FOLIAR APPLICATION OF NITROGEN TO PEACH TREES

by

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B. S., Utah State Agricultural College, 1950

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1951

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INTRODUCTION

The present day horticulturist, in order to keep astride of the ever increasing competition, is continually trying to improve his cultural practices. Over the years the fruit grower has found that one of his foremost problems in producing a large amount of high quality fruit is keeping the plants well supplied with the proper nutrients. It has also been found that nitrogen is the nutrient element needed in largest quantities, and is, thus, the one most frequently lacking in the proper amounts.

For many years experimenters have been searching for better ways of getting nitrogen into the fruit plants. Recently it has been found that foliage sprays of urea are just as effective in supplying the nitrogen levels of certain apple varieties as is a ground application. Boynton (1950) has found that the addition of urea at a concentration of five pounds per 100 gallons of water in the calyx spray and two subsequent early cover sprays has caused nitrogen responses by McIntosh apple trees comparable to moderate spring applications of nitrogen fertilizers to the soil.

The question arises, "why should anyone want to use this method of fertilization?" Urea sprays, as a source of nitrogen, may have many advantages over the conventional method of soil application. Some of these are (1) improvement in the control of the nitrogen effects on the tree and fruit, (2) saving of labor by elimination of the operation of ground fertilization, and (3) nitrogen can be supplied to plants when root absorption is limited through drought, leaching or root injury.

Due to the response shown by apple foliage in its ability to absorb nitrogen from urea sprays it would seem highly desirable if other types of plants also showed this response. Therefore, this experiment was set up to determine if the Elberta variety of peach could absorb nitrogen through its leaves from foliage sprays of urea. Also it was deemed desirable to study the effects of different concentrations and different numbers of application of urea on the leaf nitrogen, tree growth, and internal structure of the leaves.

LITERATURE REVIEW

Foliage Sprays of Nitrogen

Hamilton, Palmiter and Weaver (1943) observed that when fermate was used in foliage sprays to control apple scab and cedar apple rust it also appeared to be of nutritional value to the trees. As a result of this observation further tests were made to determine if nitrogen could be absorbed from foliage sprays by the leaves.

Apples. Hamilton, Palmiter, and Anderson (1943) reported the first use of applying nitrogen to apple trees in the form of foliage sprays. Chilean nitrate, synthetic sodium nitrate and potassium nitrate when applied as foliage sprays to mature McIntosh apple trees seemed to increase the intensity of the leaf color, but severely injured the foliage. Ammonium sulfate did not noticeably increase leaf color and did not injure the foliage. Uramon (urea) at 5#/100 gallons increased leaf color and nitrogen content of the leaves without showing any foliage injury.

Pickett and Bates (1946) found that spraying the foliage of Wealthy, Winesap and Jonared apple trees with 0.5 percent solutions of NH_4 NO_3, $NaNO_3$, and Urea increased the R value of the leaves above that of the untreated checks.

Fisher, Boynton and Skodvin (1948) after extensive tests in three orchard locations reported that three pounds of urea in the soil was more effective in increasing terminal growth, set and yield, while urea sprays increased chlorophyll content and fruit size. They concluded that the effects of spray applications of urea nitrogen on yield and color of McIntosh apples are greatly dependent on the timing of the sprays as well as on the dosages. It was found, later, by Fisher and Cook (1950) that fruit set, yield and fruit color were about the same with either foliage sprays or soil applications of the same amount of nitrogen.

Harley's (1950) studies indicate that at present recommended rates, leaf sprays of nitrogen may not supply enough nitrogen for best growth in large apple trees; however he points out that application of nitrogen in leaf sprays has several advantages: (1) it saves labor; (2) urea penetrates apple leaf tissue rapidly; (3) cost of nitrogen is about on par with that of other forms, and (4) trees suffering from root injury will probably recover more rapidly if aided by nitrogen taken directly into the leaves.

Rodney (1946) increased the nitrogen content of leaves on Richardred apple trees as much as 57 percent by spraying with an aqueous solution of Nugreen.

Fisher (1950) stated

> ... it would appear that after several years experience with a given block, the leaf spray method might give somewhat more control over the desired nitrogen level of the trees than would the soil application method. Nitrogen is needed by the growing tissues early in the season when it will influence terminal growth, leaf size, leaf color and fruit set. These processes should be completed within about 4 weeks following bloom,

> after which it would be desirable to have the nitrogen supply reduced so that carbohydrates could accumulate. This is desirable for good quality fruit and to favor the hardening processes of the tree. When nitrogen is applied as a ground application, the time required for it to reach the growing points will depend on the soil type and the weather. The leaf spray method is more direct and can be timed to meet the immediate needs of any particular process such as shoot growth or fruit set.

Peaches. Weinberger, Prince and Havis (1949) in tests conducted at Fort Valley, Georgia, and Beltsville, Maryland, found that foliar applications of urea to peach trees were practically ineffective. The varieties-- Dixigem, Sullivan Early Elberta, Redhaven, and Sunhigh were treated with varying concentrations of urea used both as foliage sprays and soil applications. The foliar applications were ineffective as shown by leaf color, leaf analysis, harvest records and fruit color. Concentrations of 25 and 50 pounds of urea per 100 gallons of water resulted in no nitrogen increase, but did cause marginal burning of the leaves.

Norton (1950) has obtained increase in nitrogen content of peach foliage by using equal molar concentrations of urea and sucrose. The sucrose acted as a buffering material permitting high concentrations (25 to 50 pounds per 100 gallons) of urea to be used without foliage injury.

