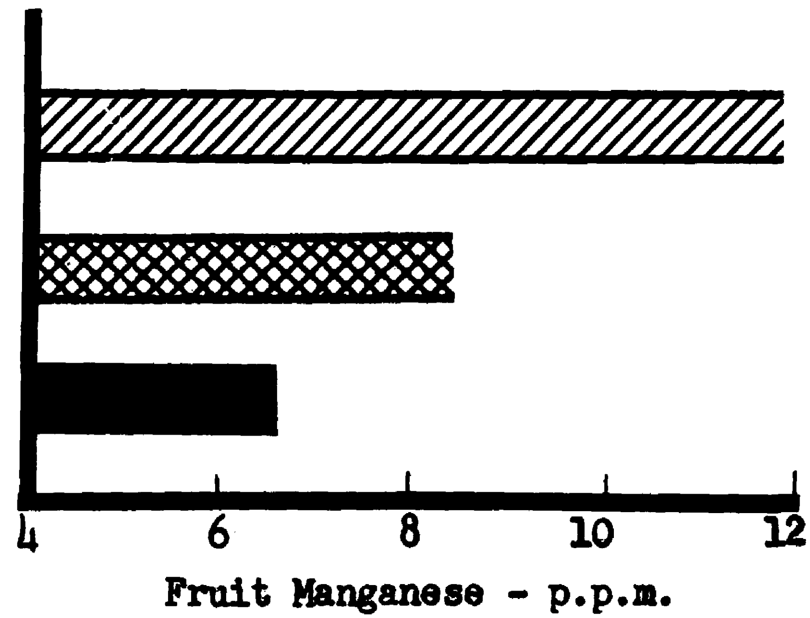


Figure 9



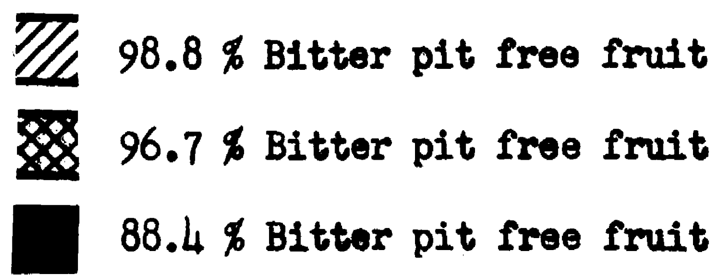


Figure 10

Average percent of fruit free of bitter pit as affected by the average percent of nitrogen in the fruits. (Data are presented in Table VI. Values are rounded to the nearest second decimal)

Figure 11

Average percent of fruit free of bitter pit as affected by the average percent of phosphorus in the fruits. Data are presented in Table VI. Values are rounded to the nearest second decimal)

Figure 10

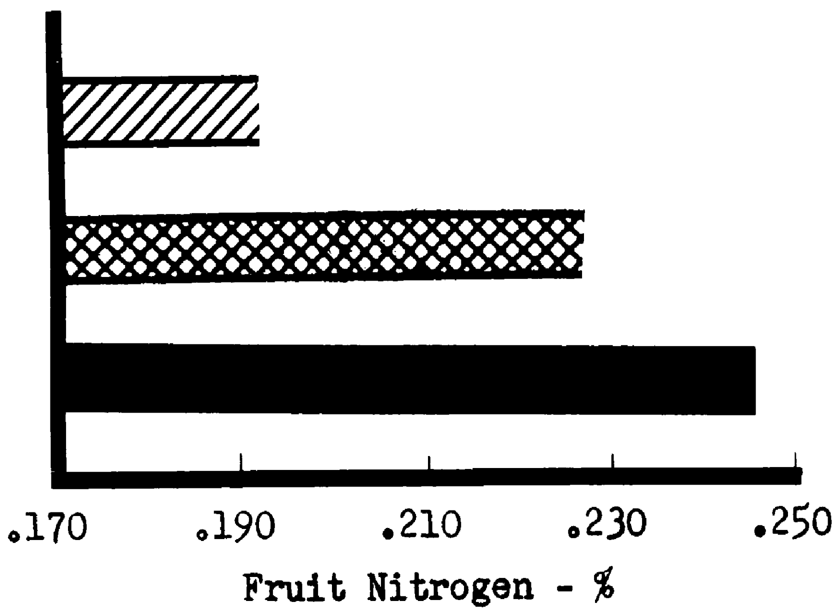
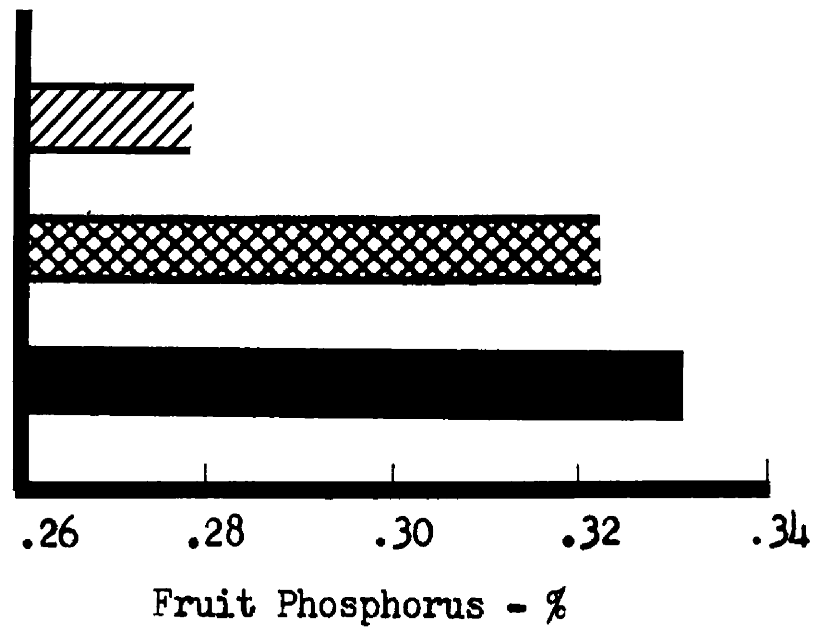
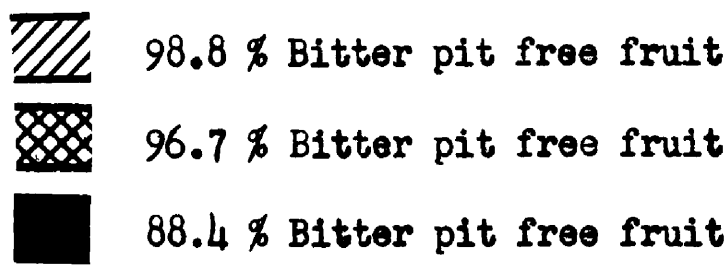


Figure 11





dividing the percent of magnesium by the percent boron gave values of 20.8, 18.6, 15.4 for the low, medium and high percent bitter pit groups, respectively. These values, according to Shear, Crane and Myers (39) would have produced slight boron toxicity symptoms on the tung trees.

Although the boron content of the Northern Spy apple leaves did not appear to be in excess or deficiency, when the boron content of the fruit greatly exceeded the boron content of the leaves, there appeared to be an increase in the percentage of pitted apples.

Dunlap and Thompson (22) reported effective control, of what they called bitter pit in Maryland, on the York Imperial variety. They used heavy applications of Solubor during full bloom and at petal fall.

Boron applications applied during the later stages of fruit development did not significantly decrease or increase the percentage of pitted apples. However, higher boron levels may be required during the early stages of seed formation and fruit development than may be required during the periods of fruit enlargment and maturation. Therefore, boron applications made later in the season may be ineffective in altering the occurrence of bitter pit.

DISCUSSION

Of the 23 factors, which were studied as a possibility of having an influence on he development of bitter pit, the percentage of manganese found in the leaf samples was the only factor which did not correlate with bitter pit development in at least one or more orchards. These findings help to explain some of the discrepancies which are found in the literature.

Studies confined to a single orchard may not agree with the finding of a larger population. For example, the entire population of the 18 orchards showed a significant relationship between the occurrence of bitter pit and leaf manganese. However, no one orchard showed such a relationship.

The possibility of forecasting the occurrence of bitter pit from leaf, fruit or twig analysis would appear to be relatively remote. However, the relationships found for the entire population suggest that the occurrence of bitter pit may be related to nutritional conditions. The best method of assessing the nutritional factor is not immediately apparent. Consideration of the relative level of nutrition in individual orchards will be necessary to more accurately diagnose the factor or factors influencing bitter pit development.

Throughout the literature, references were made to boron as being effective in the control of other corky disorders, without having an effect on the control of bitter pit.

Results from this study indicate that high levels of boron in the leaf or mature fruit tissue may increase the tendency for Northern Spy apples to pit.

Boron appears to function in certain enzymatic systems as a catalyst or reaction regulator. When boron is in either excess or is deficient, necrotic areas appear in the flesh of the fruit. Because of the similarity in appearance between bitter pit and other physiological disorders, most of the research has been with the addition of boron in an attempt to correct the disorder.

High levels of phosphorus in the flesh of the apple appeared to increase the percentage of pitted fruits.

Phosphorus is essential for the formation of nucleic acids, lecithin and nucleo-proteins. Phosphorus is also very essential in the respiratory processes involving high energy phosphate bonds. If the respiratory processes were increased, collapse of the cell wall could possibly occur. It would then be necessary to establish whether the high phosphorus levels increased the rates of respiration, or the increased rate of respiration brought about the high phosphorus levels.

Although leaf nitrogen did not appear to have an effect on the percentage of bitter pit, the amount of nitrogen in the flesh of the apple apparently did increase the percentage of pitted apples. As the percent of nitrogen increased in the apple flesh, the percentage of pitted apples also increased. Excessive nitrogen levels in the fruit has a tendency to reduce the soluble solids and help create a large soft fruit, with a short storage life. The high nitrogen values found in the low percent bitter pit free group would support this theory. Many of the trees which had the highest percentage of pitted apples were also very high in nitrogen.

Butler and Dunn (7) reported that high potassium levels appeared to increase the percentage of bitter pit and this was particularly true if high levels of nitrogen were also present. The orchards which had the highest percentage of pitted fruit in this study were also orchards which were high in both nitrogen and potassium.

Of all the factors which were correlated to an increase in the percentage of bitter pit, potassium probably has the greatest influence. Averages of 1.82, 1.89 and 2.03 percent potassium were found in the low, medium and high percent bitter pit groups respectively. As the percentage of potassium increased in the leaves and in the fruits, the percent of bitter pit fruit increased.

The values for the percent of potassium found in the leaves were considerably higher than the standard composition value of 1.50 percent reported by Kenworthy (33).

The high potassium values found in the leaves may account for the significant positive correlation coefficients obtained between leaf potassium and the percent of magnesium found in the leaves and the percent manganese found in the leaves and the fruits. An excess of potassium decreased the absorption of magnesium and manganese. As the levels of potassium increased in the leaf samples, the percent of magnesium and manganese found in the leaves decreased. Highly significant negative correlation coefficients of -.654 existed between leaf potassium and leaf magnesium and -.329 between leaf potassium and leaf manganese. A correlation coefficient of .160 was needed to be significant at the one percent level.

A significant negative correlation of -.193 existed between the percent potassium in the leaves and the percent manganese in the fruit and a significant correlation coefficient, at the five percent level between the fruit potassium and the fruit manganese.

