RINGING HERBACEOUS PLANTS.

U. P. HEDRICK, O. M. TAYLOR AND RICHARD WELLINGTON.
BOARD OF CONTROL.

GOVERNOR CHARLES E. HUGHES, Albany.
COMMISSIONER CHARLES A. WETING, Albany.
STEPHEN H. HAMMOND, Geneva.
LYMAN P. HAVILAND, Camden.
EDGAR G. DUSENBURY, Portville.
THOMAS B. WILSON, Halls Corners.
MILO H. OLIN, Perry.
IRVING ROUSE, Rochester.
ALFRED G. LEWIS, Geneva.

OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND,  
President.

WILLIAM O’HANLON,  
Secretary and Treasurer.

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND,  
Thomas B. Wilson.

LYMAN P. HAVILAND,

STATION STAFF.

WHITMAN H. JORDAN, Sc.D., Director.

GEORGE W. CHURCHILL,  
Agriculturist and Superintendent of Labor.

WILLIAM P. WHEELER,  
First Assistant (Animal Industry).

FRED C. STEWART, M.S., Botanist.

G. TALBOT FRENCH, B.S.,  
Assistant Botanist.

LUCIUS L. VAN SLYKE, Ph.D.,  
Chemist.

ERNEST L. BAKER, B.S.,  
FRANK H. HALL, B.S.,  
Editor and Librarian.

ALFRED W. BOSWORTH, B.S.,  
Percival J. Parrott, M.A.,  
Entomologist.

ANTON R. ROSE, B.S.,  
HAROLD E. HODGKISS, B.S.,  
Assistant Entomologists.

MORGAN P. SWEENEY, A.M.,  
WILLIAM J. SCHONE, B.AGR.,  
Horticulturist.

PERCY W. FLINT, B.S.,  
ULYSSES P. HEDRICK, M.S.,  
Assistant Horticulturists.

Lucius L. Van Slyke, Ph.D.,  
NATHANIEL O. BOOTH, B.AGR.,  
Foreman in Horticulture.

Ernest L. Baker, B.S.,  
RICHARD WELLINGTON, B.S.,  
*F. Atwood Sirrine, M.S.,  
Assistant. Special Agent.

Alfred W. Bosworth, B.S.,  
Frank E. Newton,  
Assistant Chemists.

Anton R. Rose, B.S.,  
Jennie Terwilliger,  
Bacteriologist.

Morgan P. Sweeney, A.M.,  
Willard F. Patchin,  
Assistant Bacteriologists.

Percy W. Flint, B.S.,  
Adin H. Horton,  
Assistant Chemists.

Harry A. Harding, M.S.,  
Computer and Mailing Clerk.

Lucius L. Van Slyke, Ph.D.,  
JULIA H. HOEY,  
Chemist. Junior Clerk.

Address all correspondence, not to individual members of the staff, but to the New York Agricultural Experiment Station, Geneva, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

*Riverhead, N. Y.
RINGING HERBACEOUS PLANTS.

U. P. HEDRICK, O. M. TAYLOR AND RICHARD WELLINGTON.

SUMMARY.

1. The objects of ringing are: To cause unproductive plants to set fruit; to increase the size of the fruit and thereby the productiveness of the plant; and to hasten the maturity of the fruit.

2. Many woody plants, especially the apple and grape in America, have been advantageously ringed. But the operation does not seem to have been used on herbaceous plants though theoretically it can be practiced as well on exogenous herbaceous plants as on woody plants.

3. This Bulletin is a report of experiments in ringing two herbaceous plants, the tomato and the chrysanthemum, chosen because their product and the manner of growth of the plants should show most advantageously the effects of ringing.

4. In ringing, a wound is made through the cortex and the bast of a plant. Usually a band of bark of greater or less width is removed. Plants are ringed during the period of growth when the bark peels most readily from the wood.