Tomatoes. In using urea sprays to increase nitrogen levels in tomatoes grown under glass, it was found that the recommended 5 pounds per 100 gallons of water caused burning, Emmert and Klinker (1950). They assumed that high concentrations of carbohydrates must be present in the leaf tissues to combine with the urea as it enters the tissue if burning is to be prevented. Since tomatoes do not maintain the carbohydrates necessary for this, spraying with sucrose in the urea solutions was tried. Equal molar solutions of sucrose mixed with urea solutions stopped urea burning in all cases and enabled ten times as much urea to be used on tomatoes without burning as when no sucrose was used; namely, 50 lb. instead of 5 lb. to 100 gallons.

Other Fruits. Jones and Parker (1949), in tests conducted over a three year period with Washington naval and Valencia oranges, found that nitrogen is readily absorbed by the leaves of orange trees. They also observed that a more rapid increase of the nitrogen in the leaves can be accomplished by spray application than by soil application. Haas (1949) obtained similar results with lemon foliage by using 44.8 pounds of urea per 100 gallons.

Factors Affecting Urea Absorption

Leaf Structure and Arrangement. Boynton (1950) reported that the efficiency of absorption of a spray application and the tolerance of the leaves to a given concentration vary according to the kind of fruit and its leaf arrangement or structure. He pointed out that it is probable that the efficiency of leaf absorption by the pineapple is far greater than the apple because the leaves point upward and form a dense crown with which to catch the spray material. On the other hand, apple leaves may be more efficient in absorption of urea sprays than peach leaves due to the character of the under-surfaces. Boynton stated

> ... the wooly hairs and the reticulate pattern of the veinlets on the under surfaces of apple leaves seem to permit much more spray material to remain on a given amount of area than is the case on the relatively smooth under-surfaces of peach leaves.

In an extensive anatomical study of McIntosh apple leaves, Roberts, Southwick, and Palmiter (1948) found that there is much pectinaceous substances in intermittent parallel layers in the outer wall of the epidermal cells interspersed with cutinized areas. The pectinaceous substances form a continuous path reaching from the outside of the leaf and extending to the walls of the vein extensions.

In decribing this finding, Roberts stated

> ...The epidermal cell walls of the McIntosh apple leaf can not longer be considered as covered with a continuous cuticle which prevents the absorption of water. The amount and location of pectinaceous substances present in the leaves account for the entrance of water soluble materials such as minor elements, nitrogen, hormones, and organic fungicides sprayed upon apple trees.

Rodney (1946) reported that apple leaves of the Richardred variety that had been sprayed on the upper surface contained 1.24 percent nitrogen (dry weight basis) as compared with 1.40 percent in leaves that had been sprayed on the lower surface, indicating that more absorption occurs through the lower surface than through the upper surface. He attributed this difference to the presence of stomates on the lower surface. Cook (1950), working with McIntosh apple leaves, found that 58.1 percent of urea was absorbed by the upper surface.

pH of Spray Solution. Cook (1950),studying the effects of varying levels of pH, found that the absorption rate, for the first few hours seems highest at pH's below 7, goes through a minimum at a little over 7 then increases again as the solution becomes more alkaline.

Rate of Absorption and Translocation. Cook (1950) found that the amount of urea absorbed by McIntosh apple leaves varies considerably for the first few hours but is then remarkably consistent in the amount of absorption. Time runs were made at 2, 8, 24, and 48 hour intervals. The 2-hour rates varied from 20 to 55 percent absorption. The longer periods gave consistent values. The averages for four runs gave 69 percent for 8 hours, 84 percent for 24 hours, and 90 percent for 48 hours.

In conversion and translocation studies Cook found little change in 8 hours, a little more in 24 hours, and a larger conversion or translocation in 48 hours.

Methods of Measuring Nitrogen Increase

According to Miller (1938) nitrogen enters into the structure of chlorophyll, the amino acids, amides, alkaloids, protein, and the protoplasm of the plant. The size of the plant is thus largely a measure of the rate of nitrogen metabolism. Frear and Anthony (1947) found a high degree of correlation between air-dry leaf weights and amount of nitrogen present in a plant. Thus, the photosynthate produced by the plant should be an index to nitrogen supply in that plant.

There are three general methods discussed by Miller (1932) for measuring the rate or total amount of photosynthesis: 1) the rate of oxygen liberated in the process, 2) the amount of carbon dioxide absorbed, and 3) the amount of dry matter produced. In each method respiration biases the measurement because the end products of photosynthesis are the raw materials for the respiration process which is proceeding at the same time.

Sachs in 1884 was the first to use the dry weight methods in determining the rate of photosynthesis of leaves. He removed one-half of an attached leaf, along the midrib of the leaf blade, and then determined the dry weight of the severed portion. After exposure to light for a given period, the other half of the leaf was removed after the same manner and its dry weight determined.

Ganong (1908) devised a leaf punch that removes a disk of leaf with an area of 1 sq. cm. This development presented a standard for experimental comparisons and decreased the intensity of objections to Sachs' original method.

According to Miller (1932), the increase in dry weight that is obtained for a given area of leaf does not represent the total weight of the product formed by photosynthesis during that period. Translocation of products from the leaf takes place during the period of photosynthesis, while a certain amount of the product of photosynthesis is utilized in respiration, which is proceeding simultaneously with photosynthesis. As given in Miller (1932), Sachs considered that the total weight of photosynthate made during the day in a given area of leaf could be determined by adding to the gain during the day the loss in weight of the same area during the night. This should give the total increase in weight due to photosynthesis, provided that respiration and translocation proceed at the same rate during the daylight hours as they do during the night.

Denny (1930) introduced the "twin-leaf" method of measurement which takes advantage of the fact that opposite leaves on plants are under more nearly identical conditions of growth than are two half leaves.