Although the percent of magnesium found in the leaves and the percent manganese found in both the fruits and leaves showed significant positive correlation coefficients at the one percent level with the percent of bitter pit fruit, they probably had little if any effect upon fruit pitting. The relationship between the occurrence of bitter pit and either magnesium or manganese may be directly related to potassium, since potassium fertilizers have been applied, thus the level of potassium may be the operative factor.

Additional studies would have to be conducted with lower levels of potassium to determine whether or not magnesium and/or manganese could be considered factors in reducing the percent of bitter pit fruit.

The average calcium percentage for the 250 Northern Spy trees, which were under observation, was 1.16 percent. Only five orchards out of the 18 used in this study approached the standard composition value of 1.40 percent, which was reported by Kenworthy (33), and five orchards had an average of 1.00 percent or less.

In this study, the percent of calcium in the leaves did not appear to influence the percent of calcium in the fruits. The correlation coefficient between the leaf calcium and the fruit calcium was +.050, whereas .125 was needed to be significant at the five percent level. This relationship was also apparent from the leaf calcium means. The orchards with the high calcium in the leaves were found in the high, medium and low bitter pit groups.

Low levels of calcium have been associated to some extent with soft fruits. General observations indicated that the most severely affected fruits were those which had the appearance of being soft and adnormally large.

Low clacium levels in the fruit were also found by DeLong (20) to be associated with an increase in the percentage of bitter pit.

An interaction between potassium and calcium also exists. As the percentage of potassium increases, the percentage of calcium decreases. Significant negative correlation coefficients existed between the percent of calcium found in the fruit and percent of potassium found in both the leaves and fruits.

It is interesting to note that high levels of the three major elements (nitrogen, phosphorus and potassium) appear to increase the percentage of bitter pit fruits, while magnesium and calcium tend to decrease the percentage of bitter pit.

The survey sheets returned by he growers indicated no orchard operations or soil management practices, during the last three years, which could account for the differences in the percentage of bitter pit between orchards. However, some general observations could be made by reviewing changes which have occurred during the last fifteen years.

Prior to 1946, bitter pit was not the problem it appears to be at the present time, as bitter pit was not reported as being severe on older bearing trees. However, bitter pit has always been a problem on young Northern Spy trees just coming into production.

About 1946, the processors started to demand larger apples, as apples under 2 1/2 inches in diameter were graded down because of the wastage which occurred during the peeling process. To obtain the larger apples a shift was made in the fertilizer program to increase the level of nitrogen. Also, about 1948, the general use of complete fertilizers began according to Kenworthy (32). At the same time, speed-sprayers were coming into practice and to facilitate the new method of spraying, heavy pruning practices were adopted. The extra pruning resulted in the same effect as the addition of heavy applications of nitrogen fertilizer.

The years following World War II were good years for the apple producers. Most of the orchardists made money on apples, consequently more money was spent for fertilizer than ever before.

By 1953 or 1954, the full effect of the increased fertilizer program plus the more rigorous pruning practices were beginning to have their full effect. Since 1953-54, bitter pit has become a major problem with the Northern Spy apple producers. Not only are the more susceptible varieties bothered with this disorder, but it is now being observed in varieties such as Delicious, which have had a resistance to the disorder.

From this study, it would appear that perhaps the percentage of bitter pit apples may be reduced by discontinuing the indiscriminate use of fertilizer, particularly potassium, and applying Dolomitic lime to increase the level of magnesium and calcium. With an increase of calcium, the level of boron and potassium may be reduced. However, as heavy lime applications become effective, an abundance of nitrogen, which could also be detrimental, may be released and the potassium level become too low.

There is no doubt in the author's opinion that other factors, such as climatic conditions, may be correlated to bitter pit development. There is also no doubt that a balanced nutritional program is one of the major factors in reducing the percentage of bitter pit within an orchard. However, it appears doubtful that any one treatment will solve the bitter pit problem. With so many factors to consider as causal agents, each orchard, or even sections of an orchard may have to be considered independently.

When hypothetical values for leaf and fruit composition were calculated from the variance and co-variance of each factor, the hypothetical value of each of the eleven factors found to be associated with bitter pit, were very similar to the average values for the six orchards which had the least amount of bitter pit.

SUMMARY

Many varieties of apples are affected with a physiological disorder known as bitter pit. The Northern Spy variety, Michigan's leading processing apple, is severely affected by this disorder.

This study was undertaken to determine the effect of mineral nutrition on the occurrence of bitter pit in Northern Spy apples in Michigan.

Ten trees at the Michigan State University Horticultural farm, East Lansing, 20 trees at the Michigan State University Graham Experiment Station, Grand Rapids, and 15 trees in each of 16 commercial orchards located in the major apple producing areas, were used for this study.

Twig samples consisting of the 1957 shoot growth were collected from all trees in March 1958, except the 20 located at the Graham Experiment Station. The average length of terminal growth was measured and the average dry weight per centimeter of growth was calculated. The percent of nitrogen and potassium was determined in the twig samples.

Leaf samples were collected from all trees in July 1958 and analyzed for boron, calcium, copper, iron, magnesium, manganese, nitrogen, phosphorus, and potassium.

To test the effectiveness of calcium nitrate and boron sprays for the control of bitter pit, the 15 trees in each of the 16 commercial orchards

were divided into three blocks of five trees each. Five trees received one pound of boric acid per 100 gallons of spray six weeks following full bloom. Five trees received two applications of calcium nitrate at one pound per 100 gallons of spray at four and six weeks prior to harvest. Five trees were not treated.

Fifty apples were collected from each tree at harvest and stored for two weeks at room temperature. Forty apples were then selected, weighed, evaluated for external pitting, sliced, and evaluated for internal pitting. A section was taken from the center slice of each apple to form a fruit sample, which was analyzed for the same nine elements that are listed for the leaf samples.

Analysis of variance on the percentage of fruit free of bitter pit found in the sixteen commercial orchards showed there were no significant differences due to treatments. A significant difference at the one percent level did exist between orchards. The interaction between treatments and locations was not significant.

Correlation coefficients were calculated by orchards for 23 measured variables on each tree in 17 orchards, and 20 variables on the 20 trees at the Graham Experiment Station, against the percentage of bitter pit free fruit. All variables showed a significant correlation in at least one or more orchards with the exception of the percent manganese in the leaf samples.

Correlation coefficients were calculated for 23 observations on 250 trees against the percent of bitter pit free fruit. The results showed the following relationships:

1. The percent of fruit with bitter pit increased as:
   a. Size of fruit increased.
   b. Boron in the leaves increased.
   c. Boron in the fruits increased.
   d. Potassium in the leaves increased.
   e. Potassium in the fruits increased.
   f. Nitrogen in the fruits increased.
   g. Phosphorus in the fruits increased.

2. The percent of fruits with bitter pit decreased as:
   a. Calcium in the fruits increased.
   b. Magnesium in the leaves increased.
   c. Manganese in the leaves increased.
   d. Manganese in the fruits increased.

From this study it would appear that bitter pit could be caused by many factors. It was noted that when one or more of the above elements was out of balance the percentage of bitter pit was increased. However, as a general program, the discontinuation of the use of complete fertilizers to reduce the potassium levels and applications of dolomitic lime to increase the calcium levels and decrease the levels of boron and potassium are recommended.

With a proper balance of mineral nutrition, it would appear that the percentage of bitter pit apples may be reduced.

LITERATURE CITED

1. Allen, F. W. Maturity and rate of ripening of Gravenstein apples in relation to bitter pit development. Proc. Amer. Soc. Hort. Sci. 28: 639-645. 1931.

2. Association of Official Agricultural Chemists (1955), Official Methods of Analysis. 8th Ed., 104-105.

3. ______________________________ (1955), Official Methods of Analysis. 8th Ed., 317-318.

4. Britton, J. E., Fisher, D. V., and Palmer, R. S. The influence of some horticultural practices on bitter pit in Okanogan-grown apples. Sci. Agr. 23: 651-675. 1943.

5. Brooks, C., and Fisher, D. F. Irrigation on apple spot disease. Jour. Agr. Res. 12: 109-137. 1918.

6. Bünemann, Otto. Some physiological factors affecting the development of bitter pit on Northern Spy apples. Report to Cherry Growers Incorporated, Traverse City, Michigan. 1958-59.

7. Butler, O. R., and Dunn, S. Studies on the bitter pit disease of apples. N. H. Agr. Exp. Tech. Bul. 78: 1-10. 1941.

8. Carne, W. M. A preliminary note on a theory as to the origin of bitter pit in apples. Rev. App. Mycol. 7: 102. 1928.

9. ________, and Martin, D. Studies concerning the so-called bitter pit of apples in Australia, with special reference to the variety Cleopatra. Council Sci. and Indus. Res. (Australia) Bul. 41: 1-101. 1929.

10. ____________________. Apple investigations in Tasmania: Miscellaneous notes. I. The virus theory of bitter pit. Council Sci. and Indus. Res. (Australia) Jour. 7: 203.214. 1934.

11. ________, Pittman, H. A., and Elliott, H. G. Bitter pit in apples. Gard. Chron. (London) 88: 177-178. 1930.

12. Chandler, W. H. Sap studies with horticultural plants. Mo. Agr. Exp. Sta. Bul. 14: 491-552. 1949.

13. Cherry Growers Incorporated, Traverse City, Michigan. Unpublished data.

14. Cobb, N. A. Bitter pit of apples. Agr. Gaz. N. S. W. 6: 859-861. 1895.

15. Connar, Jane, and Bass, S. T. Use of a high-voltage A. C. arc. source for spectrochemical analysis of plant tissue. In preparation for publication.

16. Cummings, M. B. Bitter pit of apples. Rural N. Y. 101: 534. 1942.

17. ________________. Scab and bitter pit in Vermont apple orchards. Rural N. Y. 104: 7. 1945.

18. ________________, and Dunning, R. G. Bitter pit of apples. 1. In orchard and in storage. Vt. Agr. Exp. Sta. Bul. 467: 1-30. 1940.

19. Darnell-Smith, G. P. Bitter pit investigations. Mr. D. McAlpine's fourth report. Agr. Gaz. of N. S. W. 27: 279-281. 1916.

20. DeLong, W. A. Variations in the chief ash constituents of apples affected with blotch cork. Plant Phys. 11: 453-456. 1936.

21. ______________. Calcium and boron related to blotch cork. Plant Phys. 12: 552-556. 1937.

22. Dunlap, D. B., and Thompson, A. H. Personal correspondence, 1959.

23. Garman, P., and Mathis, W. T. Studies of mineral balance as related to occurrence of Baldwin spot in Connecticut. Conn. Agr. Exp. Sta. Bul. 601: 1-19. 1956.

24. Gourley, J. H., and Howlett, F. S. Modern Fruit Production. MacMillan Company. 1941.

25. Güssow, H. T. Stippen - Disease of plants. Jour. Roy. Agr. Soc. (England) 67: 259-261. 1906.

26. Heald, F. D. Introduction to Plant Pathology. 2nd Ed. McGraw-Hill Book Co., New York. 495-497. 1943.

27. Heinicke, A. J. The seed content and the position of the fruit as factors influencing stippen in apples. Proc. Amer. Soc. Hort. Sci. 17: 225-232. 1921.

28. Herbert, D. A. Bitter pit in apples: The crushed cell theory. Phytopath. 12: 489-491. 1922.

29. Hill, H. Functional disorders of apples on the tree. East Malling Res. Sta. Rep. 1936: 180-182. 1937.

30. _______, and Davis, M. R. Physiological disorders of apples. Sci. Agr. 17: 199-208. 1936.

