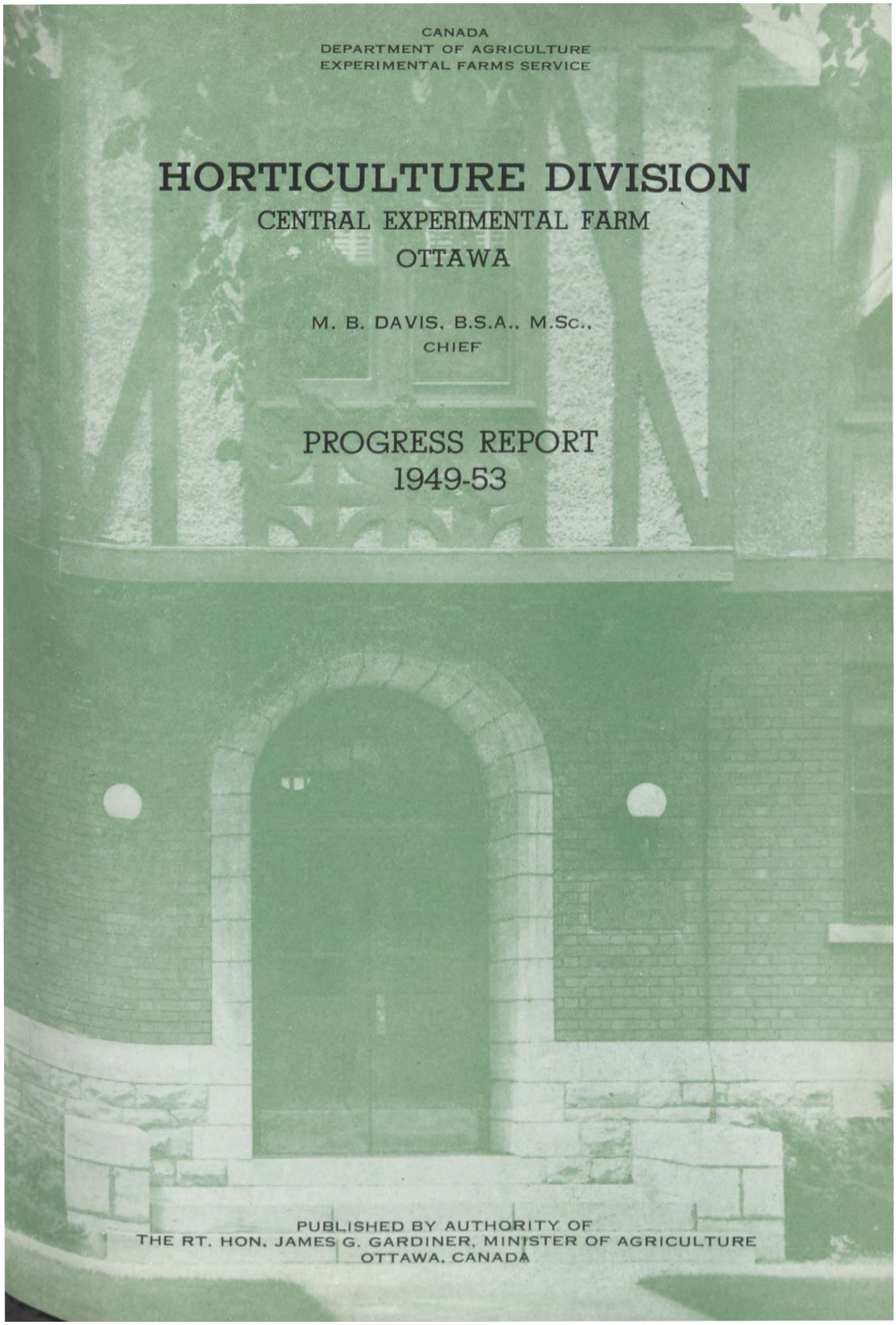

CANADA
DEPARTMENT OF AGRICULTURE
EXPERIMENTAL FARMS SERVICE

# HORTICULTURE DIVISION

## CENTRAL EXPERIMENTAL FARM
## OTTAWA

M. B. DAVIS, B.S.A., M.Sc.,
CHIEF

## PROGRESS REPORT
## 1949-53

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## CONTENTS

# HORTICULTURE DIVISION
# EXPERIMENTAL FARMS SERVICE

# PROGRESS REPORT—1949-1953

## INTRODUCTION

The last report published by this Division appeared in 1950 and covered the work for the years 1934 to 1948, inclusive. This report summarizes the work from 1949 to 1953, inclusive. Where press articles, bulletins, scientific and technical papers have been released on work in progress, such work has been briefly summarized only, and reference is made to the publication wherein the details may be found. The additional data of more recent date, and data on newer projects are presented in more detail.

The field of horticulture, covering the various fruits, vegetables, ornamentals and greenhouse crops—their breeding and the testing of new varieties, their nutrition and the amelioration of the soils in which they grow, their storage and processing—necessitates the subdivision of this report into the several sections:

A Fruits

B Genetics and Cytology

C Nutrition and Soil Management Studies

D Ornamentals and Floriculture Research

E Low Temperature Research

F Vegetable Crops

G Dominion Horticultural Substation, Smithfield, Ontario

H Dominion Experimental Substation for Mucklands, Ste. Clothilde, Quebec.

# FRUITS

## POMOLOGY

*D. S. Blair, H. B. Cannon and H. F. Beingessner*

### Apple Rootstocks

The main apple rootstock investigations at Ottawa began in 1936 when the first section of the standard orchard was planted. This report presents some results at the end of the seventeenth year, and is limited to that part of the orchard set out primarily (a), to compare seedling and vegetatively raised rootstocks and (b), to gain information on the behavior of some East Malling stocks with McIntosh and Fameuse varieties budded thereon.

This trial consisted of sixteen trees of each variety-rootstock combination planted out at 20 by 20 ft. During the seventeen-year period a considerable number of trees of some combinations died from various causes, but particularly as a result of collar rot (*Phytophthora cactorum*). The following table shows the percentage of McIntosh trees on the different rootstocks that succumbed during the course of the trial.

TABLE A-1.—PERCENTAGE OF McINTOSH TREES DEAD AFTER SEVENTEEN YEARS

| Rootstock | Percentage dead |
|---|---|
| Anis | 19 |
| Antonovka | 13 |
| *M. baccata* | 0 |
| EM I | 31 |
| EM II | 19 |
| EM IX | 50 |
| EM XII | 0 |

Tree losses have been considerably higher with EM IX and EM I rootstocks than with any other clonal or seedling rootstock in the trial. Although no isolations were made, the cause of death of trees on these two rootstocks appeared to be winter injury followed by collar rot infection. No trees on *M. baccata* or EM XII rootstocks were lost.

Table A-2 shows the variability of the remaining trees of McIntosh on both seedling and vegetatively raised rootstocks expressed as the coefficients of variability for trunk cross-section area, tree spread and tree yield.

TABLE A-2.—VARIABILITY OF McINTOSH ON SEEDLING AND CLONAL ROOTSTOCKS SEVENTEEN YEARS FROM PLANTING. TREES PLANTED 1936

| Rootstock | Co-efficient of variability | | |
|---|---|---|---|
| | Cross-section area | Spread | Cumulative yield |
| SEEDLING— | | | |
| Anis | 21 | 15 | 45 |
| Antonovka | 30 | 8 | 41 |
| *M. baccata* | ..... | 13 | 45 |
| CLONAL— | | | |
| EM I | 34 | 18 | 30 |
| EM II | 30 | 11 | 34 |
| EM IX | ..... | 23 | 24 |
| EM XII | 25 | 10 | 40 |



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Trees on all rootstocks at 17 years from planting vary considerably in tree size and particularly in cumulative yield. Little difference in variability in tree size is evident between trees on seedling roots and those on the clonal Malling stocks. However, the larger coefficients of variability shown for cumulative yield of trees on seedling stocks indicate that yields from these trees have been more variable than yields from trees on the clonal rootstocks. Also, the coefficients for tree spread are generally lower than those for cross-section area of trunk. No doubt pruning operations during the years tended to even out possible differences in tree spread.

TABLE A-3.—AVERAGE SIZE AND CUMULATIVE YIELD OF McINTOSH AND FAMEUSE TREES AT SEVENTEEN YEARS FROM PLANTING. TREES PLANTED 1936

| Rootstock | Number of trees | Cross-section area of trunk | Spread | Average yield | | Yield/ac. to 17 yr. |
|---|---|---|---|---|---|---|
| | | | | To 10 yr. | To 17 yr. | |
| | | sq. cm. | ft. | lb./tree | lb./tree | lb. |
| McINTOSH— | | | | | | |
| Anis | 10 | 237 | 18·5 | 112 | 1,495 | 161,460 |
| Antonovka | 11 | 192 | 16·6 | 90 | 1,128 | 121,824 |
| *M. baccata* | 5 | 259 | 18·7 | 131 | 1,719 | 185,652 |
| EM I | 6 | 173 | 16·1 | 77 | 1,138 | 122,904 |
| EM II | 12 | 154 | 17·1 | 80 | 1,079 | 116,532 |
| EM IX | 5 | 39 | 9·6 | 56 | 218 | 23,544 |
| EM XII | 12 | 351 | 21·7 | 94 | 1,866 | 201,528 |
| FAMEUSE— | | | | | | |
| Anis | 7 | 225 | 16·5 | 113 | 1,043 | 112,644 |
| EM I | 10 | 221 | 17·7 | 87 | 1,119 | 120,852 |

Table A-3 shows that in tree size or vigor the McIntosh trees fall into four general groups. The largest trees at 17 years from planting are those on EM XII. The two seedling rootstocks, Anis and *M. baccata,* have shown similar effects upon tree growth but have made somewhat smaller trees than those on EM XII. In the third group, Antonovka, EM I and EM II are much the same in tree spread, but EM II has formed a tree somewhat smaller in trunk diameter. The EM II rootstock itself is slender, and this characteristic appears to have been transmitted to the scion variety. The dwarfing habit of trees on EM IX, the fourth group, is very pronounced when compared with the same variety growing on other stocks. With Fameuse, the trees on Anis seedlings are about the same size as those on clonal EM I.

Rootstock effects on the yielding ability of McIntosh and Fameuse are illustrated in Table A-3. In general, the yielding ability of McIntosh and Fameuse trees on these rootstocks is closely related to tree size or vigor. At the end of 10 years McIntosh on *M. baccata* and Anis had higher yields than on Antonovka or any of the Malling rootstocks. The lowest yields were from trees growing on the dwarfing clonal EM IX.

At the end of the 17th year, the highest yield has been from McIntosh on EM XII, closely followed by those on *M. baccata.* At this time McIntosh trees on Anis yielded approximately 225 lb. per tree less than on *M. baccata.* Yields from trees on Antonovka and the two Malling rootstocks, EM I and EM II, have been similar, the average being about 800 lb. per tree less than on EM XII. At 17 years by far the lowest yields are shown by the trees on EM IX, the average cumulative yield being a little more than 200 lb. per tree.

With the Fameuse variety little difference in yield is apparent between trees on Anis and EM I rootstocks.

At the present time the McIntosh trees on EM IX have a tree spread of 9·6 feet. A spacing of 10 by 10 ft. would appear to be adequate but such a spacing is hardly feasible for practical operation such as spraying and picking. If the rows were spaced 15 feet apart there would then be sufficient room for the movement of equipment. A planting distance of 20 by 30 ft. is suggested for McIntosh trees on Antonovka, EM I and II rootstocks, and a spacing of 25 by 35 ft. for trees on Anis, *M. baccata* and EM XII. The present trend is to hedge-row planting because of the development of newer spray techniques, and for this reason the suggested spacing is greater between the row than within the row.

TABLE A-4.—CUMULATIVE YIELD OF McINTOSH TREES CALCULATED ON AN ACREAGE BASIS

| Rootstock | Suggested planting distances | To 10 yr. | To 12 yr. | To 14 yr. | To 17 yr. |
|---|---|---|---|---|---|
| | ft. | lb. | lb. | lb. | lb. |
| EM XII | 25 × 35 | 4,596 | 14,421 | 36,481 | 91,434 |
| *M. baccata* | 25 × 35 | 6,434 | 16,778 | 37,911 | 84,207 |
| Anis | 25 × 35 | 5,478 | 14,484 | 32,017 | 73,235 |
| EM I | 20 × 30 | 5,530 | 13,709 | 34,013 | 81,929 |
| Antonovka | 20 × 30 | 6,458 | 18,144 | 34,834 | 81,223 |
| EM II | 20 × 30 | 5,782 | 15,638 | 34,632 | 77,688 |
| EM IX | 10 × 15 | 16,240 | 24,331 | 33,959 | 63,104 |

Table A-4 shows the cumulative acreage yields of McIntosh on the various rootstocks calculated on the basis of the preceding suggested planting distances. At the end of 10 years, the acreage yield would have been 16,240 pounds for the dwarfing EM IX compared with 4,596 for EM XII, the largest trees. The trees on those rootstocks that are intermediate in vigor would have yielded slightly more than those on EM XII. After 14 years, the yield picture would be considerably different with all rootstocks except Anis showing slightly higher acreage production than the dwarfing rootstock, EM IX. By the end of the 17th year the trees on the dwarfing EM IX, although planted very much the closest, would have the lowest yield, 63,104 lb. of fruit per acre. The highest acreage yield would be from those trees on the most vigorous rootstock, EM XII, with a production of 91,434 lb. per acre. The next highest acreage yield would be with those trees on *M. baccata* followed by EM I, Antonovka, EM II and Anis, with trees on Anis producing approximately 10,000 lb. more fruit per acre than the trees on EM IX. Under Ottawa conditions, the difference in the possible yields per acre between EM IX and the more vigorous rootstocks used in this trial would be considerably greater in actual practice, since from Table A-1 it appears unlikely that more than 50 per cent of the dwarf trees would have survived.

It appears, then, that under the conditions of this trial, the advantage of yield is entirely in favor of the larger trees after 14 years from planting even when they are set out at their much wider spacing.

## Hardy Tree Building

When discussing the technique of hardy tree building the question is often asked whether this practice delays fruiting. The data in Table A-5 show that at the end of both 10 and 17 years the single-worked McIntosh and Melba trees had produced more fruit than the double-worked trees of these varieties. Therefore, this practice has reduced slightly the cumulative yields to 17 years.

TABLE A-5.—AVERAGE SIZE AND YIELD OF McINTOSH AND MELBA TREES DOUBLE- AND SINGLE-WORKED ON ANIS AND ANTONOVKA ROOTS. PLANTED IN 1936

| Variety | Stem builder | Rootstock | Cross-section area | Spread | Cumulative yield | |
|---|---|---|---|---|---|---|
| | | | | | To 10 yr. | To 17 yr. |
| | | | sq. cm. | ft. | lb./tree | lb./tree |
| DOUBLE-WORKED— | | | | | | |
| McIntosh | Anis | Anis | 150 | 17·1 | 43 | 1,199 |
| McIntosh | Hibernal | Anis | 167 | 17·2 | 72 | 1,372 |
| McIntosh | Antonovka | Anis | 154 | 16·5 | 32 | 1,139 |
| McIntosh | *M. baccata* | Anis | 131 | 15·0 | 46 | 807 |
| McIntosh | Antonovka | Antonovka | 132 | 15·9 | 39 | 819 |
| Melba | Antonovka | Anis | 141 | 14·6 | 82 | 698 |
| Melba | Charlamoff | Anis | 127 | 14·0 | 139 | 816 |
| SINGLE-WORKED— | | | | | | |
| McIntosh | | Anis | 237 | 18·5 | 112 | 1,495 |
| McIntosh | | Antonovka | 192 | 16·6 | 90 | 1,128 |
| Melba | | Anis | 179 | 15·8 | 190 | 949 |

The effect of the stem builder or intermediate stempiece on the performance of the scion or fruiting variety is clearly shown in Table A-5. The stem builder in these studies constitutes the main framework of the tree; that is, the trunk and some four to six scaffold limbs that were worked over to the scion variety, approximately 12 inches from the trunk. Single-worked trees of McIntosh and Melba are larger after 17 years than double-worked trees on the same rootstocks.

The most vigorous McIntosh trees at 17 years of age are those on Hibernal, Anis and Antonovka stem builders. Anis and Antonovka stem builders have shown similar effects upon McIntosh tree growth. Although trees on these three intermediates are of similar general size, the trunk cross-section area with the Hibernal intermediate is somewhat the largest. Of the four intermediates on Anis roots, *M. baccata* has shown a dwarfing influence on the McIntosh variety. Where Antonovka is used as both the stem builder and the rootstock the resulting trees are smaller than those on Antonovka stem builder with Anis roots. This supports the evidence presented in Table A-3 that Antonovka seedlings have a more dwarfing effect than Anis seedlings. The two intermediates Antonovka and Charlamoff on Anis roots have had much the same influence on tree size with the variety Melba.

The yield data show that the single-worked McIntosh and Melba trees have produced more fruit over a period of 17 years than have the double-worked trees. Of the McIntosh trees on the four stem builders on Anis roots, the highest yields have been from those trees where Hibernal was used as the intermediate stempiece and the lowest where *M. baccata* was the intermediate. Similar yields have been obtained where Anis and Antonovka intermediates were used. With the Antonovka intermediate on Antonovka roots instead of Anis, the average yield per tree of the McIntosh variety was reduced by approximately 300 pounds.