5. The theory upon which ringing is founded is: That unassimilated food passes from the roots of the plant to the leaves mainly through the outer layer of the woody cylinder. The assimilated food is distributed through vessels in the cortex of the inner bark. When plants are ringed the flow upward continues but that downward is checked and the top of the plant is thus supplied with an extra amount of food at the expense of the parts below the ring.
6. Ringing is unnatural and while it may favor some of the organs of a plant must be harmful to the plant as an individual.

7. There are other means of securing the ends attained by ringing, as the bending or the twisting of shoots, which should be less harmful to the plant than ringing.

8. Tomatoes were ringed in the winter of 1905-06; the variety was Lorillard; the soil a good greenhouse loam; plants were trained to single stems. The members of one group of plants were ringed as soon as the second cluster of fruits had set; those of a second group, when the fourth cluster had set. Plants in a third group were unringed.

9. Ringing consisted of removing a five-eighths inch strip of bark, cutting through to the woody tissue.

10. The heights of the stems were not affected; but irregular, bunchy swellings of greater or less size were to be found above all of the rings. There was a tendency toward the thickening of the whole stem above the wounds. These swellings were probably caused by stored food.

11. Ringing had no effect on the time of maturity of the fruit.

12. The average number of fruits per plant was reduced 18 per ct. by the first ringing and 10 per ct. by the second ringing. The average loss in weight per plant due to the first ringing was 16 per ct.; to the second ringing, 12 per ct. In the first ringing there was a gain of six one-hundredths of an ounce in the average fruit; in the second ringing, a loss of five one-hundredths of an ounce.

13. There were no differences to be noted in regard to either the color or the flavor of the fruits from the ringed plants.

14. The foliage of the ringed plants was more or less abnormal, taking on a curved, pendent position with elevated cushiony areas and having very succulent tissue. There was a slight yellowing in the foliage of ringed plants showing an unhealthy condition.

15. The roots of ringed plants were less well developed,
fewer in number, and smaller in size. The root system seemingly suffered from starvation.

16. Several varieties of chrysanthemums were ringed in the autumn of 1906; the plants were trained to single stems; the grouping and the manner of ringing were as with tomatoes.

17. The first group was ringed just as the buds appeared; the second group when buds were one-third grown, the interval between ringing being about two weeks.

18. The foliage began to show injury about one month after ringing. The upper leaves of many plants had a slight yellowish tinge and portions of some of them turned reddish purple. This trouble gradually increased until the end of the experiment when the foliage of some plants was ruined.

19. As with the tomatoes, the stems were more or less swollen; considerably so just above the ring and somewhat throughout the entire upper part. Ringing decreased the height of the plant.

20. The first ringing hindered the opening of the buds in all the varieties except one; the second ringing slightly hastened the maturity of all except one.

21. The size of the blossoms of all the varieties was reduced and the earlier the ringing the greater the injury.

22. The effect of the ringing on the roots of the plants was to decrease their number and lessen their vigor. Ringed plants produced almost no suckers. The first ringing harmed the roots most.

23. It is very doubtful if ringing can be made beneficial to herbaceous plants. The loss to the plant is great and there seems to be little or no compensating gain.

24. The deleterious effects of ringing on herbaceous plants are so marked that the query arises as to whether woody plants do not suffer in similar degree and the operation possibly cause a greater loss to the plant than is gained in the product.
INTRODUCTION.

The ringing of woody plants is a well known horticultural practice. Its objects are: To cause unproductive plants to set fruit; to increase the size of the fruits and thereby the productiveness of the plant; and to hasten the maturity of the fruit. In European countries particularly, all of the tree fruits are subjected to the process, but in America only the apple and the grape are advantageously ringed. Among others in this country Booth\(^1\) and Goodman\(^2\) have described the ringing of apple trees while Paddock\(^3\) has published a bulletin from this Station on ringing grape vines.