31. Hutton, K. E. Bitter pit of pome fruits. Agr. Gaz. N. S. W. 58: 205-208. 1947.

32. Kenworthy, A. L. Nutritional conditions of Michigan orchards. A survey of soil analyses and leaf composition. Mich. Agr. Exp. Sta. Tech. Bul. 237: 1-30. 1953.

33. _______________. Unpublished data. 1959.

34. McAlpine, D. Bitter pit in apples and pears: Latest results in preventive measures. Phytopath. 11: 366-370. 1921.

35. Overholser, E. L., and Fidler, J. L. Bitter pit of apples in cold storage. Calif. Un. Agr. Exp. Sta. Rep. 192-198. 1922-23.

36. Palmer, R. C. Reduction of bitter pit by picking at proper stage of maturity. Proc. Amer. Soc. Hort. Sci. 43: 63-68. 1943.

37. Rigg, T., and Tiller, L. Report of certain diseases of the apple in the Mt. Nelson Dist., New Zealand. 1925-26. Jour. Pom. and Hort. Sci. 6: 113-127. 1927.

38. Rose, D. H., Brooks, Charles, and Fisher, D. F. Market diseases of fruits and vegetables, apples, pears and quinces. U. S. D. A. Misc. Publ. 168: 7-8. 1933.

39. Shear, C. B., Crane, H. L., and Myers, A. T. Nutrient-Element balance: Application of the concept to the interpretation of foliar analysis. Proc. Amer. Soc. Hort. Sci. 51: 319-326. 1948.

40. Smith, A. J. M. Bitter pit in apples - A review of the problem. Dept. Sci. and Ind. Res. (England) Food Invest. Bd. Spec. Rep. 28: 1-24. 1926. (Abst. in Rev. Appl. Mycol. 6: 166-167. 1927).

41. Smock, R. M. Bitter pit of Gravenstein apples. 1. The effect of environmental temperature during the growing period. Proc. Amer. Soc. Hort. Sci. 34: 179-186. 1937.

42. ____________. Studies on bitter pit on the apple. Cornell Univ. Agr. Exp. Sta. Memoir 234: 1-45. 1941.

43. ____________, and Van Doren, A. The histology of bitter pit in apples. Proc. Amer. Soc. Hort. Sci. 35: 176-179. 1938.

44. Van Schreven, A. C. Storage Diseases. Institute for research on storage and processing of horticultural products. (Wageningen, Netherlands) Annual Report: 26-27. 1956-1957.

45. Van Stuevenberg, J. H. M., and Pouwer, A. Investigation into the control of bitter pit in apples (variety: Notaris). Meded. Dir. Tuinb. 13: 201-211. 1950.

46. Wallace, T., and Jones, J. O. Boron in relation to bitter pit in apples. Jour. Pom. 18: 161-176. 1940.

47. Woodbridge, C. G. The boron content of apple tissue as related to drought spot and corky core. Sci. Agr. 18: 41. 1937.

APPENDIX

Table 1
Data Collected from 29 Northern Spy Apple Trees, 1957

Tree No.[2]	%Bitter Pit Free Fruit	Ave. Wt. Apples (gr.)	%Dry Weight	%[1] Fruit Composition (Ripe)							
				N	P	K	Mg	Mn	Fe	Cu	B
33.	74	190	18.81	.267	.05	.711	.04	.0003	.0010	.0003	.0043
34.	92	170	18.24	.253	.05	.732	.05	.0004	.0014	.0003	.0038
35.	52	183	17.69	.232	.04	.672	.04	.0003	.0008	.0003	.0037
36.	100	144	18.37	.260	.05	.742	.04	.0003	.0007	.0003	.0042
37.	88	179	18.54	.239	.08	.842	.04	.0003	.0010	.0003	.0055
38.	92	173	17.51	.267	.08	.809	.05	.0004	.0010	.0005	.0063
39.	64	202	17.15	.309	.04	.752	.04	.0003	.0010	.0003	.0052
40.	84	188	19.17	.232	.04	.646	.03	.0003	.0007	.0003	.0016
41.	68	141	19.72	.246	.06	.802	.03	.0003	.0008	.0003	.0061
42.	84	179	17.95	.274	.07	.758	.04	.0003	.0011	.0004	.0036
43.	49	169	16.26	.344	.07	1.090	.04	.0003	.0010	.0003	.0035
44.	92	173	18.74	.274	.14	.752	.04	.0003	.0010	.0004	.0071
45.	76	176	17.44	.246	.05	.758	.04	.0003	.0008	.0003	.0022
46.	100	153	20.66	.267	.04	.711	.04	.0003	.0011	.0004	.0042
47.	88	173	18.46	.204	.04	.756	.03	.0003	.0012	.0003	.0045
48.	24	181	20.33	.253	.09	.819	.03	.0003	.0008	.0003	.0033
49.	88	171	20.07	.183	.05	.760	.04	.0003	.0009	.0003	.0080
50.	64	183	17.75	.239	.05	.690	.04	.0003	.0009	.0004	.0050
51.	52	182	20.29	.225	.07	.750	.04	.0003	.0013	.0004	.0028
52.	100	166	18.88	.246	.05	.626	.04	.0004	.0017	.0003	.0021
53.	92	196	19.71	.246	.06	.862	.05	.0003	.0014	.0003	.0014
54.	76	174	18.45	.218	.07	.650	.05	.0004	.0012	.0005	.0026
55.	64	181	18.66	.218	.05	.701	.05	.0003	.0010	.0004	.0024
56.	95	142	18.74	.197	.04	.681	.04	.0003	.0010	.0003	.0015
57.	92	154	18.40	.225	.04	.716	.04	.0003	.0009	.0003	.0017
58.	88	137	19.42	.232	.04	.691	.05	.0003	.0009	.0003	.0013
59.	92	143	20.11	.225	.04	.579	.05	.0003	.0012	.0003	.0016
60.	92	136	21.69	.190	.05	.675	.04	.0003	.0005	.0003	.0021
61.	92	151	20.09	.218	.05	.734	.04	.0003	.0007	.0003	.0022

Table 1 Cont'd

Tree No.	Ave. Wt. Green Fr. (gr.)	%[1] Fruit Composition (Green)							
		N	P	K	Mg	Mn	Fe	Cu	B
33.	25.2	.863	.12	1.43	.08	.0004	.0008	.0004	.0080
34.	22.2	1.080	.13	1.42	.08	.0005	.0023	.0003	.0058
35.	28.1	1.060	.14	1.44	.08	.0005	.0012	.0003	.0080
36.	23.2	.990	.12	1.37	.08	.0005	.0009	.0004	.0080
37.	22.3	.960	.14	1.42	.07	.0004	.0010	.0005	.0080
38.	27.2	.899	.13	1.46	.06	.0004	.0009	.0004	.0080
39.	25.1	.962	.11	1.40	.07	.0004	.0012	.0003	.0048
40.	21.2	1.170	.15	1.60	.06	.0005	.0010	.0003	.0072
41.	20.3	.976	.16	1.40	.08	.0007	.0010	.0003	.0080
42.	26.4	.983	.10	1.39	.06	.0003	.0011	.0003	.0080
43.	24.7	.899	.10	1.49	.05	.0003	.0008	.0003	.0080
44.	22.5	1.010	.09	1.42	.05	.0003	.0009	.0003	.0080
45.	28.3	.962	.10	1.40	.05	.0004	.0009	.0003	.0032
46.	22.5	1.100	.10	1.44	.06	.0003	.0011	.0004	.0049
47.	20.5	1.120	.10	1.35	.05	.0003	.0010	.0003	.0038
48.	21.1	1.070	.13	1.40	.04	.0003	.0007	.0003	.0037
49.	23.1	.744	.13	1.48	.07	.0006	.0010	.0003	.0080
50.	25.4	1.060	.14	1.42	.08	.0006	.0009	.0003	.0041

[1] Averages of results from replicated determinations expressed on the oven-dry basis. P, Mg, Mn, Fe, Cu and B were determined spectrographically, K flamephotometrically, and N by the Kjeldahl method.

[2] Tree numbers 51 to 61 were treated with calcium nitrate.

GROWER INFORMATION FOR BITTER PIT STUDY, 1958

The information requested below is to be used in helping to determine the factors which cause bitter pit in Northern Spy apples. This study is being conducted by the Department of Horticulture, Michigan State University, in cooperation with The Cherry Growers, Inc.

Owner (or name of orchard)__________________ Address:______________________

__________________________Age of trees:_____Date of full bloom:___________

Weather conditions during bloom:___warm, ___cool, ___ cold, ___calm, ___slight breeze, ___windy, ___no rain, ___light rain, ___heavy rain.

Yield:	1958 (estimated)	1957	1956
Light	____	____	____
Medium	____	____	____
Heavy	____	____	____

Fertilizer program for the past three years:

Year	Type of fertilizer	Amount used	Time of application	Method of application
1958				
1957				
1956				

Has the orchard been limed?______when______type of lime used_______amount

Soil management: _________sod, _________sod plus mulch, _______clean cultivation

Pruning program for last three years:	1958 (estimated)	1957	1956
None	____	____	____
Light	____	____	____
Medium	____	____	____
Heavy	____	____	____

Average length of the terminal growth:_______inches. It was ____weak, _____medium, _____vigorous

Spray program:

Method of thinning:____

Spray materials:

Insecticides:____

Fungicides:____

Stop-drop sprays:____

General remarks:

Each page of Table 2 presents the data collected from one orchard, with the exception of the last two pages, which present the data collected from one orchard.

Table 2

Data Collected from 270 Northern Spy Apple Trees, 1958

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
1.	100.0	25.7	87.4	248	2.22	.23	1.92	1.89	.41	.0136	.0272	.0013	.0046
2.	62.5	22.8	70.6	277	2.19	.28	1.96	1.60	.37	.0148	.0293	.0013	.0043
3.	100.0	23.9	81.6	280	2.16	.21	1.78	1.64	.42	.0104	.0213	.0012	.0038
4.	97.5	21.7	76.8	255	2.19	.24	1.88	1.65	.44	.0104	.0211	.0010	.0041
5.	95.0	20.1	74.0	220	2.25	.22	1.84	1.58	.38	.0125	.0269	.0020	.0034
6.	97.5	17.8	75.5	246	2.16	.25	1.84	1.23	.33	.0143	.0292	.0023	.0034
7.	95.0	21.3	71.9	270	2.29	.24	2.20	1.25	.35	.0112	.0256	.0010	.0025
8.	92.5	20.3	74.6	275	2.36	.22	2.06	1.73	.36	.0131	.0221	.0020	.0024
9.	90.0	17.0	70.1	277	2.09	.27	2.10	1.23	.30	.0125	.0333	.0014	.0034
10.	97.5	20.8	69.0	260	2.12	.29	2.10	1.26	.35	.0131	.0243	.0015	.0034
11.	100.0	20.4	79.9	241	2.27	.26	1.84	1.58	.38	.0134	.0263	.0012	.0026
12.	67.5	22.5	66.1	227	2.29	.31	1.80	1.17	.38	.0135	.0234	.0011	.0024
13.	100.0	23.6	79.6	245	2.32	.25	1.92	1.62	.44	.0148	.0196	.0012	.0031
14.	87.5	22.1	57.7	312	2.26	.25	1.74	1.13	.32	.0132	.0214	.0009	.0027
15.	97.5	20.3	79.6	258	2.23	.26	3.03	1.39	.36	.0165	.0315	.0016	.0033