In the use of the dry weight method the selection of representative leaves is important. Boynton and Compton (1944) selected 50 leaves at random from the middle portions of shoots on the outside of trees. In 1945 they noted that chlorophyll content decreased with increasing age of the leaf, and so they suggested that leaves be selected from the middle portion of shoots. Pickett (1933) sampled leaves from outer shoots on the south side of the tree.

Pickett (1937) determined the increase in total dry matter of small trees between the time of planting and the digging five months later. Each tree was weighed before planting. Three trees were killed by heat and oven dried to determine the percentage of moisture representative of all the trees planted. He used the gain in dry matter as an index to the rate of photosynthesis,

Pickett (1935) determined the rate of photosynthesis in apple leaves by the punch method, the carbon dioxide absorption methods, and the saccharification method. He reported that there is no one certain measure of photosynthetic rates. He suggested that the method employed be selected for the conditions under which one works.

Total Nitrogen. Lindner and Harley (1942) reported a rapid method for the determination of nitrogen in plant tissue. A rapid acid digestion procedure was obtained which made it possible to determine not only nitrogen, but also phosphorus, potassium, calcium, magnesium and other elements in the same sample. The use of 30 percent hydrogen peroxide in the presence of concentrated sulfuric acid was found to be a fast and thorough method for digesting relatively small quantities of plant material. The entire digestion takes only about five minutes, and total nitrogen, including nitrates, can be determined in the resulting solution by the standard nesslerization procedure using a photoelectric colorimeter of the test tube type.

It was found that either fresh or dry material saves considerable time in sample preparation. A leaf punch which cuts out one sq. cm. of leaf tissue was used, thus saving the time required to dry, grind and weigh the sample. According to Lindner and Harley, ten sq. cm. of leaf tissue of most fruit trees is equivalent to 100 mg. of the dry material, and the area basis is just as satisfactory as the dry-weight basis for comparing samples.

Harley (1950) stated that the rapid method for determination of nitrogen in plant tissue is superior to the Kjeldahl or similar methods.

Leaf Dimensions and Shoot Length. Bates and Pickett (1947) found that the leaf area of a tree can be satisfactorily determined from measurements of the length and width of all leaves on the tree. The leaf area of a Jonathan apple tree was calculated from the sum of the products of the length and width of all leaves on the tree and the ratio of the sum of the products of the length and width to a planimeter measurement of area of a random sample of leaves.

Boynton and Harris (1950) found a high degree of correlation between leaf dimensions, leaf area, shoot length and nitrogen supply in the McIntosh apple, Elberta peach and Italian prune. They suggested that measurements of leaves and shoots may be very useful in diagnosis of nutritional problems.

Leaf Structure. Pickett (1933) in a preliminary report stated that measurements of differences between the extent of intercellular spaces in the mesophyll of some apple varieties was highly significant. Liveland and Delicious varieties showed the greatest differences.

In 1934, Pickett compared the photosynthetic rates and the extent of intercellular spaces of Liveland and

Delicious apple varieties in the greenhouse and in the orchard. He found that orchard-grown Liveland leaves had more extensive intercellular spaces and more photosynthetic activity than did the Delicious variety. He proposed that the extent of exposed wall surface bordering intercellular spaces possible was an internal factor helping to regulate the photosynthetic rate.

Pickett (1937) reported that a greater extent of internally-exposed surface in the Wealthy than in the York variety furnished a more extensive moist area on which carbon dioxide was absorbed. Wealthy trees made less gain than York trees in the total dry matter produced but showed a greater gain per unit of leaf area. A given amount of chlorophyll, therefore, was capable of a greater production of photosynthate in the Wealthy variety.

Pickett and Kenworthy (1939) determined the differences in leaf structure by an actual measurement of the internally-exposed leaf area, using the formula of Turrell (1936), and the externally-exposed leaf area. The relation of the internal to the external area was designated the R value. They concluded that the extent of the internally-exposed surface of apple leaves is more important than the chlorophyll content as a factor partially governing photosynthetic activity.

In 1941 Pickett and Birkeland found that the R ratio was reduced by repeated applications of lime sulfur and lead arsenate. The assumption, therefore, was made that the spray residues may result in altered palisade tissue. This may account for reduced internally-exposed area in sprayed foliage. They suggested further that measurement of the R value could be more simply accomplished by recording direct microscopic measurements of the depth of the palisade tissue.

The same authors in 1942 reported that the ratio of the internally-exposed surface to the externally-exposed surface of both greenhouse-grown and field-grown apple leaves is reduced by the repeated application of certain spray materials, and that spray materials shock or check normal cell development in apple leaves with each variety throughout the growing season. Also, the so-called mild sprays do not exert so great a dwarfing effect as do the stronger materials.

In a Kansas Technical Bulletin, Pickett and Birkeland (1942) reported a highly significant correlation of 0.88 between the total depth of palisade layers (P), in microns, and the R values. They suggested that application of the regression coifficient $0.1122\ P + 1.33$ be applied to the P value as a simplified method of arriving at the R value. They also reported that the lower and central portions of the leaf blade had greater R values than the top and edge portions.

Pickett and Bates (1946) tested 17 spray materials or combinations of materials for their influence on R values following ten applications. They found that D D T and Fermate decreased R values on Winesap and Jonathan apple foliage. Foliage of Wealthy, Jonared and Winesap trees sprayed with nitrogenous fertilizers had higher R values than untreated leaves.

Fish (1949) found that Parathion caused a slight decrease in the R value of Winesap apple foliage. The R values of sprayed leaves of Fermate, 2,4-D, and Chlordane resembled the check.

Kwong (1949) found the depth of palisade cells in Belle of Georgia, Halehaven, and Golden Jubilee varieties of peach was reduced by the application of Fermate and D D T.