Although the Melba trees with intermediates of Antonovka and Charlamoff are approximately the same size, somewhat higher cumulative yields were obtained from those with the Charlamoff stempiece at both 10 and 17 years.

TABLE A-6.—AVERAGE SIZE AND YIELD OF VARIETIES DOUBLE-WORKED ON FOUR STEM BUILDERS, ALL ON ANIS ROOTS. PLANTED IN 1937

| Variety | Stem builder | Spread | Cumulative yield | |
|---|---|---|---|---|
| | | | To 10 yr. | To 16 yr. |
| | | ft. | lb./tree | lb./tree |
| McIntosh | Anis | 16·9 | 62 | 864 |
| | Antonovka | 18·8 | 141 | 1,291 |
| | Hibernal | 18·5 | 169 | 1,248 |
| | Patten Greening | 17·5 | 195 | 1,147 |
| Lawfam | Anis | 20·7 | 12 | 556 |
| | Antonovka | 23·3 | 50 | 1,097 |
| | Hibernal | 22·7 | 120 | 1,155 |
| | Patten Greening | 22·1 | 95 | 966 |
| Sandow | Anis | 16·1 | 21 | 469 |
| | Antonovka | 16·4 | 12 | 508 |
| | Hibernal | 16·6 | 47 | 623 |
| | Patten Greening | 16·3 | 36 | 517 |

Table A-6 shows the size and yield of McIntosh, Lawfam and Sandow on four stem builders. With all three varieties the largest trees are those with intermediate stempieces Antonovka and Hibernal, and the smallest with the Anis intermediate. Differences in the influence of these intermediates on tree size with Sandow are much less than with either McIntosh or Lawfam, probably because of the upright growth habit of Sandow. In general, trees on Patten Greening stem builder are intermediate in vigor.

Although the trees on Anis stem builder are somewhat dwarfed, they have been slow to come into bearing. Anis is slow growing. Double-working operations are, therefore, necessarily delayed, and thus the early development of the tree is retarded. Generally speaking, Hibernal and Patten Greening stem builders have been more precocious than the other stem builders.

After 16 years the trees of all varieties on Anis stem builder have yielded very much less than the trees on the other stem builders in this trial. With Lawfam and Sandow the highest yields have been obtained from Hibernal. However, with the McIntosh variety there is little difference in yield between trees on Hibernal and on Antonovka. While the trees on Patten Greening have given slightly lower yields than on either Hibernal or Antonovka, the yields are considerably higher than those with the Anis stem builder.

TABLE A-7.—AVERAGE SIZE AND YIELD OF McINTOSH AND CORTLAND DOUBLE-WORKED ON ANTONOVKA ROOTS. TREES PLANTED IN 1938

| Variety | Stem builder | Spread | Cumulative yield | |
|---|---|---|---|---|
| | | | To 10 yr. | To 15 yr. |
| | | ft. | lb./tree | lb./tree |
| McIntosh | Columbia | 18·2 | 89 | 897 |
| | Osman | 17·0 | 113 | 874 |
| | Robin | 14·7 | 63 | 532 |
| | Pioneer | 16·8 | 61 | 848 |
| | Hardy Crab | 16·6 | 86 | 832 |
| Cortland | Columbia | 18·0 | 46 | 745 |
| | Osman | 17·4 | 54 | 823 |
| | Robin | 15·4 | 32 | 557 |

The influence of the stem builder on the scion variety is further shown in Table A-7. After 15 years the largest trees of both the McIntosh and Cortland varieties are those on Columbia stem builder and the smallest are on Robin. The trees on the other stem builders Osman, Pioneer, and Hardy Crab are somewhat smaller than those on Columbia but are considerably larger than those on Robin.

At the end of 15 years little difference in accumulated yield is apparent between the various stem builders with the exception of Robin. Trees on this intermediate have yielded 300 to 350 pounds less fruit per tree.

TABLE A-8.—SIZE OF TRUNK OF FIVE VARIETIES ON *M. baccata* STEM BUILDER AND ANIS ROOTSTOCK. TREES PLANTED IN 1937

| Variety | Cross-section area |
|---|---|
| | sq. cm. |
| Bancroft | 145 |
| Donald | 149 |
| Edgar | 142 |
| Keetosh | 144 |
| Toshkee | 92 |

That the scion has an influence on the stem builder is clearly shown in Table A-8. Toshkee, itself a dwarfing variety, has had a marked dwarfing effect on the stem builder *M. baccata* as indicated by the cross-section area of the trunk. No such effect is apparent in trees of the other four scion varieties.

## Dwarf Apple Trees

Because of the growing interest in smaller apple trees, close planting (10 by 10 ft.) of a number of varieties on four dwarfing rootstocks, begun in 1941, has continued to the present. These trees were headed low, the first branch being about 12 inches from the ground. The training method has been the modified central leader type. Ordinary iron fence posts were used for the required additional support of such dwarf trees.

TABLE A-9.—AVERAGE SIZE AND CUMULATIVE YIELD OF VARIETIES ON EM VII AND EM IX ROOTSTOCKS. TREES PLANTED IN 1941

| Variety | Rootstock | Height | Spread | Cumulative yield per tree | | | |
|---|---|---|---|---|---|---|---|
| | | | | 6 yr. | 8 yr. | 10 yr. | 12 yr. |
| | | ft. | ft. | lb./tree | lb./tree | lb./tree | lb./tree |
| McIntosh | EM VII | 9 | 12 | ..... | 2 | 61 | 268 |
| McIntosh | EM IX | 6 | 8 | 7 | 33 | 74 | 243 |
| Lawfam | EM VII | 10 | 13 | ..... | 2 | 99 | 310 |
| Lawfam | EM IX | 6 | 9 | 2 | 31 | 79 | 152 |
| Lobo | EM VII | 10 | 12 | ..... | 21 | 146 | 490 |
| Lobo | EM IX | 8 | 8 | 14 | 72 | 150 | 325 |
| Melba | EM VII | 11 | 13 | ..... | 28 | 150 | 343 |
| Melba[1] | EM IX | 6 | 6 | ..... | 18 | 58 | 102 |

[1]Pate strain.

At 12 years from planting, all varieties on EM IX have made smaller trees than on EM VII rootstock (Table A-9). The trees on EM IX are only 6 feet in height and have a spread of not more than 9 feet, thus making a tree of very desirable size for the home garden.

In comparison with similar trees on EM IX rootstock, McIntosh and Lawfam trees on EM VII have been slow to come into bearing, and at the end of the 8 years from planting have only produced an average of 2 pounds of fruit per tree. After 10 years from planting, little difference in yield is evident between trees on the two rootstocks. However, at the end of 12 years from planting, trees of all varieties on EM VII rootstock have outyielded those on EM IX.

TABLE A-10.—AVERAGE SIZE AND CUMULATIVE YIELD OF VARIETIES ON EM IX AND EM VII ROOTSTOCKS

| Variety | Rootstock | Height | Spread | Cumulative yield per tree | | | |
|---|---|---|---|---|---|---|---|
| | | | | 5 yr. | 7 yr. | 9 yr. | 11 yr. |
| | | ft. | ft. | lb./tree | lb./tree | lb./tree | lb./tree |
| PLANTED 1942— | | | | | | | |
| Atlas | EM IX | 7 | 7 | 19 | 60 | 113 | 214 |
| Cortland | EM IX | 6 | 9 | 16 | 51 | 99 | 185 |
| Elmer | EM IX | 5 | 8 | 2 | 13 | 59 | 125 |
| Milton | EM IX | 5 | 10 | 16 | 40 | 119 | 240 |
| Sandow | EM IX | 7 | 8 | | | 29 | 167 |
| PLANTED 1944— | | | | | | | |
| Atlas | EM VII | 9 | 9 | 22 | 73 | 167 | |
| Sandow | EM VII | 10 | 8 | | 12 | 46 | |

The modifying influence of the scion variety on early cropping of trees on EM IX rootstock is illustrated in Table A-10. To the end of 7 years, Sandow on EM IX produced no fruit, and Elmer had produced only 13 pounds per tree. Both of these varieties are of Northern Spy parentage, a variety usually slow to come into bearing. On the other hand, Atlas, Cortland and Milton have been considerably more precocious, and at the end of 11 years from planting have well outyielded Elmer and Sandow.

A similar effect is apparent when Sandow trees on EM VII rootstocks, planted in 1944, are compared with similar trees of the Atlas variety.

TABLE A-11.—AVERAGE SIZE AND CUMULATIVE YIELD OF TREES ON EM IV AND O-524 ROOTSTOCKS. TREES PLANTED IN 1947

| Variety | Rootstock | Height | Spread | Cumulative yield per tree | |
|---|---|---|---|---|---|
| | | | | 4 years | 6 years |
| | | ft. | ft. | lb./tree | lb./tree |
| Lobo | EM IV | 7 | 7 | 10 | 69 |
| Lobo | O-524 | 8 | 8 | 3 | 54 |
| McIntosh | O-524 | 5 | 6 | 5 | 18 |
| Red Melba | O-524 | 6 | 6 | 11 | 45 |

EM IV is known as a very precocious rootstock. Table A-11 shows that O-524 is similar to EM IV in inducing early bearing in the Lobo variety. The trees on this clonal rootstock developed at Ottawa are comparable in size with those on EM IV at the end of 6 years from planting. From observation, O-524 appears to be somewhat more vigorous than EM IX.

The possibility of producing dwarf apple trees by inserting short pieces of a dwarfing variety between the rootstock and the scion variety is being investigated at Ottawa.

TABLE A-12.—AVERAGE SIZE AND CUMULATIVE YIELD OF DOUBLE-WORKED TREES AND OF McINTOSH ON EM IV ROOTSTOCK. TREES PLANTED IN 1944

| Variety | Intermediate | Rootstock | Height | Spread | Cumulative yield per tree | | |
|---|---|---|---|---|---|---|---|
| | | | | | 5 years | 7 years | 9 years |
| | | | ft. | ft. | lb./tree | lb./tree | lb./tree |
| McIntosh | EM IV | Antonovka | 9 | 10 | 13 | 95 | 207 |
| McIntosh | EM IX | Antonovka | 7 | 9 | 35 | 116 | 278 |
| McIntosh | | EM IV | 10 | 9 | ..... | 61 | 184 |
| Sandow | *M. Sargenti* | Antonovka | 9 | 9 | 3 | 38 | 118 |

Table A-12 shows that at 9 years of age, McIntosh trees with a short intermediate stempiece (four inches) of EM IV are about the same size as the trees propagated directly on the EM IV rootstock, but have produced both higher and earlier yields. There appears to have been a similar increase in precocity and total yield when EM IX was used as the intermediate, since it was shown in Table A-9 that McIntosh on EM IX rootstock with no intermediate at the end of 6 years from planting had produced only an average of 7 pounds of fruit per tree. This was apparently accompanied by a proportional increase in tree size, for in Table A-12 McIntosh on the intermediate EM IX had a spread of 9 feet at 9 years whereas Table A-9 shows that McIntosh on EM IX rootstock had a spread of only 8 feet after 12 years from planting. An intermediate stempiece of *M. Sargenti* with the variety Sandow on Antonovka rootstock appears to have brought about earlier fruiting (Table A-12) than when this variety was grown directly on EM IX or EM VII rootstocks (Table A-9).

## Clonal Rootstock Selections

*D. S. Blair and S. H. Nelson*

Since 1949 extensive stooling trials have been conducted at Ottawa in a search for hardy tree fruit rootstocks of varying vigor. To date 8,120 apple, 2,085 pear, 1,921 cherry and 186 plum seedlings, collected from countries where severe growing conditions are prevalent, have been tested.

From this material 119 apple, 15 pear, 10 cherry and 3 plum were selected on their ability to root readily by the stooling method. The apple selections were made from *Malus aldenhamensis, M. baccata, M. baccata* var. *gracilis, M. baccata* var. *sibirica, M. Prattii, M. Sargenti, M. Sieboldii, M. sikkimensis, M. stratac, M. Zumi and M. Zumi* var. *calocarpa.* The pear selections were made from *Pyrus communis* var. *caucasika, P. communis* var. *pologniana, P. austriaca,* Sabioski and Old Home seedlings. *Prunus Mahaleb,* Mazzard, *P. melanocarpa* and *P. pumila* were the source of the cherry selections. The plum selections were made from Myrobalan.

## Tree Vigor versus Root Anatomy

*M. MacArthur*

Thus far, the preliminary work on relating tree vigor to the anatomy of the root has been confined to the percentage transection area of the bark. At East Malling, the percentage of bark in rootstock roots was correlated with the vigor of the scion budded on that rootstock. A high bark percentage indicates an ultimately dwarfing tree, and conversely, a low bark percentage indicates that the rootstock will have a vigorous influence.

Percentage bark on lateral roots from a series of Antonovka and Beautiful Arcade selections from the stoolbeds showed variations of 32 to 61 per cent and 41 to 60 per cent respectively. *M. robusta* 5 alone ranged from 45 to 56 per cent. The 11 per cent range here was undoubtedly due to root size differences, for percentage bark decreases with root size. In no case was percentage of root bark sufficiently high in any selection to indicate that any of the rootstocks examined would have a dwarfing influence. The examinations will be continued.

## FRUIT BREEDING

### Apples

***Breeding for Early and Late Maturity**—M. B. Davis, D. S. Blair and L. P. S. Spangelo.*

Testing available phenotypes for their commercial value is obviously of first importance in breeding improved apple varieties. They can be considered valuable as parental material only after a test of their combining ability. For this reason extensive progeny data from all crosses since 1920 have been recorded. Since the previous Progress Report these data for fruit size, external skin and flesh color, flavor and quality, and tree hardiness, have been analyzed. The data in greater detail will appear in the forthcoming Proceedings of the American Society for Horticultural Science.

A summary of the data showed:

1. For production of commercially-sized apples, Delicious is the most desirable parent, followed in order by Duchess, Yellow Transparent, McIntosh, Wealthy, Melba, Fameuse and Crimson Beauty. The Wealthy×Delicious combination was the best for large size.

2. When two varieties with a high percentage of red color are crossed, a very desirable mean for this character is obtained. A high percentage of the Delicious seedlings had greenish flesh, while the seedlings of Wealthy× Fameuse were predominantly white-fleshed.

3. Cox Orange, McIntosh, Wealthy and Melba are good parents for quality. Delicious has been, in general, a poor parent for quality at Ottawa. Of the parents used, Crimson Beauty has the best combining ability for tree hardiness, followed by Duchess and McIntosh.

4. In certain progenies tree vigor ranged from semi-vigorous to extremely vigorous. From McIntosh×Milwaukee both the semi-dwarf variety Toshkee and the extremely vigorous seedling O-2016 were selected. These are promising and are being tested extensively.

5. Melba×Crimson Beauty and Astrachan are promising crosses for early maturity, while McIntosh×Sandow and Milwaukee, Sandow×Cortland, and Linda×Lawfam and Delicious, are desirable for late maturity.

Because of the interest in dwarf trees, more extensive but more recent tree data have been recorded in the search for a method of producing these trees. Limited sibcross progeny data have shown that inbreeding by sibcrossing can produce a reduction in vigor. The principle is being more fully evaluated.

***Pollination Studies**—L. P. S. Spangelo.*

When a promising variety or seedling is propagated for distribution to commercial growers, it is necessary to know whether or not it will be effectively pollinated by the varieties in the grower's orchard. For this reason it has been the policy of this Division to determine the pollination requirements of new selections.

The technique used is one of controlled cross-pollination. Branches of the variety to be studied are covered with cheesecloth bags before the flowers open. The flowers are not emasculated, but only three flowers per cluster are cross-pollinated. At the same time a number of flowers are self-pollinated in order to determine the actual fruit set due to the pollen parent. Pollen germination tests are made to study pollen viability. The criterion for determining the effectiveness of the pollen parent is the percentage of fruit remaining after the summer drop. The percentage of fruit necessary for a commercial crop depends on the number of flowers. The range of 3 to 5 per cent fruit has been used for all varieties and selections. Blooming dates are also studied. Suitable pollinators determined by the foregoing are given in the following list wherein the variety to be pollinated precedes the suitable pollinators.

Atlas—Lobo, McIntosh and Melba

Bancroft—Atlas, Cortland, Joyce, Lobo, McIntosh, Melba, Platt's Sport of Melba and Spartan

Lawfam—Cortland, Fameuse, Hume, McIntosh and Melba

Newtosh—Cortland, Hume, McIntosh and Spartan

O-272 and O-274—McIntosh

O-277—McIntosh and Melba

Sandow—Bancroft, Cortland, McIntosh, Melba, Newtosh, O-2016 and Spartan

Toshkee—Cortland, McIntosh and Melba

***Breeding for Resistance to Apple Scab***

To determine the possibilities of developing commercial varieties resistant to apple scab (*Venturia inaequalis* (Cke.) Wint.), a co-operative project between this Division and the Botany and Plant Pathology Division, Science Service, was begun in 1949. The Horticulture Division has been responsible for the collection and evaluation of parental material, making the crosses and growing and evaluating the seedlings. The Botany and Plant Pathology Division has been responsible for inoculum preparation and the studies on the organism.