Tree No.	Twig N	Twig K	%[1]/ Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
1.	.76	.53	.239	.41	.66	.13	.08	.0008	.0086	.0010	.0065
2.	.96	.55	.190	.41	.86	.09	.06	.0009	.0065	.0012	.0049
3.	.81	.59	.183	.37	.68	.11	.07	.0007	.0067	.0011	.0060
4.	.84	.55	.197	.38	.73	.10	.05	.0006	.0055	.0010	.0058
5.	.91	.53	.232	.39	.79	.12	.06	.0006	.0060	.0011	.0041
6.	.96	.53	.239	.39	.74	.11	.05	.0008	.0061	.0010	.0038
7.	.97	.58	.225	.40	.81	.12	.07	.0007	.0061	.0006	.0048
8.	.96	.58	.253	.35	.76	.11	.06	.0009	.0071	.0007	.0038
9.	.87	.58	.239	.52	.91	.11	.07	.0009	.0075	.0011	.0048
10.	.86	.55	.211	.39	.77	.11	.06	.0007	.0061	.0010	.0031
11.	.87	.60	.197	.44	.77	.12	.06	.0009	.0070	.0007	.0053
12.	.83	.55	.197	.47	.81	.09	.06	.0005	.0051	.0009	.0046
13.	.81	.56	.253	.36	.71	.10	.06	.0009	.0057	.0007	.0032
14.	.84	.52	.154	.39	.75	.09	.06	.0005	.0065	.0010	.0029
15.	.89	.53	.168	.42	.71	.11	.05	.0007	.0076	.0010	.0030

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%1/ Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
109.	100.0	21.1	77.0	179	2.37	.19	2.04	.87	.35	.0065	.0545	.0015	.0036
110.	92.5	15.2	73.0	213	2.33	.17	2.00	1.05	.36	.0051	.0423	.0013	.0027
111.	100.0	21.2	72.6	196	2.42	.19	1.86	.99	.38	.0046	.0362	.0013	.0026
112.	97.5	13.7	82.3	173	2.26	.20	1.98	1.02	.29	.0050	.0370	.0015	.0032
113.	100.0	18.6	73.6	179	2.29	.21	3.03	.88	.32	.0063	.0471	.0015	.0035
114.	100.0	18.7	82.6	175	2.06	.22	1.96	.80	.30	.0059	.0335	.0013	.0031
115.	100.0	12.8	75.0	189	1.83	.18	1.85	.93	.30	.0051	.0350	.0013	.0026
116.	95.0	12.8	58.9	200	2.04	.19	1.98	.87	.27	.0048	.0434	.0014	.0033
117.	97.5	15.5	74.9	179	2.13	.20	2.06	.75	.22	.0047	.0500	.0017	.0030
118.	100.0	15.3	71.6	164	2.19	.18	2.11	.80	.23	.0055	.0320	.0014	.0030
119.	97.5	16.8	75.1	162	1.97	.21	1.73	.91	.33	.0050	.0420	.0014	.0037
120.	97.5	19.8	81.9	175	2.05	.20	1.89	.83	.29	.0046	.0355	.0013	.0035
121.	100.0	16.4	78.4	154	2.04	.19	1.94	1.02	.29	.0051	.0454	.0012	.0033
122.	100.0	21.0	83.1	162	2.01	.23	1.92	.89	.30	.0036	.0356	.0013	.0038
123.	87.5	18.1	80.0	170	1.94	.26	2.62	.71	.22	.0043	.0389	.0014	.0040

Tree No.	Twig N	Twig K	%1/ Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
109.	.84	.64	.197	.22	.57	.11	.05	.0007	.0027	.0010	.0045
110.	.87	.64	.239	.26	.63	.11	.05	.0004	.0026	.0007	.0047
111.	.86	.56	.168	.20	.65	.11	.05	.0004	.0020	.0007	.0033
112.	.86	.60	.225	.32	.72	.11	.06	.0007	.0022	.0007	.0036
113.	.79	.58	.154	.35	.67	.14	.06	.0007	.0057	.0009	.0031
114.	.70	.51	.154	.33	.78	.11	.05	.0005	.0020	.0009	.0044
115.	.77	.57	.183	.28	.69	.11	.04	.0005	.0016	.0008	.0049
116.	.89	.56	.126	.29	.72	.12	.05	.0004	.0018	.0010	.0047
117.	.84	.54	.183	.30	.69	.12	.06	.0005	.0022	.0009	.0047
118.	.81	.63	.225	.34	.75	.12	.06	.0009	.0029	.0011	.0049
119.	.81	.56	.154	.24	.62	.10	.05	.0006	.0019	.0010	.0060
120.	.66	.56	.225	.34	.78	.13	.05	.0006	.0047	.0010	.0060
121.	.65	.55	.253	.29	.72	.12	.05	.0006	.0019	.0008	.0058
122.	.66	.55	.084	.36	.69	.14	.06	.0006	.0045	.0010	.0064
123.	.72	.62	.183	.36	.82	.13	.06	.0006	.0025	.0013	.0057

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1/] Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
124.	92.5	15.2	56.6	190	2.04	.17	2.16	1.02	.30	.0052	.0222	.0015	.0035
125.	97.5	14.3	60.2	206	2.02	.17	2.00	.93	.32	.0041	.0270	.0014	.0032
126.	100.0	14.0	65.0	204	1.95	.17	2.10	.95	.25	.0046	.0210	.0013	.0026
127.	100.0	13.2	56.9	199	1.95	.20	1.81	.80	.22	.0036	.0312	.0013	.0033
128.	100.0	15.9	57.4	181	1.81	.17	1.65	1.00	.34	.0043	.0380	.0014	.0030
129.	90.0	14.2	55.7	181	2.02	.20	2.10	.80	.29	.0032	.0359	.0012	.0033
130.	100.0	17.9	67.8	170	1.94	.19	2.32	1.07	.36	.0041	.0215	.0012	.0028
131.	97.5	14.6	58.3	173	2.06	.20	2.44	.65	.46	.0028	.0311	.0013	.0030
132.	97.5	15.6	61.6	201	1.88	.19	2.30	1.01	.35	.0043	.0275	.0011	.0032
133.	97.5	19.0	48.8	182	1.60	.20	2.37	.95	.38	.0050	.0379	.0013	.0030
134.	92.5	16.2	63.3	189	1.91	.18	2.38	.82	.38	.0035	.0431	.0014	.0027
135.	100.0	13.8	53.4	174	1.76	.17	2.33	.74	.28	.0044	.0394	.0012	.0028
136.	85.0	16.2	59.4	179	1.97	.20	2.50	.79	.40	.0059	.0344	.0012	.0037
137.	87.5	15.5	61.0	188	1.81	.19	2.50	.89	.26	.0036	.0193	.0011	.0027
138.	95.0	15.0	68.8	181	1.76	.19	1.98	.90	.40	.0036	.0393	.0012	.0030

Tree No.	Twig N	Twig K	%[1/] Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
124.	.84	.62	.253	.43	.92	.14	.08	.0007	.0033	.0009	.0059
125.	.83	.56	.140	.35	.81	.12	.06	.0004	.0026	.0009	.0038
126.	.83	.54	.183	.44	.80	.12	.05	.0005	.0017	.0007	.0044
127.	.86	.57	.154	.46	.79	.10	.05	.0005	.0020	.0006	.0040
128.	.77	.52	.211	.30	.67	.10	.04	.0003	.0023	.0007	.0031
129.	.80	.54	.267	.34	.74	.13	.07	.0005	.0030	.0007	.0051
130.	.70	.52	.225	.32	.82	.12	.06	.0004	.0029	.0011	.0042
131.	.79	.56	.168	.35	.66	.11	.07	.0004	.0050	.0008	.0041
132.	.77	.54	.197	.37	.74	.12	.05	.0004	.0026	.0008	.0038
133.	.74	.56	.211	.46	.92	.12	.07	.0007	.0031	.0010	.0046
134.	.87	.54	.225	.39	.88	.13	.06	.0005	.0045	.0009	.0031
135.	.89	.50	.239	.35	.76	.11	.07	.0005	.0038	.0007	.0038
136.	.80	.58	.309	.38	.78	.12	.07	.0005	.0023	.0008	.0066
137.	.73	.62	.183	.44	.79	.11	.11	.0007	.0028	.0009	.0046
138.	.79	.50	.197	.39	.74	.10	.07	.0010	.0054	.0007	.0034

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1] Composition - Leaf								
					N	P	K	Ca	Mg	Mn	Fe	Cu	B
139.	97.5	21.5	75.1	204	2.50	.18	1.62	1.28	.49	.0089	.0192	.0013	.0029
140.	92.5	18.2	82.6	211	2.51	.18	1.70	1.08	.44	.0127	.0178	.0014	.0029
141.	100.0	21.6	70.7	194	2.63	.18	1.71	1.12	.39	.0082	.0215	.0013	.0034
142.	95.0	16.8	66.7	213	2.50	.18	1.78	1.02	.40	.0099	.0192	.0011	.0032
143.	92.5	19.3	75.9	209	2.58	.18	1.85	.95	.34	.0097	.0278	.0012	.0034
144.	97.5	20.3	74.1	183	2.46	.16	1.74	1.05	.39	.0080	.0200	.0012	.0023
145.	90.0	18.0	74.9	216	2.29	.17	1.77	1.41	.39	.0082	.0177	.0014	.0024
146.	100.0	19.2	65.8	217	2.37	.18	2.00	.97	.35	.0093	.0236	.0012	.0024
147.	100.0	19.9	67.4	206	2.58	.20	1.70	1.22	.53	.0075	.0266	.0013	.0027
148.	95.0	20.3	71.8	227	2.61	.18	1.81	1.13	.40	.0089	.0185	.0012	.0026
149.	100.0	20.2	82.6	162	2.27	.18	1.78	1.29	.45	.0083	.0179	.0012	.0025
150.	97.5	22.0	82.0	192	2.57	.18	1.63	1.19	.43	.0131	.0207	.0015	.0027
151.	90.0	17.5	76.3	204	2.46	.16	2.00	1.22	.46	.0105	.0183	.0013	.0024
152.	97.5	19.6	76.2	216	2.51	.17	1.57	1.02	.44	.0098	.0230	.0012	.0024
153.	100.0	19.0	74.9	196	2.36	.19	1.81	.84	.37	.0101	.0219	.0014	.0027

Tree No.	Twig		%[1] Composition - Fruit								
	N	K	N	P	K	Ca	Mg	Mn	Fe	Cu	B
139.	1.03	.54	.407	.28	.69	.13	.08	.0010	.0037	.0013	.0035
140.	1.18	.62	.239	.27	.61	.13	.07	.0015	.0033	.0009	.0037
141.	.98	.57	.267	.23	.58	.14	.08	.0011	.0029	.0008	.0033
142.	1.01	.57	.253	.27	.63	.13	.08	.0011	.0034	.0009	.0039
143.	.96	.53	.267	.33	.67	.13	.07	.0014	.0042	.0008	.0040
144.	.96	.54	.281	.25	.69	.13	.07	.0011	.0029	.0008	.0023
145.	.97	.57	.253	.26	.64	.12	.07	.0010	.0032	.0008	.0032
146.	1.07	.62	.225	.26	.68	.16	.08	.0016	.0032	.0009	.0027
147.	.97	.53	.239	.22	.61	.13	.07	.0009	.0035	.0008	.0019
148.	1.14	.56	.267	.27	.67	.15	.09	.0013	.0033	.0010	.0033
149.	.81	.59	.309	.33	.70	.14	.07	.0018	.0051	.0011	.0021
150.	1.10	.60	.267	.30	.66	.13	.06	.0011	.0053	.0010	.0025
151.	.94	.59	.239	.25	.70	.14	.06	.0012	.0042	.0009	.0030
152.	1.05	.57	.281	.26	.63	.13	.06	.0011	.0028	.0006	.0019
153.	.91	.59	.281	.32	.70	.16	.08	.0013	.0038	.0007	.0023