Strange to say, ringing seems to have been applied almost exclusively to woody plants, though theoretically it can as well be practiced on many exogenous herbaceous ones. In practice, so far as known, herbaceous plants are never ringed and there seem to have been but few experiments to determine the effects of such an operation, though opportunity has not offered to review carefully foreign literature that might contain accounts of experiments in ringing. The only accounts of ringing herbaceous plants that have been found are by Sablon,\(^4\) Daniel\(^5\) and Hedrick.\(^6\)

If ringing would bring herbaceous plants into fruiting, increase the productiveness, and hasten the maturity of the product, as with grapes and apples, the operation would be of especial value in growing some greenhouse plants, since the qualities mentioned are essential to success in growing commercial crops under glass. It would commend itself, too, because the devitalization which eventually follows the ringing of plants would be of little consequence with most of those grown in the greenhouse, since they are grown for but one or two seasons and then discarded.

This Bulletin is a report of experiments with two plants, the tomato and the chrysanthemum, to ascertain what the

---

effects of ringing may be on herbaceous plants. Daniel has reported, in the reference given above,\textsuperscript{5} marked increase in the size of the fruits of the egg-plant and tomato; and work done in 1901 under the direction of one of the authors, as noted above,\textsuperscript{6} seemed to show an increase in the size of the flower of the chrysanthemum and a slight acceleration in time of blooming. The effects indicated in these reports gave some promise of a favorable outcome of the experiments in the way of positive results at this Station. Such has not been the case, but the results are nevertheless of interest though negative. They show, more plainly than could similar experiments on woody plants, the effects of ringing on plant organs and on the growth of the plant; and thus become of interest to the fruit-grower as well as to the gardener and florist.

RINGING.

The term "ringing" is one given to the making of a wound through the cortex and bast of a plant. It may consist of a simple cut made with a knife, or a band of bark of greater or less width may be removed. In horticultural practice the operation is performed during that period of growth when the bark peels most readily from the wood—the period of greatest cambial activity. This term is to be preferred to "girdling" since the latter is used to designate a wound which extends into the wood of a plant for the purpose of killing it. The French phrase for the operation, "décortication annulaire" (annular decortication), is more exact that either ringing or girdling.

The theory upon which ringing is founded is a simple one. Crude, unassimilated sap passes from the roots of a plant to the leaves mainly through the outer layer of the woody cylinder. In the leaves this raw material is acted upon by various agents and is distributed to the several organs of the plant through vessels in the cortex, or the inner bark. When

\textsuperscript{6} Hedrick, U. P. Amer. Florist, 17:729–730. 1901.
plants are ringed the upward flow of sap continues nearly as before the operation, but the newly made food compounds cannot pass below the injury, accumulate above it, and are supposed to supply the top of the plant with an extra amount of food at the expense of the parts below the ring. When the bark is removed the outer layers of wood dry out very quickly and because of this the upward flow of sap is also checked somewhat through evaporation from the exposed woody cylinder.

Ringing is unnatural and while it may favor some organs of a plant must be harmful to the plant as an individual. It could be of value with herbaceous plants in the ways that have been enumerated only as an exceptional treatment to secure some particular end and in cases where the plant or branch could be sacrificed for the current season’s product.

The experiments recorded here have had to do with ringing only. There are other means of securing the ends attained in ringing woody plants and they are worth trying with herbaceous plants, especially as most of them are less harmful to the plant than ringing. Thus the bending of shoots causes uneven distribution of the elaborated plant food whereby some parts of the plant are favored; so, too, twisting, whereby the bark is loosened from the wood, causes a diminution of the upward flow of raw material and supplies the buds above the twist with more than their natural amount; notching and peeling the stems are similar operations used on woody plants but not adapted to most herbaceous plants.

RINGING TOMATOES.

A test of the value of ringing tomatoes was made in the Station greenhouses during the winter of 1905-'06. The experiment was in the hands of O. M. Taylor, Foreman in Horticulture, who gave every detail of the experiment close attention. The experiment was carried through under the most favorable circumstances, the plants being extra fine and all conditions normal.