MATERIALS AND METHODS

The tests reported here were conducted on two groups of peach trees planted at different dates in different locations. The first group will here after be referred to as the green house series, and the second the field series.

Greenhouse Series

Materials. On January 11, 1951, 40 one-year-old Elberta peach trees were planted in boxes, measuring 12" x 12" x 15", which had been previously placed in the ground bed of the number three horticultural green house. The trees were in three north to south rows spaced three feet between rows and three feet within the row. The boxes were filled up to 1" from the top with soil taken directly from the ground bed. A chemical analysis of the soil showed it to be high in phosphorus and potassium, and it contained four percent organic matter. All the trees were uniform in size and appeared healthy. They were pruned lightly in order to leave as many buds as possible.

Treatments. Eight treatments were selected for comparison. They included (1) a single spray of urea at a concentration of 5 pounds per 100 gallons, (equal approximately 0.1 molar solution), (2) a single spray of urea plus sucrose at a concentration of 25 pounds urea and 150 pounds sucrose per 100 gallons (equals approximately 0.5 molar solution), (3) a single spray of urea plus sucrose at a concentration of 50 pounds urea plus 300 pounds sucrose per 100 gallons (equal approximately a 1.0 molar solution), (4), (5), and (6), two sprays one week apart of the above materials and concentrations respectively, (7) a soil treatment of ¼ pound ammonium nitrate applied at time of first spray, (8) check (untreated).

A commercial form of urea called NuGreen was used for all the urea sprays. NuGreen contains 44 percent nitrogen and is soluble in water.

For the purpose of replication, the trees were divided into five blocks with each of the eight treatments in each block. It was observed that the trees did not all break dormancy and start their growth at the same time, therefore the trees were selected for each block on the basis of the resumption of growth. All the trees in each individual block were in as nearly the same stage of growth as possible.

The first treatment was applied to each block when the leaves had reached sufficient size to permit Ganong leaf punch samples to be taken. Due to the great variation in date of breaking dormancy and rate of growth, the dates of treatments extended from March 8, 1951, when the first spray was applied to Block I up to May 14, 1951, when the second spray was applied to Block V.

The dates of treatment follow this page.

The dates of treatment were as follows:

Block I	first spray	March 8, 1951
Block I	second spray	March 14, 1951
Block II	first spray	March 14, 1951
Block II	second spray	March 21, 1951
Block III	first spray	March 28, 1951
Block III	second spray	April 4, 1951
Block IV	first spray	March 28, 1951
Block IV	second spray	April 4, 1951
Block V	first spray	May 7, 1951
Block V	second spray	May 14, 1951

The sprays were applied with an atomizer type sprayer which was powered by a quarter horse power electric motor. A water proof screen was placed around each tree during spraying to prevent any of the spray from getting on adjacent trees. Burlap bags were placed over the boxes at time of spraying to prevent any spray material from dripping into the soil. Each tree was sprayed to initial drip.

Sampling. The morning following each spray treatment 50 Ganong leaf-punch discs were taken from each tree in the same block. A single punch was made on each of 50 different leaves from the same tree at each time. Samples were collected from the opposite sides on the same leaves at 6:00 a.m., 4:00 p.m. and again the following morning at 6:00 a.m. As an aid to the punching procedure, 50 cardboard marking.tags were numbered from one through fifty and attached to the petioles of 50 representative leaves on the tree. Tags were attached methodically so that the numbers were easily read and punches could be taken consecutively without danger of missing a single leaf.

A cylindrical metal holder attached to the punch collected the leaf samples. When the 50 leaves of each tree had been sampled, the holder was unscrewed from the punch and the contents transferred into glass vials. The vials had been previously weighed, and numbered for identification (Plate V).

Oven drying of the punched material proceeded at approximately 100° C. for a period not less than 24 hours. Each vial and contents were then weighed on a chainomatic balance and the weight of punches recorded. This dry weight represented the sampling of one tree within one block for either the morning or afternoon set of punches. Subtraction of the morning dry weight from the evening dry weight gave weight in milligrams of dry matter accumulated over the loss of photosynthate by respiration and translocation. This loss was accounted for by adding the night loss in dry weight to the gain from the day before. This weight difference represented the sample datum for one treatment within one block for one leaf punch series.

A third series of punches was taken from each tree one week after the second spray treatment had been applied. The same procedure was followed as before.

At intervals of 8, 24, and 48 hours after each treatment samples were taken for total nitrogen determination. One sample was taken one week after the second spray treatment, thus making a total of seven samples from each tree in each block.

Table 1. Summary of weather imformation during periods of dry weight measurement, greenhouse series, 1951.*

Date of sampling	Character of daylight hours
March 9	Cloudy, occasional showers. Rainfall .7 inch.
March 15	Partly cloudy.
March 22	Partly cloudy.
March 29	Fair and warmer
April 5	Partly cloudy, showers and thunder storms, Rainfall .67".
April 12	Mostly cloudy. Rainfall, trace.
May 8	Partly cloudy with scattered thunder showers. Rainfall .36".
May 15	Mostly cloudy with scattered showers. Rainfall 1.45".
May 22	Partly cloudy, Rainfall .11".

* The greenhouse temperatures were kept as nearly as possible at 70° F. during the day and 50° F. at night.