Table 2 Cont'd

Tree No.	%Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf								
					N	P	K	Ca	Mg	Mn	Fe	Cu	B
154.	70.0	20.9	84.4	224	2.52	.20	2.05	.92	.37	.0061	.0228	.0016	.0044
155.	70.0	17.0	68.6	203	2.62	.20	2.07	1.10	.43	.0055	.0251	.0013	.0042
156.	92.5	19.3	70.8	220	2.55	.18	2.06	.98	.39	.0051	.0224	.0014	.0044
157.	97.5	17.1	62.7	213	2.49	.19	2.07	1.15	.41	.0052	.0300	.0018	.0041
158.	92.5	19.4	72.5	210	2.57	.21	2.18	.99	.36	.0054	.0233	.0013	.0038
159.	95.0	19.8	73.6	216	2.65	.19	2.04	1.11	.49	.0066	.0275	.0014	.0033
160.	82.5	19.1	71.3	201	2.20	.20	1.96	1.05	.41	.0046	.0241	.0014	.0033
161.	95.0	17.6	67.9	208	2.14	.20	1.97	1.13	.38	.0055	.0270	.0010	.0036
162.	87.5	21.3	77.3	192	2.51	.22	2.01	1.13	.44	.0054	.0208	.0012	.0027
163.	95.0	18.0	75.9	197	2.18	.20	1.90	1.21	.35	.0061	.0213	.0014	.0031
164.	97.5	17.4	63.9	180	2.30	.22	2.19	1.28	.34	.0067	.0265	.0014	.0040
165.	67.5	17.8	73.1	196	2.39	.22	2.08	1.08	.30	.0044	.0251	.0014	.0038
166.	90.0	18.2	78.7	172	2.38	.21	1.95	1.04	.36	.0053	.0201	.0016	.0030
167.	95.0	19.2	69.0	184	2.28	.23	1.84	.99	.32	.0059	.0303	.0014	.0034
168.	90.0	20.2	70.1	201	2.50	.22	2.19	.83	.29	.0054	.0281	.0013	.0032

Tree No.	Twig		%[1]/Composition - Fruit								
	N	K	N	P	K	Ca	Mg	Mn	Fe	Cu	B
154.	.96	.62	.295	.41	.69	.11	.10	.0011	.0081	.0012	.0052
155.	1.14	.63	.407	.32	.81	.11	.07	.0007	.0030	.0011	.0065
156.	1.05	.59	.211	.32	.72	.10	.05	.0007	.0060	.0008	.0053
157.	1.11	.60	.351	.35	.75	.13	.07	.0007	.0043	.0010	.0050
158.	.62	.98	.407	.40	.89	.13	.05	.0008	.0033	.0009	.0041
159.	1.10	.63	.295	.37	.83	.13	.07	.0008	.0028	.0011	.0044
160.	.90	.56	.407	.31	.74	.10	.06	.0006	.0033	.0009	.0028
161.	.96	.62	.309	.37	.76	.11	.05	.0005	.0021	.0007	.0042
162.	.86	.59	.351	.35	.78	.12	.06	.0007	.0026	.0009	.0025
163.	1.00	.57	.281	.28	.69	.12	.05	.0007	.0023	.0005	.0031
164.	.89	.60	.239	.32	.84	.12	.06	.0007	.0025	.0008	.0047
165.	.80	.60	.323	.33	.70	.11	.06	.0007	.0028	.0007	.0036
166.	.94	.62	.168	.31	.70	.12	.06	.0006	.0022	.0007	.0030
167.	.93	.57	.225	.28	.64	.13	.05	.0007	.0031	.0009	.0045
168.	.93	.63	.351	.33	.79	.13	.06	.0007	.0027	.0009	.0031

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%1/ Composition - Leaf								
					N	P	K	Ca	Mg	Mn	Fe	Cu	B
169.	97.5	16.8	53.3	167	2.56	.15	1.60	1.45	.45	.0062	.0230	.0014	.0030
170.	92.5	13.3	51.4	185	2.32	.13	1.32	.98	.38	.0078	.0287	.0012	.0026
171.	97.5	16.1	55.6	187	2.44	.14	1.55	1.30	.36	.0047	.0301	.0010	.0030
172.	100.0	14.9	56.6	167	2.47	.16	1.90	1.44	.34	.0130	.0325	.0013	.0025
173.	95.0	17.9	58.3	199	2.28	.16	1.70	1.54	.45	.0066	.0376	.0016	.0030
174.	97.5	14.4	48.6	170	2.41	.15	1.83	1.18	.32	.0116	.0322	.0014	.0024
175.	97.5	16.1	42.8	179	2.55	.17	1.74	1.10	.43	.0103	.0361	.0011	.0027
176.	97.5	17.4	51.3	165	2.64	.16	1.50	1.32	.43	.0108	.0311	.0013	.0025
177.	100.0	15.1	46.6	170	2.64	.18	1.25	1.10	.47	.0132	.0372	.0016	.0026
178.	100.0	15.9	55.6	170	2.60	.16	1.62	1.47	.42	.0078	.0355	.0015	.0024
179.	100.0	16.1	57.4	139	2.71	.16	1.35	1.31	.51	.0067	.0396	.0015	.0024
180.	100.0	14.5	49.8	162	2.58	.17	1.11	1.03	.47	.0081	.0495	.0016	.0026
181.	90.0	15.5	48.2	142	2.71	.16	1.54	1.34	.40	.0071	.0377	.0014	.0025
182.	100.0	14.4	47.2	169	2.57	.17	1.96	1.24	.43	.0140	.0467	.0015	.0027
183.	97.5	16.7	54.4	180	2.65	.16	1.80	.91	.33	.0067	.0456	.0015	.0025

Tree No.	Twig		%1/ Composition - Fruit								
	N	K	N	P	K	Ca	Mg	Mn	Fe	Cu	B
169.	.98	.59	.295	.21	.70	.14	.04	.0007	.0028	.0007	.0032
170.	.94	.49	.154	.22	.65	.13	.05	.0008	.0027	.0009	.0039
171.	1.11	.57	.253	.22	.61	.14	.07	.0007	.0033	.0006	.0046
172.	1.04	.62	.281	.42	.77	.15	.06	.0017	.0029	.0007	.0036
173.	1.14	.60	.267	.21	.59	.11	.05	.0007	.0035	.0006	.0040
174.	1.03	.51	.197	.22	.60	.13	.06	.0015	.0033	.0006	.0025
175.	1.29	.57	.267	.27	.61	.11	.06	.0013	.0034	.0007	.0028
176.	1.07	.47	.281	.23	.54	.16	.07	.0011	.0031	.0007	.0025
177.	1.26	.53	.253	.24	.51	.12	.07	.0010	.0022	.0008	.0020
178.	.98	.60	.239	.22	.59	.15	.06	.0006	.0020	.0005	.0021
179.	1.00	.54	.183	.20	.62	.15	.07	.0007	.0021	.0007	.0019
180.	1.18	.54	.253	.23	.55	.14	.06	.0008	.0018	.0007	.0024
181.	1.12	.60	.267	.29	.65	.14	.05	.0008	.0069	.0009	.0024
182.	1.08	.57	.211	.23	.67	.14	.06	.0015	.0049	.0007	.0019
183.	.90	.59	.183	.21	.65	.12	.05	.0008	.0019	.0008	.0023

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
199.	100.0	13.3	60.1	167	1.92	.19	1.98	1.12	.30	.0087	.0193	.0013	.0032
200.	100.0	12.0	52.9	160	1.88	.18	1.95	1.17	.36	.0093	.0165	.0013	.0029
201.	100.0	10.8	47.6	150	1.91	.20	1.94	1.14	.36	.0126	.0278	.0014	.0035
202.	87.5	11.5	51.0	182	1.70	.19	2.31	.92	.25	.0132	.0220	.0012	.0033
203.	100.0	15.0	71.1	176	1.67	.16	2.32	.88	.25	.0065	.0208	.0012	.0031
204.	100.0	15.1	55.6	182	2.01	.19	2.39	1.41	.36	.0069	.0190	.0015	.0028
205.	100.0	12.5	54.4	196	1.77	.18	2.00	1.20	.34	.0078	.0218	.0013	.0030
206.	100.0	11.8	48.5	169	1.95	.18	2.25	.90	.34	.0049	.0282	.0018	.0034
207.	100.0	9.74	50.2	159	1.85	.17	2.00	1.50	.38	.0089	.0254	.0016	.0033
208.	100.0	14.1	51.0	175	1.83	.18	2.08	1.22	.36	.0088	.0199	.0014	.0032
209.	97.5	12.6	51.0	155	1.70	.16	2.02	1.01	.26	.0051	.0187	.0018	.0029
210.	100.0	10.1	47.4	142	1.81	.16	1.64	1.36	.45	.0059	.0190	.0012	.0028
211.	100.0	11.9	44.4	156	1.81	.16	2.20	.64	.22	.0036	.0226	.0011	.0022
212.	100.0	13.1	50.1	161	2.20	.20	2.23	.82	.30	.0098	.0270	.0014	.0030
213.	100.0	11.1	53.6	183	1.80	.18	2.34	1.20	.34	.0067	.0283	.0013	.0031

Tree No.	Twig N	Twig K	%[1]/ Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
199.	.81	.59	.112	.26	.66	.14	.07	.0011	.0025	.0008	.0046
200.	.83	.51	.169	.25	.63	.16	.07	.0011	.0026	.0006	.0040
201.	.89	.53	.211	.26	.66	.16	.08	.0015	.0021	.0008	.0054
202.	.84	.63	.197	.32	.79	.14	.07	.0016	.0028	.0008	.0050
203.	.77	.56	.239	.30	.80	.15	.06	.0010	.0021	.0005	.0059
204.	.84	.54	.112	.26	.74	.16	.06	.0007	.0031	.0007	.0023
205.	.87	.60	.183	.24	.69	.12	.12	.0011	.0031	.0008	.0028
206.	.80	.56	.154	.23	.71	.16	.07	.0012	.0023	.0007	.0042
207.	.80	.56	.154	.24	.70	.15	.07	.0010	.0024	.0007	.0029
208.	.87	.66	.197	.21	.67	.14	.06	.0006	.0026	.0008	.0025
209.	.81	.54	.225	.24	.71	.14	.06	.0008	.0023	.0008	.0027
210.	.87	.59	.168	.25	.68	.15	.06	.0007	.0042	.0009	.0030
211.	.83	.59	.211	.21	.73	.16	.06	.0006	.0032	.0005	.0029
212.	.89	.63	.197	.25	.57	.13	.05	.0009	.0034	.0008	.0031
213.	.86	.57	.197	.23	.68	.15	.06	.0008	.0026	.0005	.0021