The plants.—The variety grown was the Lorillard, one of
PLATE III.—THE TOMATO PLANTS TOWARD THE CLOSE OF THE EXPERIMENT.
Plate IV.—Effect of Ringing On Chrysanthemum Roots: a, First Ringing; b, Second Ringing; c, Not Ringed.
the best forcing sorts. The seeds were sown in small boxes August 1. The young plants were pricked out into two-inch pots August 16, and were shifted into four-inch pots September 1. The plants were benched September 16. A selection for the experiment was made from several hundred plants, using only those of uniform size and vigor. Two rows were set in each bench with the rows two and a half feet apart. The plants were two feet apart in the row, with spaces alternating.

Soil.—The soil used consisted of a mixture of three parts rotted sod, one part sand, and one part compost. This mixture contained an abundant supply of plant food during the earlier period of the growth of the plants. After several clusters of fruit had set and the soil had become well filled with roots, a thin coating of well rotted stable compost was given.

Temperature.—A temperature suitable for tomatoes was maintained throughout the experiment. The night temperature averaged 60°-65° F.; the day temperature ranged from 15°-25° higher, depending on outside conditions.

Training the plants.—All plants were trained to single stems which were tied to vertical wires as growth developed. Laterals were removed as occasion required. Toward the end of the experiment the lower leaves of all plants were removed as fast as they developed the yellowish tinge which indicates that they are reaching maturity.

Ringing.—The plants were divided into three groups. The members of the first group, Numbers 1, 4, 7, etc., were ringed as soon as the second cluster of fruit had set. Those of the second group, Numbers 2, 5, 8, 11, etc., were ringed when the blossoms of the fourth cluster of fruit had set. Plants in the third group, Numbers 3, 6, 9, etc., were unringed and were the controls.

The first group was ringed on October 18. At this time nearly all blossoms in the second cluster had set and the first blossoms of the third cluster were opening. The second group was ringed on October 31. At this date the fourth cluster had set fruit and several blossoms of the fifth cluster were open.
The plants were ringed directly below the leaf which developed under the first fruit cluster. A five-eighths inch circular strip of the outer layer of tissue was removed, cutting through to the hard woody tissue. In making the cut a curved two-bladed knife was used, so that the width of material removed would be the same in every case. As the stems of tomatoes are irregular in outline, the knives cut slightly deeper at the ridges than at other places. The cut surfaces were examined from time to time during the experiment and all callus which formed in the effort to heal and bridge over the wound was removed. The wounds dried very quickly after the removal of the bark and callus began to form almost at once. In no case could any immediate ill effects to the plant from the ringing be discovered. The appearance of the ringed stems at the close of the experiment is shown in Plate I. The stems of all plants were more or less enlarged directly above the point of ringing.

Effect on the stems.—At the time of the first ringing, on October 18, all plants were measured as to height. The average height of group 1 was 35.54 inches, group 2 was 34.65 inches, and group 3 was 33.71 inches. These measurements showed that the plants were very uniform in height at the beginning of the experiment. At the close of the experiment, on January 12, the heights of the plants were again taken but it could not be discovered that the differences in the heights in the three groups had changed in the least.

As can be seen in the accompanying illustration, Plate I, there was a most marked effect upon the stem and especially on the part just above the ring. Irregular, bunchy swellings, of greater or less size, were to be found above all of the rings. There was some tendency toward a general thickening of the whole stem above the wound and with some plants a decided inclination toward fasciation. It is to be supposed that the swelling came from stored food, though most unfortunately no analyses were made of the stored material.

Effect on the maturity of the fruit.—Record was kept of the date of opening of the first blossom of each plant. The
average date of coming into bloom was very uniform for the three groups, being September 29 for Groups 1 and 2 and September 30 for Group 3. The first fruit picked in any quantity was on November 10, at which time a small and nearly uniform yield was obtained from all of the groups. During the progress of the experiment, the ripe fruits were picked twice each week, counted and weighed. The average dates of the first pickings were for first ringing, November 18; second ringing, the 16th; and for the check plants, the 18th. Thus it is seen that the ringing had no apparent effect on the time of maturity of the fruit. The general character of the plants at early and late stages is shown in Plates II and III.

Yields.—The data in regard to number and weight of fruits for the first half of the experiment are given in the first section of Table I which includes the yield up to December 14 inclusive.