*Method of Eliminating the Susceptible Seedlings.*—As soon as the fruit from the controlled crosses is harvested in the fall, the seeds are extracted and sown in flats. The flats are stored at 38°F. to mid-December. After this stratification period, the flats are taken to the greenhouse. The seedlings are first inoculated when the majority of them are at the first and second true-leaf stage. The inoculated seedlings are held in a moist chamber for forty-eight hours at 68°F.

The inoculum is a mixture of isolates of the fungus from several areas in Canada. The spore suspension used is approximately 100 spores per microscope field (100 ×). The susceptible seedlings are discarded and the resistant ones inoculated again, a procedure followed at least three times during the winter.

The resistant seedlings are planted in the field for a fruiting test, and the final selection of scab-resistant types is determined under conditions of natural infection.

Five infection classes are used to facilitate the roguing of susceptible seedlings. Seedlings that develop freely sporulating lesions are considered susceptible.

*Variability of the Organism.*—It is apparent from data reported by Shay (1) that isolates used in the inoculum at Ottawa differ in pathogenicity from those used at Purdue University. The variety Alexis is resistant in Indiana but susceptible at Ottawa. In order to study the physiological race problem, a uniform collection of trees representing all identifiable resistant genotypes is being grown in Nova Scotia, Quebec and Ontario.

*Inheritance of Resistance and Breeding Method.*—Not enough data have been collected to determine the inheritance of resistance. Data at Ottawa indicate modifying factors in all sources of resistance used. The segregation data do not appear to support the findings of other workers. This could be due to differences in physiological races.

Varieties and seedlings are being tested under optimum conditions in a continuous search for resistant clones. The desirable resistance genes are being used in a backcross program.

*Sources of Resistance and Results of Crossing.*—This Division is co-operating with J. R. Shay who is directing the co-operative project of the Universities of Purdue, Rutgers and Illinois. Sources of resistance established by Shay *et al.* are being included in the program here.

In the first crosses at Ottawa, spring of 1949, Geneva (*Malus pumila* var. *Niedzwetzkyana*, open-pollinated) was the main source of resistance. Since then the sources of resistance have been R 12740-7A (*Malus pumila*), Jonathan × (Rome Beauty × *M. floribunda*) sib, Wolf River × *M. atrosanguinea*, Wolf River × *M. prunifolia*, Wealthy × *M. prunifolia* and Wolf River × *M. micromalus.*

More than 2500 seedlings with a high degree of resistance to scab have been developed and are being set out in the field for a fruiting test.

*The Problem of Mildew Susceptibility.*—Certain scab-resistant seedlings have shown a high degree of susceptibility to mildew (*Podosphaera leucotricha* (E. and E.) Salm.) at the Smithfield Substation. It is apparent that in certain areas scab-resistant seedlings will also have to be resistant to mildew. The selection of scab-resistant seedlings resistant to mildew seems possible.

Two detailed papers on this project have been prepared for publication.

***References***

1. McCrory, S. A. and J. R. Shay. Apple scab resistance survey of South Dakota apple varieties and breeding stocks. U.S.D.A. Plant Disease Reporter. Oct. 1951.

## Pears

*L. P. S. Spangelo and A. W. S. Hunter*

Pear breeding has been limited, but the continued promising performance of the Ottawa varieties, particularly Miney and Phileson, has given encouragement. Tree hardiness and good fruit quality are probably the most important factors to be considered. Some attention is also being given to resistance to fire blight, *Bacillus amylovorus* (Burr.) Trev., which is of considerable importance on some varieties in certain years.

In 1950 a large number of crosses, using the hardy variety Karl Sabioski, the good quality variety Bartlett and a promising, high quality Ottawa selection, O-291, were made.

Four seedlings, described in the following, have been selected and are being tested extensively.

*O-291* (Winter Nelis × Bartlett).—A very late maturing seedling of very good texture and eating quality. Probably not hardy enough for the Ottawa area since some tree injury has been observed. It is hoped that it will prove useful in the area served by the Smithfield Substation.

*O-292* (Winter Nelis × Bartlett).—Also a late maturing seedling of fairly good quality. It has exceptionally good storage characteristics at 32°F., and the tree appears hardier than O-291.

*O-301* (Menie × Winter Nelis).—This pear has fairly good size, acceptable texture and quality. Tree hardiness has not been fully evaluated.

*O361* (Miney × Phileson).—A seedling with acceptable pear flavor and texture. The fruit size is commercially acceptable. Tree hardiness needs to be more fully evaluated.

***Pollination Studies—A. W. S. Hunter.***

The Ottawa pear varieties Enie, Menie, Miney, Moe and Phileson are being grown in increasing quantities in parts of Eastern Canada where the better standard sorts are not adapted. Trials were undertaken in 1951, 1952 and 1953 to determine the pollination requirements of these varieties.

The study was conducted on mature trees growing in the pear orchard of the Horticulture Division at Ottawa. In 1951 and 1952, all flowers were "low-emasculated" at the balloon stage by removing the petals, sepals and stamens in one piece. In 1953, some of the flowers were low-emasculated; some were "high-emasculated" by removing only the anthers, and still others were not emasculated. The emasculated flowers were not covered in 1951 and 1952, since in the absence of petals, pollinating insects were not attracted to the flowers. Branches of unpollinated, emasculated flowers were included for a control. In 1953, all the unemasculated flowers, the high-emasculated flowers and part of the low-emasculated flowers were covered with cloth tubes of 15-inch cheese bandage. Anthers from unopened flowers were dried in the laboratory, and the pollen was applied once only to the stigmas with a camel hair brush. The data for the 3-year period, 1951-53, have been combined and are presented in Table A-13. Considerable thinning of the blossoms was done at the time of emasculation to remove open and immature flowers. Therefore, it is estimated that mature fruit from approximately 20 per cent of the flowers pollinated would be required for a commercial crop. The results show that Enie, Menie, and Phileson is each satisfactorily pollinated by any one of the other four varieties. Miney gives a satisfactory crop when pollinated by Enie, Moe and Phileson, while Moe is satisfactorily pollinated only by Menie and Phileson. Phileson, and to a lesser extent, Enie, Menie and Miney are satisfactorily self-fruitful. Moe appears to be self-unfruitful.

TABLE A-13.—YIELD OF MATURE FRUIT EXPRESSED AS A PERCENTAGE OF FLOWERS POLLINATED. AVERAGE FOR THE THREE-YEAR PERIOD, 1951-53

| Male parent / Female parent | Enie | Menie | Miney | Moe | Phileson |
|---|---|---|---|---|---|
| Enie | 16·7 | 25·5 | 29·4 | 11·5 | 29·1 |
| Menie | 19·8 | 16·0 | 9·3 | 42·4 | 29·2 |
| Miney | 31·7 | 24·5 | 17·5 | 13·8 | 23·3 |
| Moe | 38·7 | 22·3 | 41·7 | 5·9 | 41·7 |
| Phileson | 21·5 | 23·6 | 23·1 | 44·7 | 31·7 |
| Emasculated, not pollinated | 11·6 | 15·6 | 16·1 | 2·9 | 24·7 |

An interesting result from this experiment is the discovery that these five pear varieties are regularly capable of producing an appreciable quantity of mature fruits from emasculated but unpollinated flowers. However, these fruits are virtually seedless. The same is true of the fruits resulting from self-pollinations, from Menie pollinated by Miney, and from Phileson pollinated by Enie, Menie and Miney.

Seedless fruits have been reported before in a number of pear varieties following incompatible self- and cross-pollination (1), frost damage to the styles (2), and hormone treatment (3). Incompatible pollination could account for the seedless condition of the pollinated fruits so affected, but it would not appear to be the cause of fruit set on the unpollinated checks.

Some very suggestive data pertaining to this phenomenon were secured in 1953. In that year, cross- and self-pollinations were made on all varieties, on unemasculated flowers, but not on emasculated flowers.

TABLE A-14.—EFFECT OF LOW-EMASCULATION ON SEED CONTENT IN SOME PEAR CROSSES

| Cross | Low-emasculated 1951, 1952 | | Not emasculated 1953 | |
|---|---|---|---|---|
| | Mature fruits as per cent flowers pollinated | Average number seeds per fruit | Mature fruits as per cent flowers pollinated | Average number seeds per fruit |
| Enie × Enie | 18·3 | 0·1 | 8·0 | 0·0 |
| Menie × Menie | 28·2 | 0·2 | 4·9 | 2·0 |
| Menie × Miney | 32·1 | 0·6 | 10·4 | 4·3 |
| Miney × Miney | 14·4 | 0·2 | 47·2 | 3·1 |
| Moe × Moe | 11·2 | 1·3 | 1·5 | 2·0 |
| Phileson × Phileson | 33·5 | 0 | 20·2 | 0·9 |
| Phileson × Enie | 32·7 | 1·1 | 11·1 | 6·2 |
| Phileson × Menie | 32·7 | 0·6 | 19·6 | 4·0 |
| Phileson × Miney | 31·9 | 0·3 | 31·3 | 3·6 |
| Phileson × Moe | 43·4 | 2·5 | 21·6 | 4·0 |

In Table A-14 low-emasculated flowers pollinated in 1951 and 1952 are compared with unemasculated flowers pollinated in 1953. Only those crosses are included that, on emasculated flowers, regularly result in fruits with a low seed content. In these crosses, the seed content of the fruits resulting from the pollination of unemasculated flowers shows a marked increase, but the increase is not so marked in the self-pollinations. It does appear that in these varieties, the severe wounding inflicted by the low-emasculation process may be a factor in seedless fruit production. However, this work should be repeated to give a comparison between low emasculation and no emasculation under the same conditions.

### *References*


1. Crane, M. B. and D. Lewis. Genetical studies in pears. III. Incompatibility and sterility. J. Gen. 43: 31-43. 1942.
2. Lewis, D. Parthenocarpy induced by frost in pears. J. Pomol. Hort. Sci. 20: 40-41. 1942.
3. Osborne, D. J. Attempts to produce parthenocarpic pears with growth substances. Ann. Appl. Biol. 36: 551-553. 1949.

# STONE FRUITS

*L. P. S. Spangelo*

## Plums

Since 1948, plum breeding has been on a limited scale, for interest in plums in this area has been decreasing. Probably the responsible factor is the frequent difficulty in obtaining suitable varieties for cross-pollination, particularly in the group, *Prunus salicina* × *Prunus nigra* and *Prunus americana* selections. Mount Royal (*Prunus domestica* sdlg.) is probably the best variety for the area because of its tree hardiness and reliable production. For this reason, the crossing has been largely within the *Prunus domestica* group. A rather large number of seedlings of hardy × good quality *Prunus domestica* parentage have been produced and set out for fruiting. In addition, some crosses between large-fruited, good quality, tender *Prunus salicina* varieties and hardy *P. salicina* seedlings of limited quality have been made. The seedlings from both lines of breeding have not yet come into bearing.

## Apricots

Apricot varieties and selections tested at Ottawa have not proved satisfactory because of limited fruit production. Apricot trees break their dormancy so early in the spring that the fruit buds are generally injured by later cold or protracted inclement weather. Although in most years very little fruit is produced, the spring weather conditions in 1953 were favorable, and many of the seedlings of *Prunus armeniaca* or *Prunus armeniaca* var. *mandschurica* parentage were reasonably productive. This provided an opportunity to evaluate the fruit for processing.

The canned fruits were compared with commercial packs by a taste panel. One seedling was rated fully equal to certain commercial brands and superior to others. Three other seedlings were rated acceptable in quality. Nevertheless, the aforementioned frequent crop reduction or loss makes it apparent that a prerequisite to apricot production in this area is the development of seedlings with a longer dormant period.

# SMALL FRUITS

## Strawberries

*L. P. S. Spangelo and A. W. S. Hunter*

The objectives in strawberry breeding have been increased yield, firmer and more attractive berries, and resistance to foliage diseases. From 1949 to 1953 inclusive, 27,233 seedlings were fruited; 304 were selected for additional testing as commercial varieties or for breeding.

***Seedlings Introduced Under Number***

Nine seedlings of the 304 selections were considered sufficiently valuable to be introduced under number for distribution and trial under commercial conditions. These are:

| | | | |
|---|---|---|---|
| O-481 | Valentine × Sparkle | O-486 | Sparkle × Valentine |
| O-482 | Fairfax × Valentine | O-487 | Sparkle × Valentine |
| O-483 | Valentine × Fairfax | O-491 | Maytime × Valentine |
| O-484 | Claribel × Sparkle | O-492 | Maytime × Valentine |
| O-485 | Sparkle × Valentine | | |

Virus-free stocks of five of these seedlings were propagated in 1953 for distribution to commercial growers in 1954.

***Parental Evaluation***

Commercial varieties and Ottawa selections have been used as parents. Notes on crosses expressing good combining ability are as follows:

The Sparkle × Valentine cross is probably the most outstanding used here. The production of most seedlings has been excellent; berries have been of good size and appearance and quality in general fairly good.

The combinations Premier × Fairfax and Valentine, and Valentine × Fairfax are promising early ripening crosses.

Although many Claribel × Sparkle seedlings were susceptible to leaf spot (*Mycosphaerella fragariae* (Schw.) Lind.), this combination is rather promising for berry firmness and appearance.

The Premier × Temple progeny has given a good proportion of early and medium early ripening seedlings. Several seedlings were susceptible to leaf spot and mildew (*Sphaerotheca humuli* (DC.) Burr.) but many plants were free from all foliage diseases. Production, quality, appearance and firmness of berry have been good.

The Temple × Dresden combination. which will be evaluated more extensively, has given mid- to late-season maturity, good production, very little leaf spot, but some scorch.

***Incidence of Leaf Spot in Certain Progenies***—*L. P. S. Spangelo.*

In the breeding program, an attempt has been made to avoid the selection of seedlings which are highly susceptible to leaf spot (*Mycosphaerella fragariae* (Schw.) Lind.).

A photographic scale of six infection classes facilitates roguing the susceptible seedlings (1). Seedlings without leaf spot symptoms are class 1; the most heavily infected is class 6. The rating, based on the most heavily infected leaf, is made during the late fall of the year before first fruiting.

Leaf spot data for several progenies recorded in 1951 and 1952 were analyzed. Proportions of progenies in classes 1 and 2 are shown in Table A-15.

TABLE A-15.—PROPORTIONS OF STRAWBERRY PROGENIES IN LEAF SPOT CLASSES 1 AND 2

| Variety | Selfed | | All crosses | |
|---|---|---|---|---|
| | Number of seedlings | Per cent | Number of seedlings | Per cent |
| Sparkle | 247 | 80·5 | 1,721 | 72·7 |
| Fairfax | 171 | 91·8 | 2,291 | 86·2 |
| Premier | 294 | 98·9 | 2,873 | 91·5 |

If results from selfing measure combining ability, then results from all crosses should show the same trend for general combining ability. In the column, all crosses (Table A-15), the higher proportions of Fairfax and Premier seedlings in classes 1 and 2 indicate their superiority to Sparkle as parental material for leaf spot resistance.

Premier has shown a high degree of field resistance while Fairfax is considered less resistant and Sparkle moderately susceptible. Although no cross was made for leaf spot resistance per se, it is very interesting that even though the susceptibility range of the parent varieties is from fairly susceptible to

highly resistant, a high percentage of the seedlings were in classes 1 and 2. The selection of very susceptible seedlings can therefore be avoided, and the chance of selecting seedlings with generally desirable fruit and plant characters within the fairly resistant group is good.

***References***

1. Spangelo, L. P. S. and A. T. Bolton. Suggested infection scales for roguing strawberry seedlings susceptible to *Mycosphaerella fragariae* and *Diplocarpon earliana*. Phytopath. 43: 345, 347. 1953.

***Inbreeding***

Inbred lines of Premier, Sparkle and Fairfax are being developed. The $S_2$ progenies were field planted in 1953. Probably the greatest limitation in evaluating strawberry inbreeding is the difficulty of selecting seedlings in a self progeny for continued inbreeding. Obviously, early testing of genotypes should provide some basis for selection. It is possible that phenotype, particularly in plant vigor and susceptibility to leaf diseases, might be correlated with genotype. With this in mind, certain seedlings of varying vigor and susceptibility to foliage diseases were selected for continued selfing. It is hoped that by studying their self progenies, some basis for selection in self progenies might be established.

In 1953, plant height, leaf spot, leaf scorch and mildew ratings of $S_2$ progenies were recorded.

There was no correlation between plant vigor of the parent and homozygosity based on plant height. Progeny differences in leaf spot and leaf scorch susceptibility were not evident. Neither were they evident for mildew susceptibility, but probably the data on this were not sufficiently conclusive because of the difficulty in rating mildew susceptibility.

Data on berry characteristics have not yet been recorded, and it is possible that they will reveal some correlation.

***Seed-propagated Strawberry Varieties***

Progeny data recorded in 1950 suggested the possibility of growing seed-propagated in place of clonally-propagated varieties, a procedure that might be more economical in controlling virus diseases than the present method of indexing varieties, propagating, and maintaining virus-free stocks.

In 1951 seedlings from different crosses supplied by this Division were planted by a grower in the Ottawa area for further information. They fruited next year under commercial conditions. The seedlings of some crosses were quite uniform and the berries commercially acceptable. These and other Ottawa data, particularly on the Sparkle $\times$ Valentine progeny, strongly suggested the usefulness of seed-propagated commercial varieties. As a result, a replicated yield trial was outlined in 1953, in which seven seedling progenies will be evaluated in comparison with five clonally-propagated virus-free varieties.