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1] Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
214	97.5	22.3	66.9	209	2.60	.22	1.66	1.25	.51	.0047	.0185	.0012	.0029
215.	100.0	15.1	59.8	162	2.39	.24	1.59	1.38	.46	.0051	.0161	.0012	.0030
216.	100.0	16.3	56.9	175	2.50	.22	1.54	1.31	.46	.0046	.0151	.0013	.0029
217.	100.0	14.9	59.5	179	2.50	.19	1.59	1.42	.52	.0041	.0163	.0012	.0032
218.	100.0	15.2	65.1	194	2.39	.21	1.84	1.32	.42	.0041	.0185	.0012	.0027
219.	100.0	15.1	61.0	187	2.47	.20	1.68	1.37	.47	.0047	.0165	.0011	.0034
220.	100.0	13.5	60.9	180	2.44	.21	1.93	1.37	.51	.0050	.0111	.0012	.0030
221.	97.5	17.3	68.1	172	2.46	.21	1.64	1.32	.46	.0047	.0128	.0011	.0034
222.	100.0	16.2	97.2	175	2.71	.21	1.50	1.59	.51	.0077	.0152	.0012	.0033
223.	100.0	15.7	62.3	183	2.30	.17	1.94	1.45	.48	.0043	.0143	.0014	.0031
224.	100.0	17.2	57.8	172	2.47	.18	1.44	1.44	.51	.0066	.0126	.0014	.0024
225.	100.0	16.8	62.9	167	2.58	.21	1.86	1.14	.47	.0050	.0168	.0018	.0029
226.	100.0	15.0	56.8	165	2.42	.21	1.73	1.48	.50	.0041	.0168	.0017	.0027
227.	97.5	16.6	78.5	187	2.29	.24	1.93	1.30	.45	.0043	.0155	.0011	.0028
228.	100.0	15.7	65.1	176	2.22	.20	1.80	1.44	.42	.0045	.0136	.0012	.0024

Tree No.	Twig N	Twig K	%[1] Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
214.	.83	.56	.126	.24	.61	.12	.06	.0006	.0030	.0007	.0021
215.	.94	.59	.183	.25	.59	.13	.05	.0006	.0014	.0005	.0035
216.	1.04	.60	.225	.24	.58	.13	.06	.0006	.0025	.0005	.0023
217.	.96	.62	.197	.20	.57	.14	.05	.0005	.0035	.0007	.0031
218.	.79	.54	.140	.20	.63	.13	.05	.0005	.0028	.0006	.0019
219.	.84	.59	.168	.21	.62	.13	.05	.0004	.0027	.0006	.0032
220.	.86	.62	.225	.25	.64	.15	.05	.0007	.0038	.0006	.0027
221.	.84	.60	.239	.24	.63	.13	.05	.0005	.0034	.0009	.0045
222.	.80	.64	.239	.23	.58	.12	.05	.0006	.0025	.0006	.0033
223.	.93	.62	.197	.23	.60	.11	.06	.0005	.0021	.0009	.0040
224.	1.01	.60	.211	.29	.70	.09	.06	.0006	.0034	.0007	.0070
225.	.86	.59	.253	.25	.60	.11	.05	.0005	.0028	.0009	.0028
226.	.89	.57	.211	.25	.59	.14	.06	.0006	.0025	.0008	.0022
227.	.74	.59	.197	.25	.62	.11	.05	.0005	.0025	.0006	.0028
228.	.80	.57	.168	.25	.62	.15	.06	.0006	.0024	.0006	.0023

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
229.	87.5	17.8	66.6	188	2.05	.22	1.95	1.22	.37	.0035	.0477	.0022	.0027
230.	87.5	18.6	55.4	196	2.12	.26	2.38	.90	.33	.0037	.0420	.0020	.0030
231.	87.5	16.9	53.4	203	1.84	.21	1.82	.79	.32	.0028	.0376	.0015	.0028
232.	90.0	17.2	57.8	196	2.27	.24	2.39	1.03	.30	.0048	.0300	.0015	.0030
233.	92.5	17.0	64.3	190	2.18	.24	2.17	1.20	.29	.0060	.0253	.0021	.0032
234.	97.5	15.1	54.9	167	2.16	.26	2.26	.89	.34	.0057	.0295	.0018	.0027
235.	68.0	17.0	54.2	189	2.15	.27	1.88	.90	.37	.0047	.0402	.0015	.0029
236.	82.5	14.3	56.9	174	2.30	.24	1.81	.77	.33	.0040	.0302	.0017	.0029
237.	62.5	17.2	51.8	176	2.16	.23	2.16	.95	.28	.0036	.0376	.0014	.0027
238.	90.0	16.2	52.6	132	2.36	.21	1.89	1.06	.39	.0064	.0580	.0016	.0032
239.	77.5	20.6	62.7	163	2.58	.24	2.02	1.42	.39	.0063	.0716	.0013	.0043
240.	82.5	16.2	55.1	201	2.23	.24	2.20	1.11	.41	.0049	.0537	.0016	.0040
241.	95.0	17.5	55.4	201	1.97	.25	2.12	1.03	.33	.0036	.0324	.0013	.0037
242.	85.0	19.4	60.8	207	2.08	.23	2.13	1.04	.40	.0042	.0289	.0046	.0037
243.	92.5	17.4	60.6	190	2.23	.31	2.02	.91	.39	.0039	.0492	.0047	.0048

Tree No.	Twig N	Twig K	%[1]/ Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
229.	.83	.56	.211	.35	.75	.10	.07	.0005	.0043	.0014	.0039
230.	.90	.56	.168	.32	.75	.09	.07	.0005	.0035	.0007	.0036
231.	.90	.51	.154	.35	.74	.10	.08	.0004	.0033	.0008	.0031
232.	1.00	.53	.183	.37	.81	.12	.07	.0008	.0032	.0011	.0045
233.	.84	.56	.239	.40	.77	.12	.06	.0008	.0031	.0008	.0046
234.	1.03	.60	.225	.35	.87	.11	.07	.0008	.0025	.0007	.0038
235.	.84	.53	.281	.33	.85	.11	.85	.0008	.0032	.0010	.0032
236.	.96	.57	.253	.30	.78	.10	.05	.0006	.0031	.0006	.0032
237.	.86	.57	.281	.33	.86	.10	.06	.0004	.0032	.0007	.0019
238.	.97	.54	.239	.34	.82	.11	.06	.0008	.0033	.0009	.0036
239.	.91	.54	.197	.29	.70	.10	.06	.0006	.0040	.0007	.0043
240.	.87	.59	.225	.31	.76	.10	.06	.0006	.0035	.0009	.0057
241.	.84	.54	.211	.25	.73	.12	.06	.0008	.0070	.0009	.0031
242.	.90	.56	.197	.32	.75	.11	.06	.0005	.0035	.0008	.0048
243.	.86	.50	.154	.21	.70	.13	.05	.0005	.0032	.0007	.0023

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
244.	97.5	19.7	69.4	204	2.78	.19	1.39	1.33	.56	.0064	.0335	.0033	.0025
245.	90.0	20.1	57.3	184	2.39	.16	2.00	1.27	.43	.0061	.0140	.0013	.0026
246.	95.0	16.3	48.2	174	2.25	.17	1.88	1.64	.46	.0076	.0135	.0013	.0024
247.	100.0	19.0	53.2	114	2.15	.19	2.03	1.51	.40	.0064	.0144	.0011	.0027
248.	87.5	17.8	68.4	189	2.26	.17	2.12	1.35	.43	.0059	.0128	.0012	.0025
249.	85.0	17.4	65.1	172	2.36	.16	1.90	1.55	.41	.0085	.0172	.0012	.0021
250.	97.5	19.2	65.2	177	2.27	.16	2.04	1.25	.40	.0054	.0125	.0010	.0022
251.	92.5	17.1	61.0	187	1.95	.16	2.17	1.29	.37	.0082	.0144	.0011	.0024
252.	85.0	15.3	59.2	184	2.12	.16	1.99	1.16	.36	.0043	.0109	.0015	.0032
253.	100.0	21.0	74.8	158	2.67	.15	1.46	1.36	.37	.0045	.0141	.0011	.0023
254.	100.0	21.7	67.0	147	2.56	.17	1.58	1.24	.45	.0057	.0128	.0011	.0020
255.	95.0	17.1	60.2	187	2.06	.16	2.14	1.42	.43	.0060	.0129	.0011	.0026
256.	68.0	17.7	60.7	198	1.88	.15	2.32	1.11	.29	.0041	.0124	.0010	.0031
257.	87.5	16.3	65.0	187	2.12	.15	2.56	1.05	.34	.0061	.0115	.0010	.0025
258.	95.0	16.4	59.8	210	2.11	.15	1.60	1.27	.38	.0096	.0107	.0010	.0022

Tree No.	Twig N	Twig K	%[1]/ Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
244.	.86	.54	.168	.20	.56	.12	.05	.0004	.0028	.0007	.0021
245.	1.10	.59	.183	.23	.65	.11	.05	.0007	.0027	.0007	.0025
246.	1.00	.60	.267	.21	.68	.14	.06	.0005	.0030	.0007	.0021
247.	.90	.57	.281	.33	.65	.12	.05	.0004	.0032	.0007	.0023
248.	1.01	.54	.281	.39	.68	.11	.07	.0006	.0033	.0009	.0027
249.	1.05	.57	.295	.27	.67	.11	.04	.0006	.0036	.0008	.0018
250.	.93	.51	.253	.25	.68	.15	.06	.0007	.0030	.0006	.0022
251.	.93	.56	.295	.27	.67	.13	.07	.0011	.0050	.0008	.0030
252.	1.00	.59	.225	.23	.62	.11	.04	.0006	.0042	.0008	.0038
253.	.94	.54	.197	.22	.58	.13	.06	.0007	.0036	.0006	.0016
254.	.98	.49	.239	.28	.69	.16	.07	.0007	.0036	.0007	.0025
255.	1.03	.49	.183	.23	.66	.12	.05	.0005	.0045	.0007	.0039
256.	.84	.51	.225	.24	.71	.12	.07	.0008	.0032	.0005	.0030
257.	.97	.59	.225	.27	.73	.11	.04	.0009	.0030	.0008	.0026
258.	.91	.54	.295	.22	.05	.13	.05	.0006	.0026	.0006	.0022

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1] Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
259.	100.0	21.4	57.1	191	2.84	.17	1.09	1.64	.41	.0135	.0285	.0010	.0031
260.	100.0	19.8	58.7	183	2.67	.15	1.36	1.60	.49	.0087	.0250	.0009	.0026
261.	100.0	23.7	62.7	184	2.82	.17	1.40	1.77	.49	.0213	.0301	.0010	.0031
262.	100.0	22.4	54.3	177	2.70	.18	1.17	1.43	.54	.0207	.0281	.0010	.0030
263.	100.0	23.1	59.4	164	2.63	.16	1.43	1.28	.39	.0214	.0343	.0011	.0031
264.	100.0	19.6	53.5	173	2.15	.15	1.54	1.34	.36	.0120	.0220	.0011	.0021
265.	67.5	21.7	49.8	196	2.78	.17	1.26	1.65	.52	.0212	.0340	.0013	.0023
266.	100.0	21.8	54.3	172	2.44	.16	1.12	1.70	.22	.0166	.0275	.0011	.0024
267.	100.0	22.3	61.1	187	2.63	.18	1.30	1.73	.47	.0125	.0335	.0011	.0026
268.	100.0	20.3	63.4	184	2.63	.22	1.14	1.22	.45	.0144	.0380	.0022	.0031
269.	100.0	21.3	63.8	184	2.39	.17	1.40	1.61	.44	.0143	.0325	.0009	.0024
270.	100.0	21.9	55.5	170	2.43	.18	1.18	1.56	.43	.0213	.0302	.0011	.0026
271.	100.0	21.7	59.1	164	2.46	.21	1.60	1.24	.39	.0074	.0441	.0032	.0026
272.	100.0	21.1	27.7	168	2.78	.23	1.42	1.55	.52	.0310	.0512	.0015	.0031
273.	100.0	19.8	57.2	169	2.47	.20	1.43	1.46	.58	.0174	.0362	.0029	.0027