<table>
<thead>
<tr>
<th>Total number plants</th>
<th>Total number fruits</th>
<th>Total weight of fruits</th>
<th>Average number fruits per plant</th>
<th>Average weight of fruits per plant</th>
<th>Average weight of individual fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st ringing.........</td>
<td>45</td>
<td>460</td>
<td>1769.8</td>
<td>10.2</td>
<td>39.3</td>
</tr>
<tr>
<td>2nd ringing.........</td>
<td>46</td>
<td>509</td>
<td>1920</td>
<td>11.1</td>
<td>41.7</td>
</tr>
<tr>
<td>Check................</td>
<td>46</td>
<td>484</td>
<td>1823.25</td>
<td>10.5</td>
<td>39.6</td>
</tr>
</tbody>
</table>

TOTAL YIELD, NOVEMBER 10–JANUARY 12.

<table>
<thead>
<tr>
<th>Total number plants</th>
<th>Total number fruits</th>
<th>Total weight of fruits</th>
<th>Average number fruits per plant</th>
<th>Average weight of fruits per plant</th>
<th>Average weight of individual fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st ringing.........</td>
<td>45</td>
<td>876</td>
<td>2833</td>
<td>19.5</td>
<td>63.</td>
</tr>
<tr>
<td>2nd ringing.........</td>
<td>46</td>
<td>978</td>
<td>3054.2</td>
<td>21.3</td>
<td>66.4</td>
</tr>
<tr>
<td>Check................</td>
<td>46</td>
<td>1093</td>
<td>3464.5</td>
<td>23.8</td>
<td>75.3</td>
</tr>
</tbody>
</table>

An examination of this part of the table shows that there was practically no difference between the plants of the first ringing and the check in the average number of fruits per plant or weight of the fruit. The second ringing appears to have increased the average number of ripe fruits slightly with a corresponding increase in weight. These differences are not large enough to be beyond the range of fortuitous variation and
yet since all conditions were so uniform in the experiment they may be taken as an expression of actual gain for the second ringing.

The results for the entire experiment are given in the second half of Table I. This gives the record of ripe fruit to January 12 at which time the experiment was discontinued, as the bulk of the crop had then been ripened. The results do not include the unripe fruits on the plants on January 12.

These figures show that the average number of fruits per plant was reduced 18 per ct. by the first ringing and 10 per ct. by the second ringing. The average loss in weight per plant due to the first ringing was 16 per ct., and the loss due to the second ringing was 12 per ct. There was but little variation between the average weight per fruit in the different groups, the difference in the case of the first ringing being a gain of only six one-hundredths of an ounce, and in the second ringing a loss of five one-hundredths of an ounce. These differences are not worth considering.

Effect on color and flavor of fruit.—With the tree fruits and the grape, ringing usually changes the color and the flavor of the product. The color in most cases is heightened and the quality is not so good. Because of differences in these respects, horticultural societies often refuse to award premiums to fruits which have been modified in this way. In this experiment with the tomato, however, there was no difference to be noted in regard to either color or flavor. Daniel\(^7\) reports that the product of ringed tomatoes and egg-plants in his experiments lacked flavor and that the deterioration was very marked. He says that the "flavor was insipid and less savory" than with fruits on unringed plants.

Effect on foliage.—The foliage of the ringed plants was more or less abnormal but not nearly so much so as with the chrysanthemum. The foliage of forced tomatoes not infrequently takes on a peculiar curved pendent position with elevated cushiony areas, more succulent than on normal plants. This abnormal condition results from derangement of the cell tissue because of

the disturbance of the physiological processes. When exaggerated, this condition becomes a disease, the œdema of the tomato, named and described by Atkinson.® The plants of the ringed tomatoes seemed to suffer from a mild case of œdema. According to Atkinson œdema is brought about9 "by an excess of water which stretches the cell walls, making them very thin and the cells very large." It would seem from theoretical considerations, and from the behavior of the plants as well, that ringing, in checking the flow of plastic material downward, causes an excessive quantity to be stored in the leaves and in this way brings on the swelling and the distortion of certain parts known as œdema. There were slight differences in color to be noted in the foliage of ringed and unringed plants, probably due to the breaking down of the stretched cell walls, causing the death of the cells and consequent injury to the adjacent parts followed by the yellowish tinge indicating diseased or dead tissues.