***Strawberry Viruses—A. W. S. Hunter and S. H. Nelson.***

A program was instituted in 1948 for the indexing of strawberry plants to test them for virus infection. It had become obvious by that date that much of the degeneration and running-out of strawberry stocks could not readily be explained on the basis of nutritional deficiencies or fungus disease. Unlike the condition that exists in Great Britain, for example, where the bulk of the crop is produced from varieties that are very sensitive to virus diseases, the majority of the strawberry varieties grown in Canada appeared to be tolerant

of virus diseases. Such varieties showed marked symptoms of reduced vigor, runnering and yield only when infected with a severe combination of two or more viruses. This rendered virtually impossible the effective roguing of plants in the early stages of infection.

The strawberry virus indexing program at Ottawa had four objectives:

1. Proving or disproving the presence of virus diseases in the more important standard varieties and recent introductions from this Division.

2. A search for healthy plants of some of these varieties and introductions.

3. The propagation for distribution of the current introductions from this Division in a virus-free condition.

4. The maintenance of a virus-free nuclear stock of all new selections.

Indexing is by runner-inarching to plants of a virus sensitive variety or species, using essentially the methods developed at the East Malling Research Station. The variety Marshall was used in 1948, but was discarded in favor of the more sensitive *Fragaria vesca*. Locally collected clones of this species were used in 1949, and beginning in 1950 the East Malling clone has been used exclusively.

Since 1949, something over 1,500 plants from approximately 400 Ottawa varieties and selections, standard varieties, and selections from other Stations have been indexed. The results have amply justified the belief that the earlier introductions from this Division are completely virus-infected. Although relatively minor importance was attached to the indexing of standard varieties, no healthy plants were found. The few selections from other strawberry breeding stations that were indexed indicated that the virus situation at those stations has been no different from that at Ottawa.

Beginning in 1950, all field testing of varieties that might be virus-infected was discontinued at Ottawa. The practice up to that time had been to grow new seedlings and standard varieties in contiguous blocks, a practice which gave every facility to the spread of virus. The discontinuance of this system gave us an isolation of at least one-half mile from any other strawberries and in the neighborhood of two miles from any commercial plantation.

TABLE A-16.—RELATIONSHIP BETWEEN AGE SINCE SELECTION AND NUMBER OF WHOLLY AND PARTLY INFECTED CLONES

| Year of selection | Number of varieties or clones indexed | Number of varieties or clones | | |
|---|---|---|---|---|
| | | Completely infected | Partly infected | Completely healthy |
| Before 1941 | 11 | 11 | 0 | 0 |
| 1941 | 8 | 8 | 0 | 0 |
| 1942-44 | 4 | 2 | 2 | 0 |
| 1946 | 32 | 4 | 16 | 12 |
| 1947 | 31 | 1 | 10 | 20 |
| 1949 | 6 | 1 | 2 | 3 |
| 1950 | 110 | 0 | 2 | 108 |
| 1951 | 76 | 2 | 1 | 73 |
| 1952 | 87 | 0 | 1? | 86 |

An indication of the effect of this practice on the health of Ottawa strawberry selections may be gained from Table A-16, in which the varieties and seedlings have been grouped according to the year in which they were selected. The very small proportion of infected clones among those selected after 1949, the last year in which virus-infected standard varieties were grown in the plots, is striking. The proportion of infected clones among those chosen previous to 1949 increases gradually with age since selection.

The practice presently being followed at Ottawa is to give seedlings and varieties as much protection as possible from virus infection. This is done by spraying and dusting to control aphid vectors, and by growing nuclear stocks in cold frames or a greenhouse screened with 32 by 32 mesh bronze wire screening. Runner plants of new selections are taken under cover as soon as possible after selection. Stocks for distribution to growers and other experiment stations for testing are grown from indexed plants, and are never more than two years in the field at Ottawa. Indexed virus-free plants of all selections under test are held in screened frames.

Virus-free plants of some of the more important commercial varieties have been obtained from the United States and are being propagated at Ottawa. These will be distributed for trial beginning in 1955. A test plantation will be set out in 1954 at the Smithfield Substation to compare the performance of virus-free stocks with the best available commercial stocks of infected plants. The future of the virus-free strawberry plant industry in Canada will depend upon this and other similar trials exhibiting sufficient differences to convince nurserymen and growers of the desirability of taking the extra trouble required to maintain their stocks in a healthy condition.

## Raspberries

*L. P. S. Spangelo*

The raspberry breeding objectives continue to be winter hardiness, good production of large, attractive, firm, good quality berries, and freedom from disease.

***Elimination of Seedlings Susceptible to Anthracnose***

The 10,354 seedlings from the 1948 crosses, largely intervarietal hybridizations of the Ottawa varieties, Gatineau, Madawaska, Muskoka, Ottawa, Rideau, Trent and Tweed, were transplanted into flats in 1949. In the hope that seedlings susceptible to anthracnose (*Elsinoe veneta* (Burkh.) Jenkins) could be discarded before being field tranplanted, 5,258 seedlings from the foregoing group were inoculated with anthracnose. The foliage was sprayed with a water suspension of the conidia. A temperature of 60 to 65°F. and high humidity were maintained during the 48-hour inoculation period.

The infection was very good. Under optimum conditions for fungus development, all seedlings appeared very susceptible and differences were not evident. It was, therefore, decided to field transplant all seedlings in the hope that variation in field susceptibility would be evident and that the most resistant seedlings could be selected. Unfortunately, field conditions, probably because of the limited cane number of each seedling in the first year after planting, were not conducive to anthracnose development and very little field infection developed. Therefore, elimination of susceptible seedlings should be made in the flats, and a more extensive study of infection ratings is necessary. A successful technique has not been developed.

The Botany and Plant Pathology Division carried out the research on the fungus and provided the inoculum.

***Seedlings Named or Given Introduction Numbers***—*A. W. S. Hunter and L. P. S. Spangelo.*

*Muskoka* O-201 (Newman 23 × Herbert).—Named in 1949. Particularly outstanding in hardiness. The berries are of good size, bright, attractive and fairly firm.

*Tweed* O-263 (Newman 23 × Lloyd George).—Named in 1949. Outstanding in earliness, production and hardiness. The berries are of good size, rather dark but fairly attractive.

*Thames* O-277 (Lloyd George × Newman 23).—Named in 1951. A very late maturing variety. The berries are light red in color, firm and of fair quality. This variety lacks somewhat in hardiness at Ottawa.

Four seedlings have shown sufficient promise to be introduced under number.

*O-381* ((Lloyd George × Newman 23) × Viking).—A large, medium dark berry, medium in firmness and quality.

*O-382* (Ottawa × Rideau).—A large, medium dark, medium firm, good quality berry.

*O-383* (Ottawa × Madawaska).—Resembles Madawaska and is large, medium dark, and medium in firmness and quality.

*O-384* ((Royal Purple × Newman 23) × Viking) × Trent.—A large berry, slightly rough and coarse, medium dark and of medium quality.

Of the four seedlings, O-382 and O-383 are the most promising.

In 1949, 82 selections from material crossed in 1945, and in 1952, 20 selections from the 1948 crosses were selected for additional testing.

***Inbreeding**—L. P. S. Spangelo.*

An inbreeding program was started in 1951. Six Ottawa varieties were selected on the basis of genetic diversity for selfing. It is hoped that undesirable genes will be eliminated and that superior parents will be developed. This type of breeding should provide a means of studying genotypes, and give an indication of the ability to transmit desirable characters. If seedlings more homozygous than the standard varieties are developed, they might be of value in eliminating the virus problem if grown from seed rather than by clonal methods.

Although the $S_1$ progenies have not fruited, a very pronounced reduction in vigor within most lines is evident.

***Progeny Data***

Intervarietal hybridization of the Ottawa selections, Gatineau, Madawaska, Muskoka, Ottawa, Rideau, Trent and Tweed, is based on limited genetic diversity, yet certain combinations have yielded rather promising progenies. The three noteworthy progenies were Gatineau × Ottawa, Rideau × Muskoka and Muskoka × Trent.

The mildew susceptibility of Ottawa is readily transmitted to its progenies. Many seedlings from crosses of the Ottawa selections lacked considerably in plant vigor.

***Mildew Susceptibility Progeny Data***

In 1951, 5,072 raspberry seedlings, largely from crosses between the Ottawa selections, were rated for powdery mildew (*Sphaerotheca humuli* (DC.) Burr.) susceptibility, using five infection classes, namely: 1, no infection; 2, light infection; 3, medium infection; 4, heavy infection; 5, very heavy infection.

The variety Ottawa is highly susceptible to mildew and Muskoka and Tweed are moderately susceptible. As expected, a very large percentage of the seedlings from the Ottawa × Muskoka and Tweed crosses were in classes 3 and 4. The progeny data also showed that the Ottawa × Rideau combination produced numerous susceptible seedlings. Milton appeared to be a good parent for mildew resistance.

Including all seedlings from the thirteen different progenies the distribution of the seedlings in the five classes was:

Class 1, 16·2; class 2, 12·6; class 3, 44·0; class 4, 26·9, and class 5, 0·3 per cent.

This distribution indicated that it should be possible to avoid the selection of very susceptible seedlings and that a fairly high degree of resistance can be obtained in many progenies. The Madawaska × Milton progeny with 68·8 per cent of the seedlings without infection was the most promising for mildew resistance.

***Spur Blight Susceptibility Progeny Data***

A large number of seedlings, mostly from crosses between the Ottawa varieties, were examined for susceptibility to spur blight (*Didymella applanata* (Wiessl.) Sace). Progeny differences in susceptibility were not evident, and vigorously growing seedlings with a large number of canes had more spur blight than those with a smaller number of canes. Susceptibility appeared to be correlated with number of canes and amount of foliage.

## Gooseberries

*A. W. S. Hunter*

Gooseberry breeding in the past five years was confined to testing the thornless varieties previously described, and to beginning a new breeding program to produce new thornless varieties with larger fruits.

The variety previously known as O-272 was named Captivator in September, 1949. It bears good-sized, pear-shaped fruits that turn dull red when ripe. The good quality berries have a thick skin, and the plant is completely thornless except for a short distance at the bases of the canes.

The five thornless varieties, Captivator, O-271, O-273, O-274 and O-275 were widely distributed to commercial growers and gardeners for trial. They were also planted out in 1949 in a new yield trial at Ottawa for comparison with some of the better commercial varieties. All have performed well under Ottawa conditions, and yields have equalled or exceeded the commercial varieties Clark, Fredonia and Poorman.

At other locations thornless gooseberries received a mixed reception. In general, the reaction to Captivator, O-273, O-274 and O-275 has been favorable. The thornless character has been universally hailed as a marked improvement, but the fruit is considered too small and somewhat variable in size by those who grow the largest-fruited kinds. Other commercial growers are satisfied with fruit size and yield, and most would be prepared to accept some reductions in these for the added advantage of thornlessness. The thornless varieties appear to be no more susceptible to foliage diseases than the standards. They definitely are not hardy on the Prairies; they require winter protection in such locations.

The present thornless selections do not reach the pinnacle of improvement, yet they are a definite step forward in the production of thornless, large-fruited, heavy-yielding sorts.

## Black Currants

Since the last report, the rust-resistant black currant varieties Crusader and Coronet have been widely distributed and tested, but with disappointing results. As grown at Ottawa, in a plantation of many varieties, they yielded crops equal to some of the best standard varieties. When Crusader and Coronet were grown elsewhere, they were usually planted by themselves and poor crops were the rule.

Black currant varieties in general are self-fruitful, the only complication being that many require pollination by insects. Tests at Ottawa revealed that unlike most varieties, Crusader and Coronet are almost entirely self-unfruitful, and require cross-pollination. Crusader and Coronet produce reasonable crops of fruit when hand cross-pollinated, but because of peculiarities in flower structure, pollinating insects do not readily pick up the pollen of Crusader, and miss coming in contact with the stigmas of Coronet flowers. For these reasons, Crusader and Coronet were a very unfortunate pair of varieties to introduce, and the experience serves to emphasize the importance of securing information on pollination requirements before a new variety is introduced.

#### *New Variety—Consort*

A third rust-resistant variety was named and introduced in 1951 to replace Crusader and Coronet. This variety, formerly known as O-396, is from the cross Kerry × *Ribes ussuriense* Jancz. and has been called Consort. It is much the same as the two earlier varieties in horticultural characters. It is immune from rust (*Cronartium ribicola* A. Fisch.) but susceptible to mildew (*Sphaerotheca mors-uvae* (Schw.) Berk. & Curt.). It yields heavily at Ottawa, exceeding all other varieties under test, and is a good variety for jam and jelly. Consort is completely self-fruitful and will set a good crop of fruit even when pollinating insects are excluded from the flowers. It was first distributed for trial in quantity in 1951, and although the plants are still young, the majority of the reports on its performance have been favorable.

*Resistance to Mildew.*—The principal disadvantage of Consort, in common with the other two rustless varieties, is its susceptibility to mildew (*Sphaerotheca mors-uvae*). This is serious enough to be the limiting factor in the usefulness of the rust-resistant varieties in regions such as the Prairie Provinces where mildew is normally severe.

A search for sources of resistance to mildew has resulted in the discovery of a *Ribes nigrum* plant grown from seed obtained from Poland, and a variety from a nurseryman in Saskatchewan, both of which are highly resistant to mildew at Ottawa. Crosses were made in 1953 between the Polish seedling and the rustless varieties in an attempt to combine resistance to rust and mildew.

## FRUIT VARIETY TRIALS

*D. S. Blair and L. P. S. Spangelo*

A very important part of any plant breeding program is the commercial evaluation of selected seedlings. Since nurserymen are not interested in propagating unnamed selections, the breeder is faced with the problem of disseminating promising selections for commercial test. With tree fruits, because of the long period from planting to fruiting, the final tests under commercial conditions are costly. Provided staff and funds were available, probably the ideal would be to purchase land and establish test stations in all commercial areas. This has not been possible, but planting grower-owned co-operative tree fruit test orchards has been promoted on a large scale in Quebec and Ontario and has proved of unlimited value.

### Apples

#### *Early Maturing Selections*

Apples that ripen earlier than Melba are of value in eastern Ontario and Quebec. Several selections that ripen earlier than Melba are being tested in

comparison with the early varieties, Close and Crimson Beauty. Notes on the most promising selections follow and all, with the exception of O-292, are of Melba—Crimson Beauty parentage. The O-292 seedling is of Melba × Astrachan parentage.

*O-272.*—This seedling has a tendency to overbear and should be heavily thinned. The apples resemble Melba but have a darker green ground color. They are earlier than Melba and when thinned are large.

*O-274.*—This also resembles Melba in appearance and ripens a little earlier, but resembles Crimson Beauty in eating quality.

*O-276.*—Of the group, this selection is one of the earliest to ripen. It resembles Melba in appearance, but is inferior in eating quality.

*O-277.*—Because of its earliness and appearance, this seedling is one of the most promising of the group. It tends to overbear and requires thinning. The apples are less susceptible to bruising than Melba.

*O-341.*—This apple closely resembles Crimson Beauty in appearance and eating quality. It ripens with Crimson Beauty.

*O-342.*—Ripens shortly after Crimson Beauty; is fully equal to it in appearance, and is superior in eating quality. This is a promising, early ripening seedling.

*O-362.*—The apples are of good size, attractive, inferior to Melba in eating quality, and ripen shortly after Crimson Beauty. It keeps better than most early apples.

*O-292.*—Resembles Astrachan in tree and fruit characteristics. The apples are large, well colored, ripen earlier than Melba, and are superior to Crimson Beauty in eating quality.

Close, Lodi, Mantet and the red sports of Melba are the best of the newer variety introductions.

*Close.*—The first variety to ripen at Ottawa. Although the apples are attractive and of good commercial size, they go mealy very quickly and must be carefully harvested.

*Lodi.*—Ripens a few days earlier than Melba; is the best of the yellow varieties at Ottawa, having proved superior to Yellow Transparent in fruit size and production.

*Mantet.*—Originated by the Experimental Station, Morden, Man.; is probably more valuable than Melba as an early sort in the more northerly areas. The apples are of good size, fairly attractive, ripen with Melba, and are of acceptable eating quality. The tree is very susceptible to fire blight at Ottawa.

*Red Sport of Melba.*—Several red sports of the variety have been tested. In general, they are superior to Melba in color and probably do not bruise so easily.

*Red Sport of Crimson Beauty.*—Found by H. Banks, Waterville, N.S. Crimson Beauty is a useful early variety in this area, and because of superior color, the red sport will probably replace it.

***Midseason and Late Maturing Selections***

*Red Sport of Atlas.*—Found by Wm. Sovereign, Kakabeka Falls, Ont. It is superior to Atlas in color, and is outstanding as a fall apple.

*Bancroft.*—Originated at Ottawa; has continued promising as a late maturing variety. It is an attractive apple and although it is lacking somewhat in eating quality, marketing tests have shown excellent consumer acceptance of the variety. It is highly recommended for the Ottawa and St. Lawrence River Valleys in Ontario and the fruit growing areas of Quebec. Marketing trials of this and the following variety may be found in the Smithfield Substation section of this report.