Tree No.	Twig N	Twig K	%[1] Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
259.	.94	.60	.253	.28	.64	.15	.07	.0012	.0032	.0007	.0028
260.	.96	.59	.211	.30	.55	.18	.05	.0010	.0060	.0009	.0028
261.	.94	.57	.239	.25	.60	.15	.05	.0016	.0033	.0008	.0036
262.	.91	.60	.239	.30	.62	.16	.06	.0019	.0058	.0009	.0030
263.	.89	.57	.183	.26	.60	.14	.05	.0017	.0057	.0006	.0030
264.	.88	.60	.211	.34	.69	.16	.06	.0014	.0069	.0008	.0025
265.	.94	.59	.225	.27	.57	.13	.06	.0018	.0060	.0006	.0026
266.	.97	.57	.253	.28	.60	.15	.06	.0017	.0060	.0006	.0025
267.	.84	.60	.154	.34	.60	.15	.05	.0011	.0058	.0007	.0022
268.	.90	.60	.225	.25	.57	.15	.05	.0009	.0027	.0009	.0022
269.	.91	.54	.211	.26	.61	.16	.06	.0011	.0057	.0006	.0019
270.	.84	.62	.197	.25	.58	.14	.06	.0015	.0064	.0007	.0023
271.	.84	.66	.239	.31	.66	.14	.05	.0013	.0065	.0010	.0024
272.	.94	.69	.225	.28	.61	.18	.06	.0023	.0062	.0007	.0027
273.	.90	.64	.197	.28	.61	.17	.09	.0016	.0070	.0007	.0029

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf: N	P	K	Ca	Mg	Mn	Fe	Cu	B
274.	97.5	20.6	53.9	177	2.40	.17	1.82	1.51	.47	.0097	.0477	.0020	.0030
275.	100.0	20.5	52.3	199	2.43	.17	1.62	1.14	.33	.0103	.0491	.0023	.0032
276.	97.5	20.3	58.5	216	2.36	.15	1.80	1.52	.38	.0114	.0366	.0011	.0032
277.	87.5	20.6	53.7	193	2.35	.15	1.98	1.36	.35	.0108	.0344	.0010	.0021
278.	90.0	19.7	56.0	213	2.57	.15	1.60	1.52	.37	.0082	.0310	.0010	.0029
279.	90.0	25.0	70.4	214	2.67	.14	1.54	1.30	.39	.0114	.0346	.0010	.0022
280.	100.0	21.6	62.8	201	2.65	.18	1.76	1.41	.42	.0169	.0456	.0031	.0028
281.	90.0	21.0	50.8	207	2.56	.18	1.82	1.66	.42	.0127	.0454	.0013	.0027
282.	100.0	18.8	50.7	214	2.53	.18	1.54	1.72	.51	.0185	.0671	.0015	.0029
283.	95.0	23.0	62.1	202	2.61	.16	1.56	1.64	.42	.0095	.0438	.0012	.0028
284.	92.5	21.5	58.8	195	2.67	.17	1.59	1.59	.40	.0161	.0408	.0012	.0025
285.	100.0	19.4	52.5	173	2.50	.15	1.81	1.75	.40	.0132	.0358	.0016	.0028
286.	100.0	18.9	55.2	186	2.63	.17	1.74	1.49	.42	.0155	.0473	.0013	.0036
287.	100.0	19.7	56.7	176	2.44	.17	1.59	1.40	.37	.0146	.0435	.0012	.0029
288.	95.0	22.7	57.1	180	2.49	.17	1.84	1.45	.37	.0110	.0370	.0013	.0028

Tree No.	Twig: N	Twig: K	%[1]/ Composition - Fruit: N	P	K	Ca	Mg	Mn	Fe	Cu	B
274.	.89	.63	.239	.30	.77	.14	.07	.0010	.0061	.0012	.0036
275.	.79	.64	.281	.27	.78	.12	.06	.0010	.0058	.0012	.0044
276.	.91	.66	.239	.25	.76	.10	.05	.0009	.0100	.0010	.0036
277.	.86	.63	.239	.28	.69	.13	.06	.0010	.0082	.0011	.0031
278.	.81	.63	.197	.25	.70	.13	.05	.0008	.0045	.0009	.0023
279.	.83	.59	.239	.21	.67	.13	.05	.0009	.0062	.0009	.0027
280.	.90	.59	.225	.23	.80	.13	.05	.0014	.0069	.0010	.0018
281.	.86	.63	.225	.22	.75	.12	.04	.0008	.0071	.0010	.0022
282.	.91	.60	.225	.22	.63	.12	.06	.0014	.0064	.0010	.0026
283.	.91	.63	.239	.21	.71	.14	.05	.0009	.0064	.0011	.0031
284.	.81	.62	.267	.19	.72	.12	.05	.0009	.0081	.0011	.0018
285.	.84	.60	.281	.24	.76	.14	.05	.0009	.0066	.0011	.0028
286.	.83	.62	.239	.22	.72	.14	.08	.0013	.0084	.0010	.0025
287.	.83	.60	.253	.21	.66	.15	.05	.0011	.0065	.0009	.0025
288.	.74	.64	.225	.24	.65	.14	.07	.0011	.0074	.0010	.0021

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
289.	100.0	16.7	63.4	150	1.77	.15	1.63	1.01	.37	.0178	.0127	.0011	.0026
290.	100.0	20.0	67.3	155	2.09	.18	1.84	1.08	.38	.0147	.0014	.0012	.0026
291.	100.0	18.9	60.7	159	2.35	.17	1.88	1.10	.40	.0209	.0123	.0010	.0024
292.	100.0	18.3	63.3	164	2.46	.19	1.78	.84	.33	.0215	.0117	.0011	.0026
293.	87.5	28.5	74.0	125	2.37	.18	2.06	.79	.30	.0126	.0085	.0010	.0024
294.	100.0	17.9	69.3	152	2.43	.18	1.78	1.18	.33	.0167	.0095	.0011	.0022
295.	100.0	21.9	63.6	150	2.39	.17	1.62	1.28	.45	.0178	.0080	.0010	.0021
296.	100.0	19.7	56.3	138	2.26	.18	2.02	1.18	.34	.0172	.0093	.0011	.0022
297.	100.0	17.8	66.7	133	2.33	.19	2.02	.75	.29	.0168	.0150	.0012	.0022
298.	100.0	14.5	62.7	170	2.44	.18	1.92	1.05	.34	.0117	.0100	.0012	.0022
299.	100.0	16.1	72.5	135	2.36	.18	1.87	1.06	.32	.0149	.0107	.0012	.0022
300.	100.0	20.3	69.8	164	2.61	.20	1.86	1.09	.33	.0199	.0124	.0012	.0025
301.	100.0	21.3	62.5	175	2.50	.19	1.75	.99	.38	.0228	.0122	.0013	.0024
302.	100.0	24.5	66.2	165	2.63	.19	2.00	1.10	.34	.0205	.0100	.0010	.0023
303.	97.5	20.3	73.6	172	2.40	.19	1.84	1.37	.34	.0113	.0082	.0010	.0022

Tree No.	Twig N	Twig K	%[1]/ Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
289.	.80	.57	.211	.21	.77	.11	.06	.0030	.0028	.0008	.0022
290.	.77	.57	.126	.22	.61	.11	.06	.0020	.0026	.0007	.0018
291.	.81	.62	.226	.20	.67	.14	.06	.0023	.0022	.0007	.0012
292.	.87	.67	.225	.21	.70	.12	.06	.0028	.0031	.0007	.0023
293.	.89	.66	.225	.27	.75	.13	.08	.0023	.0038	.0007	.0029
294.	.81	.66	.168	.18	.63	.13	.08	.0021	.0021	.0005	.0010
295.	1.00	.64	.225	.18	.71	.11	.06	.0020	.0031	.0007	.0014
296.	.89	.66	.183	.17	.68	.13	.05	.0038	.0017	.0004	.0018
297.	.87	.78	.197	.26	.78	.13	.07	.0030	.0034	.0008	.0013
298.	.89	.64	.168	.27	.67	.15	.07	.0024	.0024	.0005	.0012
299.	.83	.63	.197	.25	.70	.15	.06	.0022	.0036	.0007	.0013
300.	.84	.64	.239	.23	.67	.12	.06	.0021	.0022	.0004	.0015
301.	.89	.59	.154	.21	.71	.11	.06	.0027	.0020	.0005	.0012
302.	.94	.60	.225	.24	.77	.13	.06	.0028	.0051	.0006	.0017
303.	.80	.64	.239	.34	.70	.13	.05	.0016	.0030	.0007	.0016

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1/] Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
334.	97.5	11.1	76.1	114	1.98	.15	1.89	.84	.29	.0049	.0110	.0014	.0029
335.	92.5	9.8	64.3	125	2.09	.15	1.82	.77	.28	.0037	.0155	.0013	.0029
336.	25.0	11.6	71.1	174	1.88	.15	1.76	.70	.32	.0048	.0138	.0014	.0030
337.	100.0	13.8	66.9	125	1.90	.16	1.56	.72	.20	.0028	.0148	.0017	.0028
338.	87.5	17.5	69.8	148	2.20	.19	2.04	.86	.37	.0056	.0096	.0014	.0030
339.	80.0	9.5	53.6	162	1.91	.14	1.40	.87	.35	.0081	.0130	.0011	.0027
340.	100.0	14.2	68.6	145	2.26	.16	1.98	.96	.33	.0048	.0099	.0013	.0025
341.	65.0	13.0	64.8	155	2.53	.13	2.80	.77	.21	.0043	.0127	.0014	.0034
342.	90.0	12.1	69.0	185	2.18	.15	2.10	.96	.27	.0038	.0142	.0014	.0025
343.	65.0	11.0	62.9	152	2.32	.14	2.68	.75	.18	.0036	.0119	.0014	.0029
344.	62.5	11.1	65.9	166	2.26	.14	2.56	.64	.21	.0048	,0116	.0012	.0035
345.	100.0	9.6	64.4	160	1.98	.15	2.30	.86	.26	.0082	.0133	.0012	.0029
346.	70.0	11.3	63.2	159	2.20	.16	2.30	.73	.28	.0062	.0108	.0012	.0026
347.	87.5	16.8	65.6	162	2.26	.15	1.84	.83	.35	.0088	.0106	.0011	.0025
348.	77.5	19.3	61.9	169	2.25	.15	1.53	.85	.32	.0038	.0102	.0013	.0027