The procedure in sampling and total nitrogen determination was followed according to Lindner and Harley (1942). Ten leaves were taken at random from each treatment for each sample. The leaves were cleaned of all spray residue with a wet cloth. A single punch measuring one square centimeter was then taken from each of the 10 leaves. The

10 punches were immediately placed in a 50 ml Erlenmeyer flask with which 2 ml of concentrated sulfuric acid. The samples were then heated on an electric hot plate until broken down and partially dissolved. The digestion was aided by addition of 0.5 ml of 30 percent hydrogen peroxide. When the solution became perfectly clear and colorless on continued heating, it was cooled, diluted with water and transfered with washings to a 100 ml volumetric flask and made to volume. A 10 ml aliquot was transferred to a 50 ml volumetric flask. Two ml of 2.5 N NaOH was added to partially neutralize the excess acid, and 1 ml of 10 percent sodium silicate was added to prevent turbidity. The solution was then made to volume and mixed well. A 5 ml aliquot was transferred to a colorimeter tube and 4 drops of Nessler's reagent were added to the tube with the solution being mixed thoroughly after the addition of each drop. The sample was read in a Klett-Summerson photoelectric colorimeter using a blue filter (Wratten No. 44).

The colorimeter was calibrated from readings based upon standard solutions of ammonium sulfate. All readings were then recorded in percent of total nitrogen.

At the same time the last sample was taken for total nitrogen determination leaf samples were also taken for measurement of the palisade layer of the leaves. These samples consisted of a section approximately ¼ by 1 inch taken near the midrib from the same leaves which had been punched for total nitrogen determination. The section was simply taken from the opposite side of the midrib from where the punch had been taken. Four leaves were sampled from each tree.

Killing the leaf samples was hastened by dropping the freshly-cut sample into vials containing a killing solution. The procedure for fixing and embedding followed the tertiary-butyl alcohol method of Johansen (1940). After embedding the sections were cast into molds and mounted on wooden blocks. Leaf cross sections were cut at a thickness of 10 microns on a standard rotary microtome. Since permanent slides were not essential, the slide with paraffin ribbon was dipped in xylene until the paraffin was dissolved and then mounted in glycerine.

Measurement of the depth of the palisade layers was made with an ocular micrometer which had been previously calibrated with a stage micrometer. Each unit division on the occular represented 1.65 microns on high power of the microscope. Ten sample readings were made and recorded for each slide. The recorded observation was the linear distance between the upper end of the topmost layer of palisade and the lower end of the lowest layer. The mean of 10 measurements represented the sampling measurement for each slide.

Also one week after the last spray in each block terminal growth measurements were taken from 10 shoots on each tree. The average of the 10 measurements was recorded in inches.

Field Series

<u>Materials.</u> On April 28, 1951, 50 one-year-old Early Elberta peach trees were planted in the same type boxes which had been used in the greenhouse series. The boxes had been placed south of the new horticulture greenhouses in three rows running east and west. The spacing was four feet between rows and three feet within rows. The boxes were filled and the trees planted in sand. The boxes were mulched with a 1 inch layer on sphagnum moss to lessen evaporation.

A modified Knop solution made up in six parts was used to supply the plant nutrients to the trees. Nitrogen was omitted from the nutrient solution in order to insure a nitrogen deficiency of the trees. Stock solutions were made up as follows:

1. 6 gm KCl in 1 liter
2. 6 gm KH_2PO_4 in 1 liter
3. 9 gm $MgSO_4 \cdot 7H_2O$ in 1 liter
4. 7 gm Ca $SO_4 \cdot 2H_2O$ in 1 liter
5. 0.6 gm Ferric tartrate in 1 liter
6. Minor elements in 1 liter
   - Mn Cl_2 - 0.2 gm
   - Zn Cl_2 - 0.1 gm
   - H_3 BO_3 - 0.1 gm
   - Cu Cl_2 - 0.02 gm

The stock solutions were mixed together in a bucket and applied to each tree with a cup. One cupfull (approximately 120 ml) of the solution was applied to each tree every other day from May 27, 1951, to June 25, 1951.

Treatments. As with the greenhouse series, eight treatments were selected for comparison. They included (1) a single spray of urea (NuGreen) at a concentration of 5 pounds per 100 gallons (0.1 M conc.), (2) a single spray of urea (NuGreen) at a concentration of 10 pounds per 100 gallons (0.2 M conc.), (3) a single spray of urea (NuGreen) plus sucrose at a concentration of 25 pounds urea (0.5 M conc.) and 150 pounds sucrose per 100 gallons, (4), (5), (6) two sprays one week apart of the above materials and concentrations respectively, (7) a single spray of urea (NuGreen) alone at a concentration of 25 pounds per 100 gallons, and (8) check (untreated).

The trees were divided into 6 blocks with each of the eight treatments in each block. The trees were randomized within the blocks by drawing numbers from a hat.

The first treatment was applied when the leaves had reached sufficient size to permit leaf punches to be taken. All blocks were sprayed at the same time. The first spray was applied on June 19, 1951, and the second spray was applied on June 25, 1951.

The same spray equipment was used as in the greenhouse series. All boxes were covered with waterproof paper before spraying to keep spray residue from washing into them. As before, each tree was sprayed until both surfaces of the leaves were thoroughly wet.

During the course of the treatments of the field series, the weather was very variable with a great deal of rain falling usually at night. A rain of 1.48 inches starting approximately 30 hours after the first spray and a rain of 1.02 inches starting fourteen hours after the second spray may have had a nullifying effect on the treatments.

Sampling. Leaf punch samples were taken for total nitrogen determination at intervals of 24 and 48 hours after each spray treatment, and again one week after the last treatment. The procedure of Lindner and Harley (1942) was followed in the same manner as in the greenhouse series.

At the time the last samples were taken for total nitrogen determination, one week after the last spray, growth of the trees was determined by measurement of leaves and shoots. Ten representative shoots were selected from each tree for comparison. The terminal growth of each of the 10 shoots was measured and recorded in inches. All the leaves on each of the 10 shoots were measured, length by width. The leaf area of the leaves was calculated from the products of the length and width of the leaves by the products of the length and width of a random sample of 100 leaves as measured by a planimeter. The measurements of the leaves in the random sample were made from blueprints of the leaves.