*Toshkee.*—Originated at Ottawa. Although it does not keep so well as Bancroft and O-2016, it does keep longer than McIntosh and is particularly promising because of its semi-dwarf tree and annual bearing.

*O-2016* (McIntosh × Milwaukee).—An annual bearing, late maturing seedling originated at Ottawa. The apples are uniformly large and fairly attractive. Although this seedling lacks good eating quality, it has continued promising because of its late maturity. The core flush susceptibility, which it has recently shown, is being studied extensively.

***The Method of Evaluating the Keeping Behavior of New Introductions***—*L. P. S. Spangelo, P. A. Poapst, S. H. Nelson and W. R. Phillips.*

When new varieties are introduced, information on the optimum picking date and storage behavior in comparison with standard varieties is essential. Each variety is picked at three stages of maturity so that the maturity range will include the optimum. The apples are picked at random from each tree, and composite samples of 110 apples are stored on trays at 32°F. At harvest time, ground color, blush, starch and pressure data are recorded to correlate storage behavior with estimated optimum harvesting maturity. Samples are withdrawn periodically for evaluation. After the initial quality evaluation at the time of removal, the samples are ripened for one week at 68°F. and 90 per cent relative humidity. They are then examined again for quality and physiological disorders. By rating flavor, texture and appearance of successive samples numerically, the date of significant loss in quality and the maximum storage life are determined.

It has thus been determined that Bancroft remains in good condition until early April. Although O-2016 remains firmer and retains its quality slightly longer than Bancroft, it has shown a susceptibility to core flush. Toshkee is also somewhat susceptible, but otherwise will keep longer than McIntosh.

The average optimum harvesting date at Ottawa for Bancroft and O-2016 is October 9; for Toshkee, October 2. The average starch iodine index readings for the above harvest dates were Bancroft, 4·5; O-2016, 4·0 and Toshkee, 3·5.

Storage studies were also made on Edgar, Garnet, Jubilee, Kendall, Lawfam, Linda, Newtosh and Spartan. The results of such work substantiate findings previously published in the Annual Reports of the Fruit and Vegetable Products Research Committee, Canada Department of Agriculture.

***Heat Units In Predicting Apple Maturity***—*H. F. Beingessner.*

The application of phenology to maturity prediction of the McIntosh apple was investigated. Heat units were calculated on a simple remainder indices basis. Temperature statistics and related climatological data were examined in conjunction with thirteen phenological periods at Ottawa and nine at Summerland.

The phenological period initiation, the base or unit temperature below which the apple is assumed not to grow, and phenological period termination, were all considered. Starting the phenological period ten days before full bloom gave better precision than at full bloom. Of the several base temperatures examined no one base temperature or combination of temperatures was entirely satisfactory, although the base temperature of 42°F. occupied a medial position. The field record harvest date was as good for determining the end of the phenological period as was the maturity index determined in the Low Temperature Research section by the starch test and general storage behavior.

May and September were critical months for establishing base temperatures, since the average temperature for both Ottawa and Summerland did not drop below 50°F. during June, July and August in the years investigated.

Precision in harvest predictions was achieved within individual years rather than for particular base temperatures. That is, average years occurred during which all base temperatures resulted in fairly good precision at both Ottawa and Summerland, although the years were not necessarily the same.

In calculating heat units, temperature statistics other than the average, for example, minimum or night temperatures, did not improve the precision of a prediction. Certain evidence indicated that an accumulation of temperature ranges is superior to heat unit accumulation in forecasting maturity.

Very little relation could be observed between either the accumulated hours of sunshine or the limited solar radiation data and either the total heat units or the length of the phenological period. The total days in the phenological period gave a more precise prediction than the heat unit accumulation, particularly at Summerland.

## Pears

*L. P. S. Spangelo, W. R. Phillips and D. S. Blair*

In evaluating pear varieties and selections the procedure has been one of harvesting at two or three stages of maturity and conditioning at 68°F. with high relative humidity. An attempt has been made to correlate storage behavior and quality with external color, starch content and pressure testing at harvest time. Where possible, samples from all picking maturities have been processed. Standard commercial packs have been used for comparing eating quality.

A definite relationship exists between eating quality, storage behavior and maturity at harvest. Additional data are needed, however, before recommendations are made.

Of a group of Ottawa varieties, Enie, Menie, Miney, Moe and Phileson, Moe is the earliest; but it lacks in size, and in quality when processed. Miney is the most satisfactory for processing. This is followed by Phileson. In taste panel tests the processed Miney was fully equal if not superior to the commercial pack of Flemish Beauty. Miney should not be stored longer than two weeks and maximum quality is obtained by conditioning the pears immediately after picking. At Ottawa the optimum picking date for Miney is late August, and for Phileson early to mid-September. Phileson will keep at 32°F. for several weeks longer than Miney.

*O-291* (Winter Nellis × Bartlett).—The most promising of the recent Ottawa seedlings. This pear is very late in maturing and lacks a bit in size, but it has excellent texture and good quality. It will keep at 32°F. for several weeks. The tree is not fully hardy at Ottawa.

*Bantam.*—A Minnesota introduction; lacks size and quality, and is inferior to the most promising of the Ottawa introductions.

*Beierschmidt.*—An open-pollinated seedling of Bartlett, originated in Iowa. It had better eating quality than all other varieties that fruited at Ottawa in 1953. It will be closely evaluated as a commercial pear for this area.

*Karl Sabioski.*—A Polish variety obtained from Leon Bobinski in 1929. It is hardy and productive; the fruit is large and almost acceptable in quality. The variety is being tested extensively as a hardy parent.

*Lincoln.*—An old variety, widely grown in the Mississippi Valley, that has received attention in recent years because of its apparent hardiness when grown as topgrafts in Minnesota. It is worthy of mention because of its large fruit size and fairly good flavor. Tree hardiness and production have not been fully evaluated at Ottawa.

*Patten 1215.*—Originated at the Iowa Fruit Breeding Station; lacks a bit in fruit size but has good texture and flavor. Tree hardiness and production will be more fully evaluated.

*Tait No. 1.*—Originated by David Tait, Carterton, Ont.; a seedling with good uniform fruit size but somewhat lacking in good pear flavor.

## Plums

*D. S. Blair and L. P. S. Spangelo*

Yield of the red hybrid plums (*Prunus salicina, P. americana* and *P. nigra*) has been generally unsatisfactory. The factors are probably lack of effective pollinizers and generally unfavorable weather conditions at blossom time. Because of its tree hardiness, self fruitfulness and productivity, Mount Royal (*P. domestica*, open-pollinated) has proved the only reliable variety for the area. Recent variety and selection testing has largely been confined to the *P. domestica* group. In this group Carleton, Chercuts of Kharkoff, and Nepean have shown promise.

Of the red hybrid plums, Grenville, originated at Ottawa, when grown along with a suitable pollinator like Assiniboine, has continued the most promising.

## Strawberries and Raspberries

In 1949 some sixty strawberry varieties fruited at Ottawa and five, Fairpeake, Robinson, Sparkle, Suwanee and Temple, were particularly noteworthy. Sparkle was the most promising followed by Temple. Sparkle was productive; the berries were attractive, of commercial size, reasonably firm and acceptable in quality. It appeared to withstand drought better than all other varieties. The berries of Temple were of commercial size, attractive, uniform, firm and acceptable in quality.

Since 1949 varietal trials for these two fruits have not been conducted. The variety test blocks were discarded because they might be a source of infection for the virus-free stocks being propagated. The policy of this Division is to field test only the virus-free Ottawa selections and virus-free varieties when available. During this period variety testing has been carried out at the Experimental Substation, Smithfield, Ont.

## Gooseberries

Fredonia, Poorman and Silvia have continued to be acceptable commercial varieties. The Ottawa selections, Captivator, O-261, O-271, O-273 and O-274, because of their thornlessness and fruit acceptability probably will replace the old commercial varieties. They are all of Spinefree—Clark parentage and descriptive notes follow.

*Captivator.*—The most impressive of the thornless selections thus far. It is productive; the berries are about the same size as Poorman, turn red when ripe, and are of good quality.

*O-261.*—The berries are medium in size, coppery-red when ripe and fairly good quality.

*O-271.*—The berries are about the same size as Poorman, medium-red when ripe and of fairly good quality. It is fairly productive but less so than Captivator.

*O-273.*—The berries are medium to above in size, coppery-red and of good quality. It resembles Captivator in berry characteristics but ripens a few days earlier.

*O-274.*—This seedling is very productive, but the berries are smaller than those of Captivator. They are red and of good quality.

Many varieties and selections have been under test and brief notes on the most promising are given. Since the following varieties are thorny they are inferior to Captivator and the Ottawa seedlings in this respect.

*Como.*—A green variety introduced by the Minnesota Fruit Breeding Station. It has not been very uniform and has lacked somewhat in berry size.

*Early Red Sweet.*—Sent in for trial by W. Oakes, Miami, Man. Inferior to the commercial varieties in fruit size, but an early red sort.

*Glenashton.*—Also received from W. Oakes. Outstanding for its large green fruit. Along with Clark, it has been larger than all other varieties.

*Glendale* (U.S.D.A.).—Not an outstanding red, and lacks too much in berry size.

*Goldo.*—Sent in for trial by W. Oakes, Miami, Man. A very large-fruited, green variety resembling Ross; not overly productive.

*Hinnonmanen Keltainen.*—A green variety received from Norway. Although not extensively evaluated, appears equal to Captivator and other commercial varieties in berry characteristics.

*Hinnonmaki Strain No. 14.*—A green variety received from Finland. It has not been tested extensively but has acceptable berry size and appears equal to the standard varieties.

### Black Currants

Magnus, Saunders, Kerry and Climax are still highly recommended standard varieties. In recent years many varieties have been obtained from foreign countries and evaluated in comparison with the four standards. The Ottawa performance of one Finnish and several British introductions is briefly summarized.

*Brodtorp.*—Source, Finland. Although not fully evaluated, it has been very impressive. Berries are of good size and ripen evenly.

*Baldwin.*—Late maturing; berries of good size in most years, but tends to ripen unevenly.

*Blacksmith.*—Rather late maturing; berries equal to Magnus in size but ripen unevenly.

*Daniel's September.*—Late maturing; ripens unevenly and is rather variable in berry size.

*Mite Free.*—Late maturing; fairly productive, with berries of medium size that ripen fairly evenly.

*Raven.*—Berries for the most part are only medium in size but ripen fairly uniformly.

*Seabrooks.*—Not outstanding in berry size but ripens evenly.

*Tinker.*—Large, late maturing berries; probably the best of the British varieties.

*Wales.*—Not outstanding in berry size and does not ripen very evenly.

*Wellington.*—Matures later than Magnus and Saunders; some berries are very large, but generally size is not uniform. Ripens unevenly.

*Westwick's Choice.*—Berries mostly large and ripen fairly uniformly. Probably not sufficiently productive.

*Westwick's Triumph.*—Not particularly impressive in most years. Although it ripens fairly evenly, the berries are only medium in size. Probably not sufficiently productive.

## Grapes

A large number of varieties and seedlings has been tested at Ottawa and, in general, they do not mature early enough. Delaware, Fredonia, Seneca, Van Buren and Violante Early are the recommended varieties for this area. The following are brief notes on those varieties fairly well evaluated since 1948.

*Blue Jay* (Minn. 69).—A blue variety that matures early enough in most seasons. The clusters are short and compact. The berries are small, lacking in quality and are inferior to the recommended varieties.

*Hungarian.*—One of the best of the hardy blues that has been productive during the past few years even though it has been left on the trellis during the winter. The clusters are short and the berries are of medium size and quality. It is a variety that shells badly.

*Moore Early.*—A blue variety, equal to Hungarian in vine hardiness, but the berries are larger and fully equal in quality. The clusters are of medium length and fairly compact. It ripens in most years at Ottawa, and is probably the best of the hardy varieties here.

*Violante Early.*—The best of the early varieties at Ottawa. The clusters are of medium length and compact. The berries are medium in size, green, sweet, and of good quality.

Several seedlings from the New York State Agricultural Experiment Station have been tested. Of these the following have some value and are being retained for further observation.

*Geneva 11987.*—The clusters are short and compact. Berries are green, of good size and quality. They ripen early enough, but there is need for a further check on production.

*Geneva 17074.*—The clusters are of medium length and fairly compact. The green berries are medium in size and of good quality. It matures early enough and will be a useful selection if it proves productive.

*Geneva 17102.*—Clusters are of medium length, and fairly compact. The red berries are medium to above in size and acceptable in quality. It is a rather promising seedling when well matured.

*Seibel Seedlings.*—Four of the French Hybrids of the Seibel group have been tested. Of these *Seibel 2838* has been the best; the clusters are long and slightly loose. The green berries are of good size and quality and ripen fairly early. Although *Seibel 5279* is inferior to Seibel 2838 in berry size, it has long, compact clusters of green berries; is rather productive, and of fairly good quality. *Seibel 1000* and *Seibel 5455* have not matured early enough at Ottawa.

## NATIVE FRUITS

*E. L. Eaton*

### Blueberries

***Lowbush Blueberries***

The period covered by this report has been one of great commercial activity and expansion. Increased urban populations in both Canada and the United States have stiffened the demand, while better forest fire protection in Eastern Canada and the United States has reduced the local supply. Because of its preference for acid soils and the long time needed for establishment, the lowbush blueberry is rare in what are commonly regarded as the better farming regions of the continent. In Eastern Canada and New England the plant is indigenous on the well-drained, often rocky, soils where lime supplies are low. Removal of second growth forest cover often reveals a strong population of blueberries, while the smooth, lightly grazed fields of abandoned farms frequently provide the finest and most productive stands. Value of such land has multiplied many times as a result of the keen search by commercial interests.

Yields of lowbush blueberries vary widely from field to field and from season to season. Density and purity of stand, vigor of plants, pollination conditions, moisture during the growing season, to say nothing of the numerous disease and insect pests inevitably preying on the native flora, all contribute to these differences in crop. Within short distances clonal variations introduce still another factor which demands a specialized plot technique if other treatments are to be accurately measured. At Tower Hill, N.B., for example, records taken in 1949 from rod-square plots in a relatively uniform field gave yields of cleaned berries ranging from 12 bushels per acre to 222¼ bushels per acre within a short distance with a total yield for the field of 88 bushels per acre.

With good blueberry land now priced more highly than any other farm lands generally in the Maritime Provinces, growers desire information on two broad points, (1) improvement of natural, existing stands, and (2) methods of planting in open fields. It is now apparent that the answers will be far from simple, and a much more fundamental knowledge of growth, reproductive processes, nutrition and symbiotic relationships is necessary.

*Fertilizer Tests.*—So far there is little to encourage the use of fertilizers. In many of the tests, even when yields were increased, the thicker grass and weed undercover rendered picking noticeably slower. Sawdust alone and with fertilizer has helped, but costs of hauling and difficulty in spreading without injury to the plants put a limit to the practical value of this treatment.

In 1953 a comparison of ammonium sulphate and ammonium nitrate, two levels of each, was made on five locations. One plot was established in May, the others in July. The fruit buds—from a definite number of sprouts on each side of a plot margin passing through a clone—were counted as a measure of the fertilizer response. The number of buds on the treatments exceeded those on the control on the less fertile soils.

Results to date indicate that fertilizers do more harm than good on any but the lightest soils.

*Propagation.*—Square frames containing four-inch layers of sawdust, peat or vermiculite have been placed on newly burned and one-year-old blueberry plants to induce the stems to root in the loose materials. The vermiculite was unsuccessful but both sawdust and peat proved excellent propagating media. Many fine rootlets were in evidence at the end of the first year, but the root system was much better after two years. It seems likely that a further season in a fertile, well prepared nursery bed will be needed to establish satisfactory plants.

Interesting evidence on natural distribution has been secured. Skunk manure was observed to contain many blueberry seeds, which later germinated freely under greenhouse conditions. In August, 1953, robins and their associates over a considerable area at Tower Hill left a large patch of blue excreta. Germination of seed from these droppings was poorer than from the skunk manure but was still substantial. The distance that seeds might be carried by migrating birds is an interesting speculation.

*Picking Dates.*—In Newfoundland practically all blueberries grow on the public domain and local opposition has been voiced to private ownership of this valuable property. The Province does the burning and picking is practically unrestricted.

On the new Substation at Avondale a series of plots were set up in 1953 to learn the best dates for harvesting. The first berries were gathered on August 26. A week later the crop was four times as heavy, and it had grown a third more by the end of a second week. A destructive frost occurred before September 30.

*Weed Control.*—Cutting in midsummer controls many woody plants. The 2,4-D formulations are all toxic to blueberries but are useful for spot spraying. Grass is a serious problem in new plantings and ordinary cultivation destroys the underground stems by which the blueberry spreads. Kerosene and Varsol have been applied at weekly intervals to learn if they would check grass without injury to the blueberries. Preliminary tests indicate that Varsol, applied after grass starts but before blueberry buds break, may be an effective control. A further study of rates and dates of application is needed.

***Highbush Blueberries***

The highbush blueberry plantation at Kentville, set in 1926, is still vigorous and, with the exception of the Grover variety, has not missed a crop in the past 14 years, although peach, cherry and apple crops were destroyed or reduced by spring frost during several seasons of that period. For many years the Grover

variety was thought to be too tender for this climate. A change from sawdust mulch and clean cultivation through the season to mulch with a cover crop of weeds after mid-July has enabled this late variety to mature its twigs fully, and no injury has occurred in any winter.