Effect on the roots.—The theory of ringing, to promote fruitfulness by keeping the prepared plant food in the top of the plant, acknowledges that the top is fed at the expense of the roots. Should the wound of the ring never heal over, the roots must starve and die unless there should be foliage below the ring to support them. The roots of the ringed tomatoes in this experiment showed the effects of this starvation. As with the chrysanthemum roots illustrated in Plate IV they were less in number and of smaller size.

RINGING CHRYSANTHEMUMS.

To test the effect of ringing chrysanthemums, the following varieties were ringed in the fall of 1906: Ivory, Major Bonnaffon, Nagoya, White Bonnaffon and William Duckham. In most respects the experiment was a duplicate of the one with tomatoes. The experiment was in charge of Richard Wellington, Assistant Horticulturist.

9 Idem, p. 107.
Propagation.—The rooted cuttings of these varieties were potted in four-inch pots on May 7 and on June 18 one hundred plants of each of the above varieties were selected and benched in the greenhouse. The rows were 12 inches apart and the plants were set with intervals of 9 inches in the row.

Soil.—The soil used in the benches consisted of seven parts of rotted sod, five parts of well rotted stable manure, and two parts of sand, the whole thoroughly mixed. The chrysanthemum is a gross feeder and for a further supply of plant food an inch of well rotted stable compost was applied just as the buds began to form.

Pruning and training.—The plants were pruned to produce one terminal bud each. During the experiment the suckers and side shoots were kept in check by pinching. As the plants became topheavy they were tied to a wire trellis. It was thought that by training to a terminal bud, thus concentrating the whole energy of the plant in one blossom, whatever effect there might be from the ringing would be better shown.

Grouping.—The plants were divided into three groups. The plants in the first group, which consisted of every third one in the row, commencing with the first plant, were ringed September 17; those in the second group, which consisted of every third plant in the row commencing with the second plant, were ringed October 5; and those in the third group, which consisted of every third plant in the row commencing with the third plant, were left as checks.

Ringing.—When the first plants were ringed the buds had just appeared and the bark was in a very succulent condition, peeling readily from the stems. At the time of the second ringing the buds had increased considerably in size and the bark had become less succulent, especially on the Ivory and William Duckham varieties; the bark peeled far less easily than with the first group.

A penknife was used in removing the bark from the stems. Two horizontal cuts, five-eighths of an inch apart, were made, encircling the stem about 5 inches above the ground. The ring was split by a vertical cut and the bark was easily peeled
from the woody cylinder. The process was concluded by scraping the bared portion with the edge of the knife to remove all of the cambium tissue. The wounds dried almost immediately and the plants suffered no appreciable ill effects from the ringing.

*Effect on foliage.*—On October 19, the foliage of the first ringed plants of the varieties Ivory, Major Bonnaffon, White Bonnaffon and William Duckham had begun to show ill effects from the ringing. The upper leaves of many of these plants had a slight yellowish tinge and portions of a few leaves of the same plants, exposed to the direct sunlight, had turned reddish purple. This coloring was undoubtedly due to a physiological disorder, since no fungi nor bacteria were present.

At the end of the following week all the plants in Group 1 and a few Ivory and William Duckham plants in Group 2 showed the effects of the ringing. The yellow and reddish purple colors were, however, more pronounced on the group first ringed than on the second ringed plants. By the first of November all the ringed plants in Group 2 showed similar changes in color. This trouble increased gradually. As with the tomatoes, the leaves were curved and pendent, with the elevated cushiony areas and succulent tissue indicating a severe disturbance of the physiological processes. By the end of the experiment, several of the ringed plants were so badly affected that they were worthless.

*Effect on the stems.*—As the plants of the three groups of the same variety varied in height, measurements were taken two days before the cutting commenced. These measurements are given in Table II. The plants in Group 1 averaged 2.4 inches less and the plants in Group 2 1½ inch less than the check plants.