Table 2. Summary of weather information during periods of treatment of Early Elberta peach trees. Field series, 1951.

Date	Temperature (°F) Maximum	Minimum	Character of daylight hours
June 19*	92	59	Partly cloudy
June 20	83	60	Cloudy with showers, rained 1.48"
June 21	80	61	Cloudy with showers, rained 1.61"
June 25*	90	54	Partly cloudy with showers. rained 1.02"
June 26	84	65	Cloudy with showers, rained .31"
June 27	92	59	Cloudy with showers, rained .23"

* Dates of spraying.

PRESENTATION OF DATA

Greenhouse Series

Four distinct types of measurement provided the experimental data for the greenhouse series. Leaf punch increments of dry weight provided for an analysis of treatment effects upon photosynthesis. Percent total nitrogen of the leaves served to show whether nitrogen had been absorbed by the leaves. Microscopic readings provided for an analysis of treatment effect upon internal leaf structure. Terminal growth measurements gave an index to probable growth of the trees.

Photosynthesis. The dry weight measurements of photosynthetic activity, as shown in Table 3, were extremely variable throughout the three different periods of punching. It was observed that the dry weight increments of gain during the day were very sensitive to weather conditions and the fact that many days were cloudy and stormy may have had some bearing on the variability of the samples. An analysis of variance of each of the three series of punches showed them all to have very low F values and therefore absolutely no measurable significance between treatments.

Percent Total Nitrogen. As shown in Table 4, the percent total nitrogen between treatments and times of sampling was rather variable; however the spray treatments all showed higher percentages of total nitrogen than the check (untreated). An analysis of variance showed that there was a highly significant difference both between treatments and between times of sampling.

L. S. D. 's also showed that all treatments were significant at the .05 level over their corresponding check.

The percent total nitrogen was higher in treatments which had received higher concentrations of urea. Thus 1.0 M solutions gave the highest percentages and 0.1 M concentrations the lowest. Two sprays were also more effective than one. It is also noticeable that the soil treatment of ¼ pound ammonium nitrate applied at the time of the first spray had very little, if any, effect during the first sampling period. However, by the end of the two week period the soil treatment showed higher percent total nitrogen than any of the spray treatments except two sprays of urea at 1.0 M concentration.

<u>Depth of Palisade.</u> As shown by Table 5, the depth of palisade tissue was very variable within treatments. The analysis of variance showed a very low F value, indicating no significance between the treatments.

<u>Terminal growth measurements</u>. The terminal growth measurements (Table 6) were extremely variable within treatments. The F value was very low showing no trend to significance between treatments.

Table 3. Average dry weight gain of Elberta peach leaves in grams per square meter of leaf surface for each sampling series. Greenhouse series, 1951.

Time of sampling	Treatments*							
	One spray			Two sprays			soil	check
	U 0.1	U & S 0.5	U & S 1.0	U 0.1	U & S 0.5	U & S 1.0	NH_4NO_3 ¼ #	(untreated)
One day after first spray	7.75	7.31	7.20	7.25	6.07	6.25	6.34	7.02
One day after second spray	7.01	8.29	6.70	7.43	7.24	6.92	7.62	7.51
One week after second spray	4.86	5.93	4.90	4.50	5.01	5.58	5.54	4.51

F value for treatments not significant.

* U, urea; S, sucrose; 0.1, 0.5, 1.0, molar concentrations.

Table 4. Average percent total nitrogen of Elberta peach leaves. Greenhouse Series, 1951.

Time of sampling	Treatments*							
	One spray			Two sprays			soil	check
	U 0.1	U & S 0.5	U & S 1.0	U 0.1	U & S 0.5	U & S 1.0	NH_4NO_3 ¼ #	(untreated)
8 hours after first spray	2.354	2.386	2.546	2.432	2.442	2.510	2.366	2.212
24 hours after first spray	2.528	2.540	2.698	2.640	2.574	2.640	2.382	2.246
48 hours after first spray	2.474	2.480	2.656	2.580	2.636	2.590	2.380	2.226
8 hours after second spray	2.268	2.300	2.566	2.436	2.622	2.628	2.442	2.202
24 hours after second spray	2.284	2.294	2.492	2.482	2.612	2.672	2.420	2.226
48 hours after second spray	2.264	2.266	2.442	2.426	2.518	2.652	2.374	2.208
1 week after second spray	2.254	2.308	2.438	2.458	2.436	2.540	2.484	2.138

F values for treatments and sampling time significant at .05 level. All treatments significant at .05 level over corresponding check as shown by L. S. D.'s.

* U, urea; S, sucrose; 0.1, 0.5, 1.0, molar concentrations.

Table 5. Average depth in microns of palisade tissue of Elberta peach leaves. Greenhouse series, 1951.

Time of sampling	Treatments*							
	One spray			Two sprays			soil	check
	U 0.1	U & S 0.5	U & S 1.0	U 0.1	U & S 0.5	U & S 1.0	NH_4NO_3 $\frac{1}{4}$ #	(untreated)
one week after second spray	55.778	55.068	55.828	55.396	55.888	53.730	54.828	56.348

F value for treatments not significant.

* U, urea; S, sucrose; 0.1, 0.5, 1.0, molar concentrations.

Table 6. Average length in inches of shoot growth of Elberta peach trees. Greenhouse series, 1951. Ten shoots on each tree measured and recorded in inches.

Time of sampling	Treatment*							
	One spray			Two sprays			soil	check
	U 0.1	U & S 0.5	U & S 1.0	U 0.1	U & S 0.5	U & S 1.0	NH_4NO_3 ¼ #	(untreated)
one week after second spray	9.98	10.76	11.54	8.46	12.0	11.02	8.52	10.62

F values for treatments not significant.