A co-operative test at Oxford, N.S., set in 1945, has averaged over two quarts per bush for several years. The land received sawdust mulch at planting time and has since received 4 inches of planer shavings which have given equally as good results as sawdust.

*Cultural Tests.*—Several different methods of applying mulch have been tried at Kentville. Sawdust harrowed into the soil before planting, sawdust plowed under before planting, sawdust in a deep trench beneath the plants and sawdust as a surface treatment have all given excellent results. Peat moss buried beneath the plants is equally good but a barrel of peat moss per plant on top of the soil after planting has been useless.

*Propagation.*—The tight glass, burlap shaded cover for the peat-filled cold frame has always demanded careful adjustment of ventilation to prevent the rapid destruction of cuttings by molds. A lattice made of laths with a 2-inch spacing has been found to root cuttings a little more slowly but quite as well and more ventilation is needed only in extremely hot, humid weather.

*Breeding.*—Fifty-seven individual plants have been chosen from some thousands of seedlings as meriting further study. Rooted cuttings have been made from many of these which are to undergo a further rigid test. A number appear to possess superior plant and fruit characters.

Crosses between highbush and native lowbush gave plants intermediate between the parents in size of plant and fruit. The $F_2$ generation displays a much greater range of plant type and is expected to fruit in 1955.

Open-pollinated progeny of Kengrape, Jersey and Stanley have all given a large proportion of vigorous plants bearing high quality fruit. Burlington and Rancocas seedlings are much less attractive.

*New Varieties.*—The varieties Earliblue, Bluecrop, Herbert, Berkeley and Coville, recently introduced by the United States Department of Agriculture, are said to provide a succession of very large-fruited berries throughout the season. Berkeley and Coville, fruiting at Kentville in 1953, fully lived up to expectations. Coville may be too late to mature well in some seasons. The other three and Ivanhoe, a variety bred for the South, are expected to fruit in 1954.

## Cranberries

*Nova Scotia.*—In most years the Early Black has outyielded Howes or natives. Since frost is a hazard in many areas, earliness is an advantage.

From the collection of wild plants at Aylesford, two have been chosen for multiplication and further test. One of these is a week earlier and is a more attractive berry than Early Black. The other is later than Howes and has given a high yield.

A new section of bog has been prepared by the use of chemical weed killers without removing the turf. Ditching and sanding have been done in the usual way. This is being used as a multiplication area for the selections mentioned in the preceding paragraph and to test new varieties from the U.S.D.A. breeding project.

Crosses have been made between the two native selections and also between the early native and Early Black.

*New Brunswick.*—The area at Cumberland Point has demonstrated that Early Black and Howes are both adapted to local conditions and that kerosene is a useful aid in grass control. A test of the two superior native selections was begun in 1953.

*Prince Edward Island.*—Cranberry vines planted on light soil near the north shore have become slowly but well established. Varsol in early spring has checked grass and stimulated the cranberries. The addition of fertilizer with the Varsol has been a further help.

A similar test with Early Black and Howes vines is to be made on damp soil on the south side of the Island. This land was prepared in 1953 and is to be planted in 1954.

### Elderberries

A change in the personnel at two processing plants, technical difficulties with the product, and a sharp reduction in cull apple supplies terminated the joint project to introduce a commercial blend of elderberries and apples for juice, jelly or jam.

Four large-fruited early seedlings of the Adams variety have been developed at Kentville, and plants are available for test by those interested.

Attempts have been made to cross the purple elder, *Sambucus canadensis* with the much earlier but inedible red elder, *Sambucus racemosa,* using the latter as the pollen parent. Several hundred seedlings have been grown but the results of the project are not yet known.

### Bake-Apple

A new project has been initiated from which it is hoped a cultivated bake-apple berry, *Rubus Chamaemorus,* may be developed. The foundation material has been received from the New Hampshire Experimental Station where various *Rubus* crosses have been made. A few parent plants were secured and a large number of seedlings are being grown. The object is to produce a bake-apple berry on a raspberry bush which may be grown under ordinary garden or field conditions.

## USE OF CHEMICALS IN APPLE PRODUCTION

*D. S. Blair and S. H. Nelson*

### Thinning Apples with Chemicals

During the past ten years at Ottawa, extensive investigations have shown that chemical thinning is practical. It is less costly than hand thinning, and since it can be done earlier in the season, it results in better fruit size and more uniform annual bearing. But an orchardist must know when and whether to apply the thinning spray. He must have previous knowledge of the bearing habit of the orchard and observe carefully the suitability of the weather for pollination during the blossom period. These are most important in determining whether or not chemical thinning can be used profitably. Certain heavy setting varieties such as Melba, Yellow Transparent, Duchess, Wealthy and Fameuse need thinning, but other usually lighter setting varieties need thinning only when pollinating conditions are ideal. One of these is McIntosh. Varieties like Atlas, Lobo and Cortland which normally produce fruits of large size should not be thinned.

In 1949 experiments were carried out at two locations, the Horticulture Division, C.E.F., Ottawa, and the Rideau Fruit Farm, Manotick, Ont. The treatments were the dinitros, Krenite, DN289, DN2, Elgetol, and App-l-set, the sodium salt of naphthaleneacetic acid. The varieties sprayed included Duchess, Lawfam, Melba, McIntosh, Wealthy and Yellow Transparent.

TABLE A-17.—APPLE THINNING EXPERIMENTS, OTTAWA, 1949

| Material | Concentration | Bloom stage | Average number of blossoms | Average per cent set |
|---|---|---|---|---|
| LAWFAM— | | | | |
| Elgetol | 1¾ pt. | full | 1,175 | 3·00 |
| Elgetol | 2 pt. | full | 938 | 1·50 |
| Elgetol | 2½ pt. | full | 1,135 | 1·25 |
| Krenite | 2 pt. | full | 1,119 | 5·75 |
| DN2 | ¾ lb. | full | 1,285 | 1·63 |
| DN2 | 1 lb. | full | 933 | 4·73 |
| DN2 | 1¼ lb. | full | 1,147 | 2·68 |
| DN289 | 1 pt. | full | 1,023 | 0·53 |
| App-l-set | 5 oz. | calyx | 1,175 | 0·08 |
| App-l-set | 7½ oz. | calyx | 1,115 | 3·45 |
| App-l-set | 10 oz. | calyx | 1,247 | 0·21 |
| Control | | | 1,145 | 4·98 |
| McINTOSH— | | | | |
| Elgetol | 1¾ pt. | full | 1,203 | 2·55 |
| Elgetol | 2 pt. | full | 913 | 2·72 |
| Krenite | 2 pt. | full | 1,030 | 5·87 |
| DN2 | ¾ lb. | full | 1,203 | 2·96 |
| DN2 | 1¼ lb. | full | 878 | 4·58 |
| DN289 | ¾ pt. | full | 1,020 | 7·89 |
| DN289 | 1 pt. | full | 1,150 | 0·77 |
| DN289 | 1¼ pt. | full | 890 | 0·34 |
| App-l-set | 5 oz. | calyx | 1,170 | 1·80 |
| App-l-set | 7½ oz. | calyx | 1,025 | 3·56 |
| App-l-set | 10 oz. | calyx | 1,310 | 3·59 |
| Control | | | 1,003 | 4·94 |
| MELBA— | | | | |
| Elgetol | 2 pt. | full | 1,195 | 6·85 |
| Krenite | 1¾ pt. | full | 723 | 18·04 |
| Krenite | 2 pt. | full | 1,140 | 9·92 |
| Krenite | 2½ pt. | full | 1,155 | 4·94 |
| DN289 | 1 pt. | full | 1,265 | 5·00 |
| App-l-set | 7½ oz. | calyx | 1,085 | 5·27 |
| Control | | | 863 | 9·28 |
| MACOUN— | | | | |
| Elgetol | 1¾ pt. | full | 1,128 | 2·19 |
| Control | | | 1,070 | 4·86 |
| EARLY McINTOSH— | | | | |
| Elgetol | 1¾ pt. | full | 955 | 6·28 |
| Control | | | 930 | 27·20 |
| NEWTOSH— | | | | |
| Elgetol | 1¾ pt. | full | 700 | 11·43 |
| Control | | | 920 | 6·52 |

At the Horticulture Division, as shown in Table A-17, effective thinning was obtained on Melba with 2½ pt. Krenite, 1 pt. DN289 and 7½ oz. App-l-set, and partial thinning with 2 pt. Elgetol. On McIntosh severe thinning resulted from both 1 and 1¼ pt. DN289, while effective thinning was obtained from the use of 1¾ and 2 pt. Elgetol, ¾ lb. DN2 and 5 oz. App-l-set. Unlike the results on Melba, Krenite appeared to be ineffective on McIntosh, while partial thinning was obtained with both 7½ and 10 oz. App-l-set. Elgetol at 2 and 2½ pt. and DN2 at ¾ lb. were effective on Lawfam. The 5 and 10 oz. treatments of

App-l-set and the 1 lb. treatment of DN289 were too severe, while Krenite was ineffective on this variety. Elgetol at 1¾ pt. gave favorable results with Macoun and Early McIntosh but proved ineffective on Newtosh. However, these last three varieties were single tree trials and, therefore, their results should not be considered definitely conclusive.

TABLE A-18.—APPLE THINNING EXPERIMENTS, RIDEAU FRUIT FARM, 1949

| Material | Concentration | Bloom stage | Average number of blossoms | Average per cent set |
|---|---|---|---|---|
| DUCHESS— | | | | |
| DN289 | ½ pt. | full | 975 | 6·67 |
| DN289 | 1 pt. | full | 845 | 2·72 |
| Elgetol | 2 pt. | full | 1,153 | 8·24 |
| Control | | | 1,115 | 4·48 |
| MELBA— | | | | |
| DN289 | ½ pt. | full | 697 | 6·69 |
| DN289 | 1 pt. | full | 685 | 2·97 |
| DN2 | 1 lb. | full | 932 | 5·38 |
| Elgetol | 2 pt. | full | 923 | 7·16 |
| App-l-set | 8 oz. | *f+2 wk. | 1,027 | 7·68 |
| App-l-set | 8 oz. | †c+2 wk. | 1,030 | 7·75 |
| Control | | | 1,155 | 5·97 |
| Y. TRANSPARENT— | | | | |
| DN289 | ½ pt. | full | 1,110 | 6·31 |
| DN289 | 1 pt. | full | 1,120 | 10·15 |
| DN2 | 1 lb. | full | 1,190 | 6·81 |
| App-l-set | 8 oz. | f+1 wk. | 1,115 | 9·24 |
| App-l-set | 8 oz. | c+1 wk. | 1,095 | 13·15 |
| Control | | | 1,115 | 9·78 |
| WEALTHY— | | | | |
| DN289 | 1 pt. | full | 993 | 5·04 |
| Elgetol | 2 pt. | full | 995 | 5·48 |
| App-l-set | 8 oz. | f+2 wk. | 1,122 | 6·35 |
| Control | | | 1,175 | 7·58 |

* f+2 wk.=two weeks after full bloom.
† c+2 wk.=two weeks after calyx.

At the Rideau Fruit Farm (Table A-18) only the 1 pt. treatment of DN289 gave effective thinning on Duchess. The other two treatments gave a greater percentage set than the control trees. With Melba, it was again DN289 at 1 pt. that gave effective thinning, while the remaining treatments were ineffective or gave only partial thinning. DN289 at ½ pt. and DN2 at 1 lb. on Yellow Transparent gave only partial thinning, while the other treatments were relatively ineffective on this variety. Wealthy, a difficult variety to thin, responded partially to treatments of DN289 at 1 pt. and Elgetol at 2 pt.

Problems such as the varying results in successive seasons and the unexplainable fluctuations between concentrations as shown in Tables A-17 and A-18 still remain. Further, Elgetol and Krenite caused a burning of the initial leaves, an effect that might be expected from these dinitro materials, and the growth regulating material, App-l-set, caused blade puckering and curvature of the midribs as noted in previous years.

The 1950 trials were confined to the Rideau Fruit Farm because of lack of suitable trees at Ottawa. Elgetol, DN2, App-l-set and Parmone were used on Crimson Beauty, Duchess, Lobo, Melba, Wealthy and Yellow Transparent. The results obtained are shown in Table A-19.

TABLE A-19.—APPLE THINNING EXPERIMENTS, RIDEAU FRUIT FARM, 1950

| Material | Concentration | Bloom stage | Number of trees | Average number of blossoms | Average per cent set |
|---|---|---|---|---|---|
| MELBA— | | | | | |
| Elgetol | 2 pt. | full | 5 | 1,148 | 13·04 |
| Elgetol | 2¼ pt. | full | 5 | 1,228 | 8·09 |
| Elgetol | 2½ pt. | full | 4 | 1,489 | 11·31 |
| DN2 | 1 lb. | full | 5 | 1,104 | 12·69 |
| App-l-set | 8 oz. | calyx | 5 | 1,312 | 5·29 |
| Control | | | 3 | 2,184 | 21·11 |
| WEALTHY— | | | | | |
| Elgetol | 2½ pt. | full | 4 | 1,553 | 25·28 |
| Parmone | 8 oz. | calyx | 5 | 1,330 | 24·72 |
| Control | | | 2 | 2,495 | 24·35 |
| Y. TRANSPARENT— | | | | | |
| Elgetol | 2 pt. | full | 5 | 1,087 | 11·66 |
| Elgetol | 2½ pt. | full | 1 | 1,157 | 10·46 |
| Control | | | 2 | 1,538 | 14·60 |
| CRIMSON BEAUTY— | | | | | |
| Elgetol | 1½ pt. | full | 2 | 2,469 | 13·15 |
| Control | | | 2 | 3,367 | 16·31 |
| LOBO— | | | | | |
| Elgetol | 1½ pt. | full | 3 | 1,843 | 11·77 |
| Control | | | 2 | 2,671 | 13·65 |
| DUCHESS— | | | | | |
| Elgetol | 2¼ pt. | full | 5 | 1,021 | 10·46 |
| Control | | | 3 | 1,420 | 23·21 |

Only App-l-set at 8 oz. gave sufficient thinning on Melba; the other materials gave partial thinning. Elgetol at 2¼ pt. reduced the crop by one-half on Duchess while on Wealthy neither Parmone at 8 oz. nor Elgetol at 2½ pt. had any effect. With the varieties Crimson Beauty, Lobo and Yellow Transparent, Elgetol thinned only slightly. The lesser thinning obtained this year with the same sprays and concentrations as were used in previous years substantiates the assertion that seasonal variations play an important role, particularly when the dinitro materials are used.

The apple thinning trials of 1951 were conducted at Ottawa on McIntosh and Lawfam. The dinitros were applied to Lawfam only, since previous work had shown that the hormones are more satisfactory for thinning McIntosh. The growth regulating substances were applied to both varieties at several stages of fruit development: calyx, calyx-plus-one-week, calyx-plus-two-weeks and calyx-plus-three-weeks. The results are presented in Table A-20, a summary of the obtained thinning and grading data.

***Thinning on Lawfam***

DN289 at 1 and 1½ pt. not only caused severe burning but almost completely removed the crop and defoliated the trees. However, the trees recovered and appeared quite normal at harvest time. Elgetol and DN1 did not materially reduce the set below that of the control trees. Severest thinning with the growth regulating material App-l-set occurred when applied three weeks after calyx at concentrations of 12½ and 17½ oz., while the 7½ and 2½ oz. concentrations at the calyx-plus-one-week were also severe. Applications of 5 and 10 oz. at calyx, and 10 and 15 oz. at calyx-plus-two-weeks, did not reduce the crop sufficiently. No explanation can be given for the

rather erratic effect on the different dates. The temperature in all cases was over 70°F. and the weather was clear and sunny. On the other hand, in comparison with Lawfam, McIntosh trees treated on the same days were fairly consistent.