As with the tomatoes, the stems were more or less swollen, sometimes greatly so just above the ring. So, too, the swelling throughout the entire upper part of the stem was noticeable and there was also the same tendency to fasciation as with the tomatoes. The swellings were most marked on Group 1. See Plate IV.
The stems of one of the varieties, Nagoya, showed numerous small, wartlike outgrowths scattered over almost the entire length. These protuberances were much more numerous and more highly developed on the ringed than on the unringed plants, and especially so on the swollen parts just above the rings. These outgrowths were light brown in color; stuck out sharply from the stems; and were composed of parenchymatous tissue with a trace of woody tissue in the central portion. From the fact that when damp moss was tied about the stems the outgrowth developed into true roots, there can be no doubt but that they are rudimentary, aerial rootlets. The point of special interest is that the formation of these rudimentary organs was greatly favored by the ringing.

**Table II.—Effect of Ringing on Height of Chrysanthemum Plants.**

<table>
<thead>
<tr>
<th>VARIETY</th>
<th>Early Ringing.</th>
<th>Late Ringing.</th>
<th>Not Ringed.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of plants ringed.</td>
<td>Average height.</td>
<td>Number of plants ringed.</td>
</tr>
<tr>
<td>Ivory</td>
<td>34</td>
<td>2.86</td>
<td>34</td>
</tr>
<tr>
<td>Major Bonnaffon</td>
<td>34</td>
<td>3.64</td>
<td>34</td>
</tr>
<tr>
<td>Nagoya</td>
<td>32</td>
<td>4.68</td>
<td>32</td>
</tr>
<tr>
<td>White Bonnafon</td>
<td>34</td>
<td>2.80</td>
<td>34</td>
</tr>
<tr>
<td>William Duckham</td>
<td>34</td>
<td>3.58</td>
<td>34</td>
</tr>
<tr>
<td>Average height</td>
<td>3.51</td>
<td>3.67</td>
<td></td>
</tr>
</tbody>
</table>

**Effect on maturity of blossoms.**—A record was taken each week, commencing October 20 and ending November 13, of the date when the buds began to open, when half opened, and when fully opened. These results are given in Table III. A few White Bonnaffons and several Nagoya buds had not matured at the later date. From the above data the following conclusions can be drawn: The first ringing hindered the opening of the buds in all varieties except the Major Bonnaffon; the second ringing seemed to very slightly hasten the maturity of all the varieties with the exception of Nagoya.
TABLE III.—Effect of Ringing on Maturity of Chrysanthemum Blossoms.

<table>
<thead>
<tr>
<th>VARIETIES</th>
<th>Dates</th>
<th>EARLY RINGING. FLOWERS—</th>
<th>LATE RINGING. FLOWERS—</th>
<th>NOT RINGED. FLOWERS—</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Opening</td>
<td>Half opened</td>
<td>Opened</td>
</tr>
<tr>
<td>Ivory</td>
<td>Oct. 20</td>
<td>11.8</td>
<td></td>
<td>94.1</td>
</tr>
<tr>
<td></td>
<td>Oct. 26</td>
<td>94.1</td>
<td>26.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 2</td>
<td>97.1</td>
<td>94.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 9</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Major Bonnaffon</td>
<td>Oct. 20</td>
<td>76.5</td>
<td></td>
<td>85.3</td>
</tr>
<tr>
<td></td>
<td>Oct. 26</td>
<td>97.1</td>
<td>17.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 2</td>
<td>100</td>
<td>94.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 9</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Nagoya</td>
<td>Oct. 26</td>
<td>6.9</td>
<td></td>
<td>65.6</td>
</tr>
<tr>
<td></td>
<td>Nov. 2</td>
<td>58.6</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 9</td>
<td>96.6</td>
<td>41.4</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>Nov. 13</td>
<td>100</td>
<td>82.8</td>
<td>17.2</td>
</tr>
<tr>
<td>White Bonnaffon</td>
<td>Oct. 20</td>
<td>61.8</td>
<td></td>
<td>14.7</td>
</tr>
<tr>
<td></td>
<td>Oct. 26</td>
<td>88.2</td>
<td>51.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 2</td>
<td>90.9</td>
<td>78.8</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Nov. 9</td>
<td>100</td>
<td>90.9</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td>Nov. 13</td>
<td>100</td>
<td>100</td>
<td>90.9</td>
</tr>
<tr>
<td>William Duckham</td>
<td>Oct. 20</td>
<td>35.3</td>
<td></td>
<td>11.8</td>
</tr>
<tr>
<td></td>
<td>Oct. 26</td>
<td>97.1</td>
<td>32.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 2</td>
<td>100</td>
<td>97.1</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Nov. 9</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Nov. 13</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Effect on size of blossoms.—The diameters of all the blossoms that matured were taken and these are given in Table IV. The blossoms in Group 1 averaged .48 inch less; and the blossoms in Group 2 averaged .11 inch less than those in Group 3. These results, as in the case of the measurements of the height of the plants, indicate a direct injury to the plant through ringing and that the earlier the ringing the greater the injury.