* U, urea; S, sucrose; 0.1, 0.5, 1.0, molar concentrations.

Field Series

Three types of measurement provided the experimental data from the field series. Percent total nitrogen of the leaves showed whether any absorption of urea had taken place. Terminal growth measurements and measures of leaf were used to determine the growth response of the treated trees.

Percent Total Nitrogen. The percent total nitrogen of the Early Elberta peach leaves followed closely the results observed in the greenhouse series. As shown in Table 7 the treated trees were consistently higher in nitrogen than the untreated checks. Analysis of variance of the different treatments was significant in all cases indicating that absorption had taken place. As was the case in the greenhouse series, the higher concentration sprays resulted in more leaf nitrogen and two sprays were more effective than one.

It was also observed that sprays of 10 and 25 pounds urea which had not been buffered with sucrose caused foliage injury (Plates VI and VII). The one spray of 25 # urea per 100 gallons (0.5 M concentration) caused severe burning on much of the tree foliage within a few hours after the spray was applied. One spray of 10 # urea per 100 gallons (0.2 M concentration) caused little injury, but after a second spray had been applied the injury was very noticeable.

Terminal Growth and Leaf Area Measurements. Tables

8 and 9 show there was little consistency between the treatments as shown by these measurements. The low F values of both terminal growth and leaf area measurements indicate no significant differences between the treatments.

Table 7. Average percent total nitrogen of Early Elberta peach leaves. Field series, 1951.

Time of sampling	Treatments*							
	One spray				Two sprays			check
	U 0.1	U 0.2	U & S 0.5	U 0.5	U 0.1	U 0.2	U & S 0.5	(untreated)
24 hours after first spray	1.041	1.188	1.231	1.335	1.128	1.228	1.266	1.025
48 hours after first spray	1.075	1.195	1.246	2.328	1.178	1.298	1.336	1.058
24 hours after second spray	1.286	1.466	1.565	1.528	1.548	1.878	1.915	1.130
48 hours after second spray	1.286	1.425	1.570	1.598	1.611	1.890	1.980	1.183
1 week after second spray	1.550	1.680	1.818	1.740	1.755	2.163	2.106	1.263

F value for treatments significant at .01 level
F value for sampling times significant after first spray only
L. S. D.'s showed all treatments significant over checks at .05 level.

* U, urea; S, sucrose; 0.1, 0.2, 0.5, molar concentrations.

Table 8. Average leaf area in square inches of Early Elberta peach leaves. Field series, 1951.

Time of sampling	Treatments*							
	One spray				Two sprays			check
	U 0.1	U 0.2	U & S 0.5	U 0.5	U 0.1	U 0.2	U & S 0.5	(untreated)
1 week after second spray	3.090	3.015	3.401	3.048	3.051	3.230	2.835	2.726

F value for treatments not significant

* U, urea; S, sucrose; 0.1, 0.2, 0.5, molar concentrations.

Table 9. Average length in inches of shoot growth of Early Elberta peach trees. Field series, 1951.

Time of sampling	Treatments*							
	One spray				Two sprays			check
	U 0.1	U 0.2	U & S 0.5	U 0.5	U 0.1	U 0.2	U & S 0.5	(untreated)
1 week after second spray	4.913	4.813	5.750	4.866	5.016	4.800	4.150	3.416

F value for treatments not significant

* U, urea; S, sucrose; 0.1, 0.2, 0.5, molar concentrations.

DISCUSSION OF RESULTS

Greenhouse Series

Dry Weight Measurements. The dry weights of the samples of peach leaves taken after each spray treatments and one week following the second spray treatment were very variable and showed a great deal of inconsistency within the treated blocks. Part of this variation may have been due to the unfavorable weather conditions for photosynthetic activity during much of the sampling period. This could be substantiated by the fact that during periods of cloudy weather very little photosynthate was produced. Also, it must be assumed that respiration and translocation may have had an abnormal influence on the weight records. Whatever the cause of the inconsistency it is assumed that for this experiment the dry weight measurements did not serve as an index to the true nitrogen percent of the leaves.

Percent Total Nitrogen. F values and L. S. D.'s showed that all sprays of urea resulted in significantly higher percents of total nitrogen than the corresponding untreated checks; therefore it is assumed that the peach foliage absorbed nitrogen from the urea sprayed on the leaves. As shown by sampling periods of 8, 24, and 48 hours after each spray treatment, the absorption was the most rapid for the first 24 hours after spraying. It was also evident that the amount of total nitrogen increased progressively with the concentration of the spray, and that two sprays were more effective than one.

Depth of Palisade Tissue and Terminal Growth Measurements. Analysis of variances of depth of palisade tissue and terminal growth measurements indicated no significance between treatments. This seems to indicate that the amount of leaf nitrogen did not have any effect on either the depth of palisade tissue of leaves or the terminal growth of shoots at the time these samples were taken.

Field Series

Percent Total Nitrogen. The results of the field series were very similar to those of the greenhouse series in that F values and L. S. D.'s indicated significant differences between the trees receiving foliage sprays of urea and the untreated trees. All treatments were higher in total nitrogen indicating absorption of nitrogen from the urea sprays. It was apparent that two sprays were more effective than one and that the higher concentration sprays were more effective than the lower.

One of the most striking observation was of the value of sucrose as a buffering material. In a spray of 0.5 M concentration, severe foliage burning took place when sucrose was omitted; whereas the same concentration spray with sucrose added gave no burning of foliage. Two sprays of

0.2 M concentration urea without sucrose also gave moderate foliage injury.

Leaf Area and Shoot Growth. The inconsistency of the leaf area and shoot growth measurements in this experiment as compared with the total nitrogen shows that there was no correlation between the amount of nitrogen in the leaf and the resultant tree growth. A possible explanation may be that the increased nitrogen in the leaves may not have had time to effect either leaf area or increase in shoot length when the measurements were taken.