TABLE A-20.—APPLE THINNING EXPERIMENTS, OTTAWA, 1951

| Material | Concentration | Bloom stage | Average number of blossoms | Average per cent set | Percentage of apples with diameter | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | +2¾ in. | 2¼–2¾ in. | 2–2¼ in. | under 2 in. |
| LAWFAM— | | | | | | | | |
| Elgetol | 1½ pt. | full | 1,605 | 4·37 | 30·19 | 54·28 | 10·34 | 5·20 |
| Elgetol | 2 pt. | full | 2,134 | 5·60 | 33·64 | 47·82 | 11·16 | 7·33 |
| DN1 | ¾ lb. | full | 1,644 | 3·10 | 18·95 | 52·39 | 18·48 | 10·22 |
| DN2 | 1 lb. | full | 1,253 | 9·92 | 22·52 | 59·08 | 12·98 | 5·43 |
| DN289 | 1 pt. | full | 1,496 | 0·0 | | | | |
| DN289 | 1½ pt. | full | 1,647 | 0·027 | None on tree at harvest | | | |
| App-l-set | 5 oz. | calyx | 1,560 | 3·19 | 15·36 | 60·38 | 19·65 | 9·63 |
| App-l-set | 10 oz. | calyx | 1,661 | 3·67 | 46·60 | 43·76 | 6·42 | 2·73 |
| App-l-set | 7½ oz. | *c+1 wk. | 1,774 | 1·15 | 23·04 | 55·58 | 15·25 | 6·14 |
| App-l-set | 12½ oz. | c+1 wk. | 1,829 | 0·57 | 27·32 | 58·00 | 8·60 | 6·08 |
| App-l-set | 10 oz. | c+2 wk. | 1,175 | 5·46 | 9·17 | 54·52 | 18·47 | 7·71 |
| App-l-set | 15 oz. | c+2 wk. | 1,559 | 3·79 | 27·87 | 59·52 | 9·54 | 5·08 |
| App-l-set | 12½ oz. | c+3 wk. | 1,676 | 0·12 | 48·40 | 48·80 | 2·24 | 0·57 |
| App-l-set | 17½ oz. | c+3 wk. | 1,290 | 0·15 | 38·89 | 52·78 | 5·56 | 2·78 |
| Control | | | 1,734 | 3·93 | 7·33 | 64·30 | 17·90 | 10·38 |
| McINTOSH— | | | | | | | | |
| App-l-set | 5 oz. | calyx | 4,325 | 8·17 | 34·47 | 41·64 | 7·47 | 12·43 |
| App-l-set | 10 oz. | calyx | 6,013 | 7·21 | 57·83 | 38·66 | 2·89 | 0·63 |
| App-l-set | 7½ oz. | c+1 wk. | 5,538 | 10·61 | 35·66 | 52·11 | 8·20 | 3·54 |
| App-l-set | 12½ oz. | c+1 wk. | 10,335 | 9·87 | 46·92 | 46·75 | 4·87 | 1·46 |
| App-l-set | 10 oz. | c+2 wk. | 4,265 | 9·59 | 33·90 | 53·07 | 8·34 | 4·70 |
| App-l-set | 15 oz. | c+2 wk. | 7,768 | 5·17 | 20·11 | 62·36 | 10·46 | 6·08 |
| App-l-set | 12½ oz. | c+3 wk. | 5,605 | 9·43 | 46·19 | 48·94 | 3·93 | 0·96 |
| App-l-set | 17½ oz. | c+3 wk. | 3,295 | 6·60 | 23·91 | 61·88 | 9·41 | 4·76 |
| App-l-set | 8 oz. | calyx | 9,003 | 8·60 | 44·77 | 50·15 | 3·86 | 1·22 |
| Parmone | 8 oz. | calyx | 5,168 | 8·27 | 62·52 | 34·04 | 3·35 | 0·10 |
| Liqui-Stik | 8 oz. | calyx | 5,128 | 10·78 | 24·04 | 54·61 | 12·45 | 8·31 |
| Control | | | 4,723 | 14·39 | 45·15 | 33·28 | 11·48 | 10·11 |

* c+1 wk. = one week after calyx.

***Thinning on McIntosh***

Good thinning was obtained from applications of 15 and 17½ oz. of App-l-set at two and three weeks after the calyx respectively, while Parmone at 8 oz. and App-l-set at 5 oz., 8 oz. and 10 oz., all at calyx, gave only fair results. The latter group reduced the crop by one-half. Applications of Liqui-Stik, 8 oz. at calyx, and of App-l-set, 7½ oz. at calyx-plus-one-week, 12½ oz. at calyx-plus-one-week, 10 oz. at calyx-plus-two-weeks and 12½ oz. at calyx-plus-three-weeks only removed approximately one-third of the crop and thus gave definite under-thinning. The results with McIntosh were fairly consistent this year and, with the exception of the first two mentioned, little difference occurred between chemicals or time of application. Foliage was injured in all cases, but the delayed application did reduce the injury in this variety. Severest injury occurred with the 10 oz. concentration at calyx, while the least was with 12½ oz. at calyx-plus-three-weeks. In all cases, the stronger concentration on a given date resulted in more severe injury. At the calyx stage, Liqui-Stik dwarfed the foliage most severely but crinkled it the least. Parmone and App-l-set were about equal in dwarfing and crinkling, and the over-all appearance of the trees was slightly better than those treated with Liqui-Stik.

The crop from both the Lawfam and McIntosh trees was graded and thinning was generally associated with increased size. As for the effect of time of spraying on size, with Lawfam there was only slight indication that delayed spraying was associated with smaller size, while in McIntosh delayed spraying resulted in a slight but definite size reduction.

From the experimental results obtained in the 1949, 1950 and 1951 trials, it was apparent that effective thinning with the dinitro preparations depends upon accurate timing, but because of adverse weather during bloom in Eastern Canada, timing may be off and then the spraying either cannot be carried out or is unsuccessful. Moreover, observations indicate that the dinitros can also cause leaf injury if application is followed by cool, wet weather. On the basis of these findings, it was concluded that the dinitro materials are not generally satisfactory for thinning apples in Eastern Canada.

Since the naphthaleneacetic acid preparations can be used with greater safety, they are now recommended and have been widely used in these commercial apple growing regions.

Because the earlier thinning gives greater size at picking time and more uniform cropping, the naphthaleneacetic acid sprays should be applied soon after calyx stage. However, when varieties, notably McIntosh and Duchess, are sprayed with NAA preparations in the calyx stage, the young leaves may be dwarfed. This dwarfing can be reduced by spraying the susceptible varieties one week after calyx. The NAA preparations should not be applied two to three weeks after calyx, since these later applications may cause early maturity, particularly with the early ripening varieties.

In search of a chemical for thinning apples that will not cause foliage injury, extensive investigations with a naphthaleneacetamide preparation were carried out in 1953 at three locations in Ontario and Quebec. It is apparent from the 1953 trials that naphthaleneacetamide is quite as effective as the sodium salt of naphthaleneacetic acid for thinning apples and that it will cause less foliage injury. This material should be applied at petal fall when maximum benefits are derived from thinning, and for this reason is well adapted to the summer varieties.

These thinning chemicals can be applied by any sprayer that has adequate power to assure good coverage. However, the results with 2× and 4× concentrations have been somewhat erratic, and the grower must have his sprayer well calibrated when applying these stronger concentrations. In the 1953 trials the 4× concentrations gave uniform thinning.

Because chemical thinning is influenced by the weather and by such orchard conditions as management, drainage, etc., it is impossible to lay down hard and fast recommendations to fit the many variations. Therefore, each grower must proceed on a trial basis until he has made a study of his own set of conditions, for chemical thinning is an orchard practice which can give very beneficial results.

### Reduction of Pre-harvest and Harvest Drop in Apples by Spraying with Growth Regulating Substances

Many workers have investigated harvest sprays but the action of the chemical is not yet fully known. One theory advanced by Luckwill, Long Ashton Research Station, England, is that the growth of apple, pear and other fruits is under the control of a hormone produced in the seeds. He found that in the final stages of fruit growth the hormone content of the seed fell rapidly. This appeared to be correlated with the degeneration of the endosperm and the occurrence of the pre-harvest drop. This evidence suggests that the formation

of the abscission layer is normally held in check by the presence of natural growth substances, and its development is due to their local exhaustion. The onset, degree and duration of the pre-harvest drop are influenced by such factors as weather, location, orchard management and varietal characteristics.

The use of growth regulating substances to reduce the pre-harvest drop in apples, and thereby increase the growers' profits, has become a standard orchard practice in many apple growing regions in Canada. It is now not so much a matter of "Will a grower use these chemicals?" but "What chemicals will the grower use?" Until recently, the naphthaleneacetic acid preparations provided the answer to this second question. But in search of a more effective chemical to reduce the pre-harvest drop the Horticulture Division has conducted extensive trials in several apple growing regions.

Research workers (1, 2, 3, 5) in the United States have found that 2,4-dichlorophenoxyacetic acid (2,4-D) was effective in delaying the abscission of fruits on the Winesap varieties. However, McIntosh did not respond to this chemical and the foliage was injured. Having found that 2,4-D was selective, these investigators tested other closely related compounds in search of a chemical that might be selective to McIntosh. Mitchell, Hamner and Toenjes (4) tried 2-methyl-4-chlorophenoxyacetic acid. This chemical differs from 2,4-D in that a methyl group replaces the two-position chlorine atom. They found that this material gave promising results on McIntosh.

The 2-methyl-4-chlorophenoxyacetic acid, also known under the trade names "Toloxy" and "A-814", was tested on McIntosh at Ottawa in 1948. It proved quite effective when applied at a 5-ounce concentration.

A further test in comparison with the standard recommendation, 5 p.p.m. of the sodium salt of naphthaleneacetic acid, was carried out at Ottawa in 1949. However, unlike the superior results obtained in 1948, this new chemical was only equal to the sodium salt of naphthaleneacetic acid in reducing the pre-harvest and harvest drop on the McIntosh variety, as shown in Table A-21.

TABLE A-21.—REDUCTION OF DROP IN McINTOSH BY HARVEST SPRAYS, OTTAWA, 1949

| Treatment | Number of trees | Number of hand picked fruit | Number of wind-falls | Per cent drop |
|---|---|---|---|---|
| A-814 (2-methyl-4-chlorophenoxyacetic acid) | 4 | 770 | 175 | 18·52 |
| App-l-set (sodium salt of naphthaleneacetic acid) | 5 | 825 | 187 | 18·48 |
| Control | 3 | 236 | 225 | 51·93 |

In a further test at Ottawa in 1950, all treatments were better than the untreated control. However, the sodium salt of naphthaleneacetic acid at a 5-ounce concentration was slightly superior to both the 4- and 5-ounce concentrations of A-814. On the basis of these trials extending over a 3-year period, it was concluded that 2-methyl-4-chlorophenoxyacetic acid is probably about equal but not superior to the sodium salt of naphthaleneacetic acid in reducing the pre-harvest and harvest drop of the McIntosh apples.

In search of a more effective chemical extensive trials have been conducted by this Division in several apple growing regions. Preliminary trials with two new growth regulating substances, 2,4,5-trichlorophenoxypropionic acid (2,4,5-TP) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) were conducted at Ottawa in 1951 on Crimson Beauty and Melba trees growing in pots in the greenhouse.

When these trees under glass were sprayed prior to harvest in midsummer, the apples remained on the trees until they became mealy and split open; certainly a very definite indication of the ability of the spray to prevent drop in Crimson Beauty and Melba, under such conditions.

In the field trials in 1951, at the Central Experimental Farm, Ottawa, (Table A-22), the varieties Melba and McIntosh were sprayed with 2, 4, 5-TP at a concentation of 10 oz. to 100 Imperial gallons (20 p.p.m.). The Melba trees were sprayed at about 3-, 2-, and 1-week intervals before the anticipated harvest date.

TABLE A-22.—HARVEST SPRAY EXPERIMENT, OTTAWA, 1951

| Materials | Concentration | Time applied before harvest | Windfalls | Per cent color by weight | | |
|---|---|---|---|---|---|---|
| | | | | Extra fancy | Fancy | Domestic |
| | | days | % | | | |
| MELBA— | | | | | | |
| 2,4,5-TP | 20 p.p.m. | 10 | 10·57 | 9·17 | 32·58 | 58·30 |
| Control | | | 38·92 | 4·02 | 16·43 | 79·55 |
| RED MELBA— | | | | | | |
| 2,4,5-TP | 20 p.p.m. | 14 | 8·92 | 35·44 | 22·80 | 41·75 |
| Control | | | 86·79 | 12·45 | 27·17 | 60·38 |
| McINTOSH— | | | | | | |
| 2,4,5-TP | 20 p.p.m. | 17 | 8·12 | 61·47 | 31·71 | 6·81 |
| 2,4,5-TP | 20 p.p.m. | 11 | 21·00 | 60·43 | 34·74 | 4·82 |
| 2,4,5-TP | 20 p.p.m. | 6 | 26·40 | 54·25 | 38·55 | 7·20 |
| Control | | | 27·51 | 53·30 | 40·35 | 6·35 |

Both the drop control and color increase were outstanding on Melba and Red Melba at the times given in Table A-22. Although drop control was not so significant with McIntosh as with Melba and Red Melba, a noticeable control resulted from that application made 17 days prior to harvest, while the applications made 11 and 6 days before harvesting were not so effective. The application made 17 days prior to harvest gave the greatest increase in the number of "Extra Fancy" McIntosh apples. Moreover, time of application and color were definitely related; that is, the crop from trees sprayed earliest was the most highly colored.

Investigations in 1952 with 2,4,5-T and 2,4,5-TP at concentrations of 10 p.p.m. and 20 p.p.m. were carried out at three locations: Central Experimental Farm, Ottawa; Experimental Substation, Smithfield, Ont., and Experimental Substation, Ste. Clothilde, Que. At Ottawa with Melba (Figs. A-1 and A-2) and at Ste. Clothilde with McIntosh (Fig. A-3), 2,4,5-T was superior to 2,4,5-TP at the respective concentrations in both degree and duration of effectiveness. At Ste. Clothilde, when 20 p.p.m. of 2,4,5-TP was applied to McIntosh the number of "Extra Fancy" apples was increased; results similar to those obtained in Ottawa in 1951. Neither 10 p.p.m. 2,4,5-TP, nor 10 p.p.m. 2,4,5-T, nor 20 p.p.m. 2,4,5-T increased the color.

The apparent margin of safety in the 1951 results suggested that the cost of this operation could be reduced by the use of more dilute concentrations. However, this was not substantiated in the 1952 trials for in these the 10 p.p.m. was equal to the 20 p.p.m. concentration in drop control for a period of time but, on the other hand, the duration of effectiveness was greatly reduced.

It is evident (Fig. A-2) that the 10 p.p.m. concentrations began to lose effectiveness after 9 days and showed a sharp decline in effectiveness at 12 days after application. With the 20 p.p.m. 2,4,5-TP treatment windfalls became more

numerous after 12 days, but the 20 p.p.m. 2,4,5-T treatment remained fairly stable at harvest time (15 days). Picking of Red Melba (Platt's strain) was delayed 23 days—considered 4 or 5 days past normal harvest date. The deliberate delay beyond harvest date was for the purpose of studying the loss of effectiveness in the 20 p.p.m. concentrations. The results are shown in Fig. A-1 and are similar to those obtained with Melba. Both the 20 p.p.m. concentrations of 2,4,5-TP and 2,4,5-T lost their effectiveness on the 19th day, but the latter substance to a lesser degree.

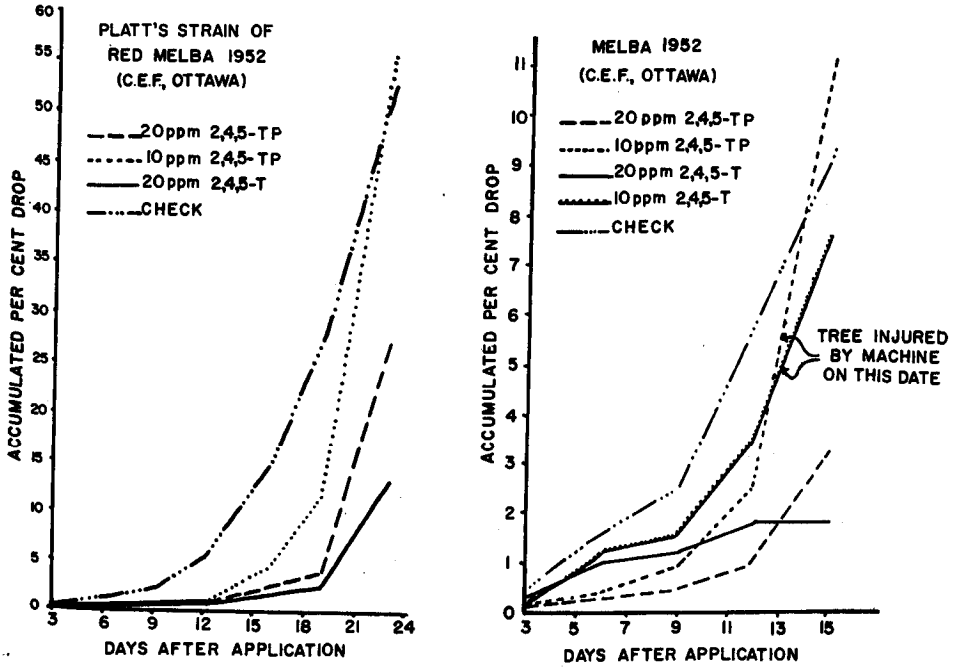


Fig. A-1—The effects of 2,4,5-T and 2,4,5-TP in delaying drop on Red Melba (Platt's strain) at Ottawa, Ontario.

Fig. A-2—The effects of 2,4,5-T and 2,4,5-TP in delaying drop on Melba at Ottawa, Ontario.

Once the effectiveness is lost there is a deluge of windfalls. These windfalls are the apples that would have dropped normally but that were retained by the tree during the influence of the chemical. The 1952 results indicate that the 10 p.p.m. concentration cannot be safely recommended when effectiveness beyond 10 days is desired.

The use of maleic hydrazide for the reduction of the pre-harvest and harvest drop did not stop the drop as expected (Fig. A-4). Likewise, it did not seem to reduce the effectiveness of the 2,4,5-TP when the two were mixed together (Fig. A-5). Although there is a slight decline in effectiveness on the picking date, it is impossible to say how serious this may be.