Tree No.	Twig N	Twig K	%[1/] Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
334.	.67	.56	.183	.30	.77	.16	.08	.0009	.0026	.0008	.0074
335.	.76	.51	.154	.31	.64	.14	.07	.0006	.0033	.0007	.0053
336.	.69	.53	.183	.50	1.08	.11	.07	.0008	.0030	.0009	.0051
337.	.77	.51	.168	.32	.62	.13	.04	.0003	.0029	.0007	.0042
338.	.73	.54	.183	.40	.72	.12	.08	.0008	.0033	.0009	.0057
339.	.96	.50	.154	.40	.69	.11	.09	.0006	.0023	.0007	.0023
340.	.76	.57	.253	.36	.78	.14	.08	.0008	.0034	.0008	.0024
341.	.80	.66	.211	.38	1.12	.12	.08	.0006	.0032	.0008	.0059
342.	.84	.59	.295	.25	.72	.12	.06	.0005	.0033	.0008	.0035
343.	.77	.57	.197	.31	.85	.11	.06	.0007	.0048	.0009	.0054
344.	.69	.51	.225	.29	.81	.11	.06	.0007	.0033	.0008	.0049
345.	.87	.60	.197	.35	.76	.16	.06	.0006	.0029	.0009	.0029
346.	.81	.64	.295	.26	.87	.12	.06	.0008	.0048	.0010	.0043
347.	.77	.57	.281	.34	.73	.10	.05	.0007	.0044	.0009	.0032
348.	.84	.56	.281	.39	.71	.12	.05	.0005	.0031	.0009	.0035

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1]/ Composition - Leaf N	P	K	Ca	Mg	Mn	Fe	Cu	B
349.	95.0	24.2	72.9	197	2.70	.16	2.09	.77	.29	.0035	.0136	.0014	.0029
353.	100.0	19.9	66.0	132	2.61	.19	2.20	.53	.23	.0043	.0111	.0020	.0048
354.	85.0	17.6	65.6	129	2.91	.16	1.85	.74	.26	.0023	.0133	.0013	.0035
355.	65.0	23.2	79.5	148	2.65	.15	2.19	.75	.27	.0033	.0125	.0013	.0031
356.	95.0	24.3	71.1	125	2.77	.19	2.46	.60	.22	.0029	.0173	.0013	.0034
357.	100.0	18.0	59.1	114	2.54	.19	2.19	.73	.35	.0033	.0336	.0016	.0029
358.	97.5	23.4	69.9	130	2.63	.19	1.71	.63	.32	.0024	.0280	.0017	.0029
359.	95.0	18.1	68.8	118	2.78	.19	2.25	.57	.26	.0029	.0235	.0016	.0032
360.	87.5	26.3	76.7	153	2.81	.20	2.02	.69	.33	.0031	.0193	.0013	.0034
361.	100.0	22.7	62.1	156	2.67	.18	1.76	.61	.33	.0031	.0148	.0020	.0030
362.	90.0	19.4	71.0	139	2.67	.16	2.17	.75	.28	.0030	.0119	.0013	.0026
363.	100.0	14.0	61.3	129	2.84	.19	2.27	.81	.28	.0055	.0169	.0013	.0033
264.	100.0	14.2	54.9	107	3.16	.22	2.02	.84	.39	.0040	.0174	.0016	.0024
365.	100.0	18.1	60.1	119	2.61	.16	2.00	.81	.37	.0027	.0204	.0017	.0029
366.	97.5	21.7	66.7	140	2.60	.17	1.80	.79	.42	.0027	.0275	.0016	.0028

Tree No.	Twig N	Twig K	%[1]/ Composition - Fruit N	P	K	Ca	Mg	Mn	Fe	Cu	B
349.	.76	.62	.281	.29	.86	.14	.09	.0008	.0029	.0008	.0039
353.	.84	.69	.267	.37	.79	.11	.06	.0006	.0028	.0007	.0099
354.	.90	.57	.351	.26	.72	.12	.07	.0004	.0033	.0006	.0075
355.	.80	.63	.323	.25	.81	.13	.06	.0006	.0034	.0007	.0051
356.	.76	.59	.267	.29	.78	.13	.07	.0005	.0027	.0007	.0045
357.	.86	.60	.253	.29	.83	.13	.08	.0006	.0036	.0008	.0062
358.	.77	.56	.281	.39	.84	.14	.08	.0005	.0036	.0009	.0037
359.	.77	.60	.295	.30	.76	.13	.06	.0004	.0030	.0007	.0036
360.	.84	.59	.337	.29	.90	.11	.06	.0003	.0031	.0011	.0051
361.	.90	.59	.211	.27	.66	.12	.07	.0005	.0027	.0006	.0036
362.	.80	.60	.211	.32	.74	.12	.07	.0005	.0053	.0007	.0062
363.	.81	.63	.225	.31	.80	.16	.08	.0010	.0032	.0007	.0062
364.	1.08	.66	.379	.36	.89	.15	.06	.0008	.0031	.0007	.0030
365.	.87	.57	.281	.31	.84	.15	.08	.0006	.0061	.0009	.0043
366.	.87	.54	.197	.36	.84	.15	.09	.0006	.0036	.0008	.0039

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Twig Length (cm.)	Twig Vigor	Ave. Wt. Apples (gms.)	%[1] Composition - Leaf								
					N	P	K	Ca	Mg	Mn	Fe	Cu	B
378.	95.0	18.8	67.2	175	1.95	.19	2.38	1.02	.27	.0033	.0190	.0013	.0027
379.	95.0	22.1	66.9	172	2.13	.18	2.15	.97	.35	.0039	.0101	.0016	.0026
380.	92.5	17.3	59.5	170	2.22	.20	1.97	.94	.29	.0026	.0217	.0015	.0029
381.	97.5	19.0	62.1	182	1.97	.18	2.09	1.13	.42	.0028	.0190	.0017	.0026
382.	100.0	16.0	59.3	161	2.39	.20	1.68	1.01	.41	.0049	.0201	.0022	.0026
383.	100.0	16.5	88.0	179	2.18	.18	1.80	1.12	.20	.0035	.0259	.0021	.0029
384.	100.0	17.3	60.0	159	2.09	.19	1.90	1.04	.37	.0028	.0200	.0021	.0031
385.	100.0	14.9	54.7	161	1.74	.19	1.75	.89	.37	.0040	.0257	.0015	.0030
386.	97.5	15.6	55.0	150	1.66	.19	1.78	.89	.35	.0032	.0196	.0029	.0026
387.	97.5	15.5	58.1	167	1.90	.18	1.58	.83	.38	.0029	.0230	.0018	.0033

Tree No.	Twig		%[1] Composition - Fruit								
	N	K	N	P	K	Ca	Mg	Mn	Fe	Cu	B
378.	.94	.64	.239	.52	.86	.17	.09	.0009	.0029	.0009	.0042
379.	.81	.64	.211	.54	.86	.14	.09	.0009	.0036	.0011	.0036
380.	.89	.62	.168	.51	.76	.14	.09	.0008	.0031	.0010	.0036
381.	.90	.60	.183	.56	.87	.16	.09	.0007	.0030	.0009	.0047
382.	.93	.62	.197	.42	.75	.15	.07	.0009	.0028	.0009	.0024
383.	.80	.59	.211	.38	.71	.15	.08	.0006	.0034	.0012	.0027
384.	.84	.56	.168	.46	.76	.14	.07	.0006	.0026	.0009	.0040
385.	.81	.51	.168	.36	.66	.13	.05	.0006	.0029	.0008	.0038
386.	.83	.57	.197	.46	.77	.15	.09	.0006	.0029	.0009	.0054
387.	.84	.64	.112	.36	.67	.15	.07	.0004	.0036	.0013	.0046

Table 2 Cont'd

Tree No.	% Bitter Pit Free Fruit	Ave. Wt. Apples (gms.)	%[1/] Composition - Leaf								
			N	P	K	Ca	Mg	Mn	Fe	Cu	B
388.	100.0	194	1.71	.21	2.00	.88	.38	.0059	.0404	.0029	.0031
389.	100.0	218	2.06	.19	1.80	1.01	.49	.0065	.0472	.0019	.0029
390.	100.0	187	1.73	.17	1.59	.98	.46	.0125	.0542	.0014	.0027
391.	100.0	175	1.83	.22	2.02	1.09	.33	.0078	.0660	.0023	.0031
392.	92.5	209	1.67	.20	1.94	.75	.32	.0054	.0542	.0052	.0032
393.	97.5	188	1.52	.16	2.06	.84	.33	.0063	.0445	.0024	.0028
394.	97.5	179	1.94	.19	2.02	.86	.34	.0080	.0438	.0069	.0032
395.	100.0	201	2.30	.23	1.58	1.36	.41	.0148	.0535	.0013	.0033
396.	100.0	184	2.09	.21	1.87	1.36	.39	.0083	.0482	.0012	.0032
397.	100.0	172	2.26	.22	1.60	1.17	.41	.0060	.0640	.0013	.0035
398.	100.0	148	2.13	.21	1.78	1.31	.40	.0118	.0757	.0012	.0036
399.	100.0	152	2.27	.20	1.94	1.45	.51	.0107	.0630	.0012	.0031
400.	97.5	162	2.33	.19	1.92	1.17	.28	.0093	.0437	.0012	.0031
401.	100.0	176	2.12	.19	1.68	1.15	.40	.0094	.0482	.0011	.0030
402.	100.0	159	1.84	.18	1.56	.97	.37	.0098	.0530	.0010	.0033
403.	100.0	170	1.76	.21	1.79	1.30	.34	.0121	.0425	.0013	.0034
404.	100.0	178	1.94	.20	1.74	1.29	.38	.0073	.0575	.0014	.0034
405.	100.0	195	2.64	.19	1.85	1.79	.50	.0123	.0542	.0014	.0035
406.	100.0	166	2.43	.19	1.94	1.42	.41	.0091	.0555	.0012	.0032
407.	100.0	182	2.40	.21	1.90	1.43	.43	.0085	.0477	.0015	.0038

Table 2 Cont'd

Tree No.	%[1]/ Composition - Fruit								
	N	P	K	Ca	Mg	Mn	Fe	Cu	B
388.	.112	.42	.73	.15	.08	.0008	.0045	.0008	.0053
389.	.112	.39	.67	.15	.10	.0010	.0036	.0009	.0039
390.	.239	.27	.63	.15	.06	.0013	.0034	.0009	.0036
391.	.140	.37	.73	.17	.07	.0010	.0037	.0009	.0050
392.	.168	.41	.74	.11	.08	.0007	.0029	.0009	.0035
393.	.154	.38	.74	.12	.06	.0007	.0033	.0007	.0033
394.	.112	.37	.72	.14	.06	.0009	.0041	.0009	.0038
395.	.197	.31	.65	.13	.06	.0013	.0029	.0010	.0037
396.	.168	.35	.73	.16	.07	.0009	.0044	.0009	.0043
397.	.225	.39	.68	.16	.07	.0007	.0035	.0008	.0038
398.	.154	.37	.73	.18	.08	.0016	.0032	.0008	.0044
399.	.140	.31	.66	.18	.08	.0015	.0031	.0009	.0046
400.	.211	.29	.63	.14	.06	.0010	.0032	.0009	.0033
401.	.183	.32	.68	.15	.07	.0010	.0027	.0008	.0027
402.	.168	.28	.73	.17	.07	.0014	.0032	.0008	.0035
403.	.211	.37	.79	.18	.09	.0019	.0041	.0010	.0056
404.	.112	.35	.64	.14	.08	.0010	.0071	.0010	.0042
405.	.197	.33	.71	.15	.07	.0010	.0039	.0010	.0041
406.	.183	.28	.74	.16	.07	.0010	.0035	.0009	.0030
407.	.140	.33	.65	.16	.07	.0008	.0039	.0009	.0042

[1]/Values are expressed on the oven-dry basis. B, Ca, Cu, Fe, Mg, Mn and P were determined spectrographically and N by the Kjeldahl method. The values for N are mainly results from single determinations.