Table IV.—Effect of Ringing on Size of Chrysanthemum Blossoms.

<table>
<thead>
<tr>
<th>VARIETIES</th>
<th>EARLY RINGING</th>
<th>LATE RINGING</th>
<th>NOT RINGED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of mature blossoms</td>
<td>Average diameter</td>
<td>Number of mature blossoms</td>
</tr>
<tr>
<td>Ivory</td>
<td>34</td>
<td>3.6</td>
<td>34</td>
</tr>
<tr>
<td>Major Bonnaffon</td>
<td>34</td>
<td>4.39</td>
<td>34</td>
</tr>
<tr>
<td>Nagoya</td>
<td>5</td>
<td>4.45</td>
<td>28</td>
</tr>
<tr>
<td>White Bonnaffon</td>
<td>30</td>
<td>4.00</td>
<td>33</td>
</tr>
<tr>
<td>William Duckham</td>
<td>33</td>
<td>4.39</td>
<td>34</td>
</tr>
<tr>
<td>Average diameter</td>
<td>4.17</td>
<td>4.54</td>
<td></td>
</tr>
</tbody>
</table>

Effect on roots.—The effect of the ringing was very conspicuous on the roots of the plants, as is shown in Plate IV. The roots of the plants of Group 1 were weak and few in number; the roots of the plants of Group 2 were more abundant and slightly stronger; while the roots of the plants in Group 3 were very numerous and strong. The difference was still further marked by the sprouts which had been produced by the plant for future growth. The roots of the plants in Group 1 had but 1.7 per ct. as many sprouts as Group 3, while the roots of the plants in Group 2 had but 17 per ct. as many sprouts as Group 3.

CONCLUSION.

The outcome of the experiments in ringing tomatoes and chrysanthemums is not promising for the ringing of herbaceous
plants. It is true that these experiments cover but two species of plants, but both are species which, because of their vigor, the nature of their product, their manner of growth, and other qualities should show most advantageously the effects of ringing. It is true also that the time, manner, and place of ringing might be varied with these and other species and give somewhat different results. But the deleterious effects of the treatment were so marked on several plant organs, and especially the root system, that it is extremely doubtful whether varying the method of ringing, on these species at least, could have given widely different results.

It is shown by most of the experiments in ringing woody plants that there is considerable loss in the economy of several plant organs; there is, however, with the apple and grape among woody plants some compensating gain in other organs, chiefly the fruit. Why is there not such a compensating gain in herbaceous plants? This is a question for the plant physiologist. Meanwhile it does not seem that in practice the fruit grower is finding the ringing of plants, except in rare cases, a valuable orchard or vineyard operation. The gains scarcely offset the losses. The investigation here recorded shows that the loss in the root and leaf systems in particular of herbaceous plants is most severe. Is it not more than likely that there is a similar loss to these organs in woody plants, thereby accounting for their decrease in vigor?