The final observations drawn from both the greenhouse and field series indicate that peach leaves are able to absorb nitrogen from foliage sprays of urea.according to the results gathered from total nitrogen determinations. However, it is possible that sufficient nitrogen was not absorbed to affect other growth processes as evidenced by the negative results of all the other measurements.

SUMMARY

1. Spray applications of different concentrations of urea were applied to Elberta and Early Elberta peach trees to determine if the peach foliage could absorb nitrogen from the urea sprays. The effects of urea sprays on the photosynthesis, growth of shoots and leaves, and depth of palisade tissue of the leaves were also measured for comparison between treatments. The investigations were conducted at Manhattan, Kansas, during 1951.

2. Elberta peach leaves did not show any significant differences between treatments as measured by dry weight gain in grams per square meter.

3. The percent total nitrogen of both Elberta and Early Elberta peach leaves was significantly higher in treated than untreated trees.

4. The differences in depth of palisade tissue of Elberta peach leaves was not significant between treatments.

5. Terminal growth measurements of Elberta and Early Elberta peach shoots showed no significant differences between treatments.

6. Leaf area measurements of Early Elberta peach leaves indicated no significant differences between treatments.

EXPLANATION OF PLATE I

Early Elberta peach trees of field series, 1951. Shown growing in boxes with water proof paper covers.

PLATE I

EXPLANATION OF PLATE II

Spraying Early Elberta peach tree field series, 1951. Showing atomizer type spray equipment and water proof screen.

PLATE II

EXPLANATION OF PALTE III

Appearance of leaves after the first, second, and third punch as taken for dry weight measurements.

PLATE III

EXPLANATION OF PLATE IV

Tagged leaves following the first set of morning punches.

PLATE IV

EXPLANATION OF PLATE V

Ganong leaf punch used for all leaf punching operations.

PLATE V

EXPLANATION OF PLATE VI

Injured leaves resulting from 0.5 molar concentration of urea spray. Uninjured leaves from trees sprayed with 0.5 molar concentration of urea plus sucrose.

PLATE VI

EXPLANATION OF PLATE VII

Injury of leaves resulting from two sprays of 0.2 molar concentration of urea.

PLATE VII

ACKNOWLEDGMENT

The author wishes to express his grateful acknowledgment to Dr. W. F. Pickett, Head of the Department of Horticulture for suggesting this problem and for instruction in carrying out the work; to Dr. G. A. Filinger and Dr. C. C. Singletary for aid in the manuscript; to Dr. H. C. Fryer for explanation of the statistical analysis of the data, and to his wife Lorna for her assistance and encouragement throughout the problem.

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FOLIAR APPLICATION OF NITROGEN TO PEACH TREES

by

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Abstract of a Thesis

Department of Horticulture

1951

PURPOSE

The purposes of this experiment were--

1. To determine if the Elberta variety of peach could absorb nitrogen through its leaves from foliage sprays of urea.

2. To study the effects of different concentrations and different numbers of applications of urea on the leaf nitrogen, tree growth, and internal structure of the leaves.

METHODS

The experiment was carried out on two related series of trees. In the first series, 40, one-year-old Elberta peach, trees were grown in the greenhouse. These trees were treated as follows: (1), one spray of urea at 5# per 100 gallons (0.1 molar concentration), (2), one spray of 25# urea plus 150# sucrose per 100 gallons (0.5 molar concentration), (3), one spray of 50# urea plus 300# sucrose per 100 gallons (1.0 molar concentration), (4), (5) and (6), two sprays of each of the above, respectively, (7), a soil treatment of 1/4# ammonium nitrate applied at time of first spray, (8), check (untreated).

The sampling data consisted of four types of measurement.

1. Leaf punch discs were taken from each tree to determine the amount of photosynthate produced. A sampling series was taken one day after each spray treatment and

again one week after the second spray. The photosynthate for the sampled period was then recorded on a dry weight basis in grams per square meter of leaf surface.

2. Samples for total nitrogen were taken 8, 24, and 48 hours after each spray treatment. Percent total nitrogen was determined using a photoelectric colorimeter following the lindner, Harley method of nitrogen determination.

3. Growth response was determined by measuring the terminal growth of 10 shoots on each tree.

4. The depth of palisade tissues of the leaves was measured in an attempt to determine effects of urea on the internal structure of the peach leaves.

The second series consisted of fifty, one-year-old Early Elberta, trees which were grown outside in sand. They were treated with urea in molar concentrations of 0.1, 0.2, and 0.5. The 0.5 molar concentration was applied both with and without sucrose as a buffering material. As in the greenhouse series, one and two spray treatments were applied to defferent blocks.

Three types of measurement furnished the sampling data for the field grown trees.

1. Percent total nitrogen determined by Lindner, Harley method from samples taken at intervals of 24 and 48 hours after each spray plus one sample a week following the second spray.

2. Ten shoots on each tree were measured to determine effect of treatments on terminal growth.

3. The average leaf area of treated and untreated leaves was determined from planimeter measurements of a random sample of leaves.

RESULTS

1. Elberta peach leaves did not show any significant differences between treatments as measured by dry weight gain in grams per square meter.

2. The percent total nitrogen of both Elberta and Early Elberta peach leaves was significantly higher in treated than untreated trees.

3. The difference in depth of palisade tissue of Elberta peach leaves was not significant between treatments.

4. Terminal growth measurements of Elberta and Early Elberta peach shoots showed no significant difference between treatments.

5. Leaf area measurements of Early Elberta peach leaves indicated no significant differences between treatments.