On the basis of the trials conducted at Ottawa, Smithfield, and Ste. Clothilde, it is apparent that both 2,4,5-T and 2,4,5-TP are effective in reducing the pre-harvest drop of apples. Although not having so long a period of effectiveness as 2,4,5-T, 2,4,5-TP gave an increase in the red color of the apples, especially the early maturing apples. The most significant result of the trials was that in comparison with the present widely used NAA preparations, the new hormones had a longer period of effectiveness. For this reason

2,4,5-TP is recommended to replace the NAA preparations as a pre-harvest spray applied at the rate of 20 p.p.m. ten days prior to anticipated harvest of the variety concerned. 2,4,5-T preparations have not as yet been manufactured for commercial use.

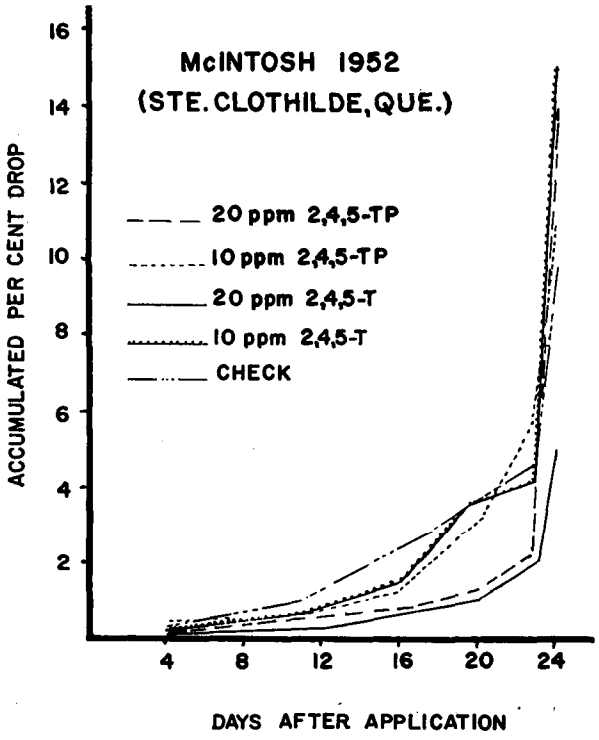


Fig. A-3—The effects of 2,4,5-T and 2,4,5-TP in delaying drop on McIntosh at Ste. Clothilde, Quebec.

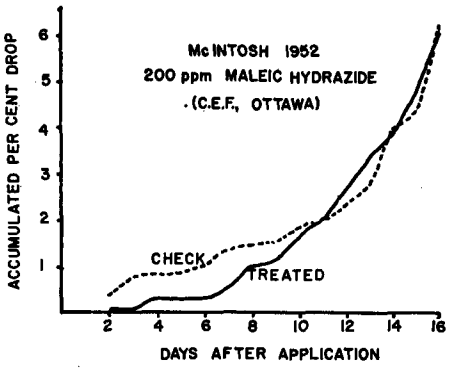


Fig. A-4—The effect of maleic hydrazide in delaying drop on McIntosh at Ottawa, Ontario.

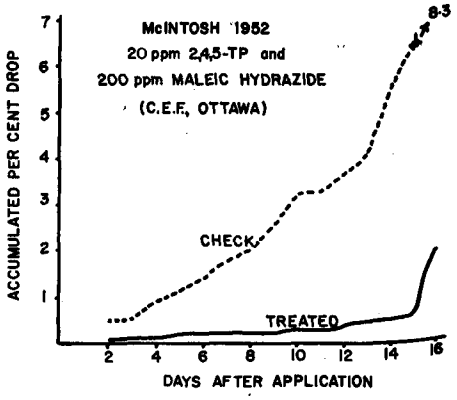


Fig. A-5—The effects of 2,4,5-TP and maleic hydrazide in delaying drop on McIntosh at Ottawa, Ontario.

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# GENETICS AND CYTOLOGY

## INDUCED POLYPLOIDY IN HORTICULTURAL CROPS

*A. W. S. Hunter and G. W. R. Walker*

The study of the application of colchicine induced polyploidy to the breeding and improvement of horticultural crops, described by Hunter and Danielsson (5), has been continued. The following is a report on the progress during the last five years.

### FRUITS

#### Apple

The objectives for the use of tetraploid apples are now well on their way to fulfilment. The required tetraploids have been produced, and in a few years it should be possible to make a preliminary assessment of the value of tetraploid apples as varieties and as parents.

***Production of Tetraploids***

The earlier report described the methods used in treating seeds and seedlings of open-pollinated *Malus baccata*, McIntosh and Northern Spy. From these treatments, 158 seedlings bearing leaves with large stomata survived and were planted in an orchard in the spring of 1952. None of the McIntosh or Northern Spy seedlings has blossomed yet, but 31 of the 50 *M. baccata* seedlings have produced flowers. Interest lies solely in using these tetraploid *M. baccata* seedlings as parents and not in the effect of tetraploidy on the size of their fruit. Therefore, the principal concern is the condition of the inner tissue layers of the plants from which the germ cells arise. On the basis of pollen grain size it was determined that 10 of the 31 seedlings have tetraploid internal tissue and will breed as tetraploids.

The tetraploids were produced by several different treatment methods. The results to date indicate that the most effective treatment of *M. baccata* seed is to place afterripened seeds in a petri dish on filter paper soaked with 1·0 per cent aqueous colchicine solution until germination which may take from one to several days.

*Treatment of Shoots.*—A method of treating growing shoots with colchicine for the production of tetraploids of named varieties has been devised (4). Waterproofed gelatin capsules, containing 1·0 per cent colchicine in 0·65 per cent agar in water, are placed over the exposed terminal buds of rapidly growing shoots. Most of the shoots treated in 1949 and 1951 have now borne flowers. On the basis of pollen grain size, tetraploid sectors have been identified in the varieties Elmer, Joyce, Logsdail, Melba (Pate red strain), Northern Spy (Kinkead red strain), O-244, Patricia, Sandow, Spartan and Trail. These tetraploid sectors have been propagated by budding.

***Crosses with Tetraploids***

In 1951, 1952 and 1953, crosses were made between several diploid varieties and the aforementioned tetraploids. Most of these crosses were made with diploid McIntosh as the female parent. A few tetraploid×tetraploid crosses were attempted in 1953. The results, presented in Table B-1, indicate that the diploid×tetraploid cross is quite compatible so that there should be no difficulty in producing in quantity triploids of known parentage for selection. In contrast, the tetraploid×tetraploid crosses so far attempted have been almost completely incompatible. The majority of the latter crosses had tetraploid *M. baccata* seedlings as the female parent and the amount of pollen produced by the tetraploid male parent was very small. Better results may be secured when there is more material to work with.

TABLE B-1.—RESULTS OF DIPLOID × TETRAPLOID AND TETRAPLOID × TETRAPLOID APPLE CROSSES

| Year crosses made | Number of flowers pollinated | Number of fruits harvested | Number of good seeds | Number of seedlings growing, 1954 |
|---|---|---|---|---|
| 2-ploid × 4-ploid— | | | | |
| 1951 | 100 | 18 | 108 | 95 |
| 1952 | 831 | 98 | 293 | 248 |
| 1953 | 1,508 | 122 | 781 | 619 |
| Total | 2,439 | 238 | 1,182 | 962 |
| 4-ploid × 4-ploid— | | | | |
| 1953 | 507 | 11 | 46 | 38 |

The triploid seedlings from these crosses are markedly superior to comparable diploid seedlings in vigor and leaf size. This is particularly evident at germination.

***Tetraploids from Seeds of Open-Pollinated Triploid Varieties***

In an attempt to discover tetraploids among the seedlings grown from open-pollinated seeds of triploid varieties, chromosome counts were made on seedlings of Baldwin, Gravenstein, Rhode Island Greening and Stark. Only one tetraploid, a Rhode Island Greening seedling, was found among the 275 plants examined. This is a lower frequency than that given by Einset (2), but is explained by the absence of preliminary selection for plant vigor. Many of these chromosome counts were made on leaf squashes taken from very young seedlings in which such selection was not possible.

Only approximate chromosome counts were obtained from most of the leaf squash preparations so that an analysis of chromosome numbers is not possible. However, it can be stated that 8·0 per cent of the seedlings have approximately the diploid number (2n=34); the majority, 84·4 per cent, are aneuploids with chromosome numbers ranging from 36 to 49; 4·0 per cent have approximately the triploid chromosome number (2n=51), and 3·3 per cent have more than 52 chromosomes. Two-thirds of this last group have fewer than 60 chromosomes.

## Cherry

Attempts to produce hexaploid cherries by doubling the number of chromosomes in triploid hybrids from crosses between tetraploid sour cherries and diploid sweet cherries were continued. The seed-peeling, culture-bottle technique described in the last report was abandoned in favor of treating germinating

afterripened triploid seeds. One hexaploid, confirmed by chromosome counts from leaf squashes, was obtained from a triploid seed exposed at room temperature for 48 hours to 1·0 per cent aqueous colchicine solution on filter paper in a petri dish. Three other hexaploids, determined only by stoma measurements, resulted from treatment with 1·0 per cent colchicine for 24 hours at 37°C. on filter paper in a petri dish. These hexaploid seedlings are still small and will not fruit for several years.

The hexaploid European plum, *Prunus domestica*, arose from a natural triploid hybrid between the tetraploid *P. spinosa* and the diploid *P. cerasifera*. It will be interesting to see if a duplication of this type of evolution will result in similarly useful cherry hybrids.

### Saskatoon

The saskatoon (*Amelanchier alnifolia* Nutt.) is a popular wild and garden fruit in parts of Canada. The Dominion Experimental Station at Beaverlodge, Alta., has selected seedlings for large fruit size. With the thought that tetraploidy might be accompanied by a further increase in fruit size, seed was secured in 1949 from one of the best selections at Beaverlodge. This seed was afterripened at Ottawa and treated with 1·0 per cent colchicine on filter paper in petri dishes for 48 and 96 hours. Among the seedlings grown therefrom, 16 were judged to be tetraploids on the basis of stoma size, and leaf shape and thickness. These seedlings have not fruited.

## VEGETABLES

### Asparagus

Testing the tetraploid asparagus reported previously has been delayed by the slow production of a sufficient quantity of seed. The small amount of seed resulting from hand pollination of the single tetraploid female was planted to provide a seed multiplication block. This should bear a good crop of seed in 1954.

### Radish

Tetraploid lines produced by colchicine treatment of seed of Scarlet Globe in 1946 and 1947 were field tested in 1949 and 1950. Most of these lines were very variable. Therefore, some of the more desirable roots were chosen for re-selection and multiplication. The best line is now quite uniform and will be included in the 1954 Vegetable Merit Trials. Tetraploid radish has a larger top than the comparable diploid; the taproot is slightly coarser; the flavor is hotter; the texture is good, and at the same size of root the tetraploids tend to be less pulpy. This may be associated with the slower maturation of the tetraploids. The tetraploid appears to have little advantage over the diploid Scarlet Globe, but the outcome of the 1954 Merit Trials will be awaited before making a final decision.

### Spinach

Tetraploids of the hermaphroditic Ottawa strain of Long Standing Bloomsdale spinach were produced in 1951 by treating the seed with 0·4 per cent colchicine for 24 and 48 hours. In the spring of 1953 a small population of 28 tetraploids from seed of the treated plants was grown in pots in the greenhouse for preliminary observation of plant characters and sex expression, and for the

multiplication of seed. Twenty-six of these plants blossomed. Using the terminology of Bemis and Wilson (1), 24 were intersexes with male and female flowers in more or less equal numbers. One male intersex and one female intersex were found, but there were no pure male or pure female plants.

The individual plants were isolated and self-pollinated in the greenhouse. Thirteen plants each bore between five and ten grams of seed. This is considered a reasonable seed yield under the circumstances, and indicates that seed production of tetraploid lines will present no problem.

Thirteen tetraploid lines were compared in the field in 1954 with the parental and other diploid varieties. The tetraploids were more variable than the diploids. The tetraploid leaves were much thicker, but the leaves and plants were smaller. Tetraploids of this particular variety appear to have no advantage over diploids.

## ORNAMENTALS

### Antirrhinum

Continuation of the work with tetraploid snapdragons has involved (a) the commercial testing of tetraploid and triploid hybrid varieties, (b) the production of tetraploids from additional diploid varieties and their testing as varieties and as the parents of hybrid varieties, and (c) the study of the inheritance of flower color in tetraploids.

#### *Tetraploid and Triploid Hybrids*

Beginning in 1951 tetraploid hybrid varieties were distributed annually to selected commercial growers across Canada. These hybrids are pink in color, and are the result of crosses between red and ivory tetraploids. The general reaction to the hybrids has been favorable when they are grown for a late spring crop. If grown for a winter crop, the spikes are shorter, more compact, and less graceful in appearance than similar diploid hybrids. In the longer, warmer days of April and May, however, the tetraploids have longer, heavier spikes on stouter stems than the diploids (Fig. B-1).

Triploid hybrids, from crosses between tetraploid and diploid varieties, have very long spikes. The flowers are intermediate in size between those of diploids and tetraploids, and cut spikes keep fresh longer. Triploid seed is produced only with difficulty. Therefore the triploids must be propagated by cuttings. Several of these hybrids are being tested commercially, and their acceptance will depend upon their being sufficiently better than other sorts to justify the added expense of vegetative propagation.

Since the start of this experiment in 1940, tetraploids of 21 different greenhouse varieties have been produced by colchicine treatment. Intervarietal crosses were made between most of these to investigate the value of the hybrids. Individual plants of the same tetraploid variety differ markedly in their value as parents. Therefore the parents of selected hybrids must be propagated vegetatively. The most successful combinations have been crosses between red and ivory tetraploids, giving pink hybrids. Other interesting hybrids are a very good pale pink from a cross between a red and a yellow tetraploid, an ivory from a cross between two ivories, a bronze from a cross between two bronzes, and a magenta from a cross between a magenta and a yellow tetraploid. All attempts to find a good yellow and a good white combination have so far been unsuccessful.

***Seed Production***

Seed production in intervarietal crosses is variable. One-way incompatability is frequently, and two-way incompatibility is sometimes, encountered. Therefore, parents must be selected on their ability to give a good seed yield as well as on the horticultural value of the hybrid.

Fig. B-1—Snapdragon spring crop. Left, diploid hybrid Christina; right, Ottawa Tetraploid Hybrid No. 2. Seed sown January 9; benched March 17; photographed May 22, 1952. Note larger florets, rippled petal margins, longer spikes and heavier stems of the tetraploids.

Seed setting appears to be adversely affected by low temperatures and short days. The procedure adopted at Ottawa is to bring the parent plants into bloom early in April and to flower them in a warm house (night temperature 60 to 65°F.). Anthesis normally does not occur until after the flower opens. Unopened flowers are emasculated by removing the corolla to which the stamens are attached. Pollen, which should be from freshly dehisced anthers, is applied by a camel hair brush, the tip of the finger, or an anther grasped by a pair of forceps.

An indication of the quantity of seed that may be expected may be gained from the results in 1953 from two Ottawa tetraploid hybrids. A total of approximately 9,500 flowers were pollinated from which 6,800 capsules, containing in all approximately 50 grams of seed, were harvested. This was enough seed to make 100 trade packets each (0·5 gm.) holding approximately 2,000 seeds.

***Garden Varieties***

Tetraploids were produced in 1947 by treating the seedlings of eight garden varieties of antirrhinum with colchicine. Selected tetraploid lines were tested in the garden in 1952 and 1953. The plants were more vigorous, the stems stronger, and the flowers larger, but the tetraploids were not so good for garden subjects as the same diploid varieties. They were coarser in habit and the flowering period was shorter. The tetraploid garden varieties have been discarded.

## Kalanchoë

The horticultural varieties of *Kalanchoë Blossfeldiana* v. Poellnitz are popular greenhouse plants for the Christmas trade. Since larger flower size would be advantageous, young seedlings of the Tom Thumb variety were treated in 1952 with colchicine by placing a drop of 1·0 or 2·0 per cent aqueous solution on the terminal bud.

Seed was obtained from all eleven tetraploid plants found, and small populations were grown in 1953 for comparison with the diploid variety. The tetraploids differed little from the diploids in vegetative characters, but the flowers were larger, somewhat fewer, and borne on slightly longer flower stalks and pedicels. The general effect is a looser, more attractive plant. Commercial growers who have seen the tetraploids are much interested in them.

*K. Blossfeldiana* is naturally self-fertilized. Most of the tetraploids are satisfactorily self-fruitful, and seed production appears to present no problem. One or more of these tetraploids will be released to the trade as soon as sufficient seed is available, probably in 1955.

## Lily

A method for the induction of tetraploid Easter lilies by treating bulb scales with colchicine has been described by Emsweller and Lumsden (3). Bulb scales of several of Miss Preston's lily hybrids and a diploid clone of *Lilium tigrinum* were treated with 0·2 per cent colchicine in a similar manner in 1948. The treatments and results are listed in Table B-2.

TABLE B-2.—COLCHICINE TREATMENT OF LILY BULB SCALES

| Variety | Length of treatment | Number of scales treated | Number of tetraploids |
|---|---|---|---|
| | hr. | | |
| Addington | 2 | 29 | 1 |
| Coronation | 2 | 56 | 0 |
| Hurricane | 2 | 19 | 1, + 2 chimeras |
| Mosquito | 2 | 35 | 2, + 1 chimera |
| 37-12-01 | 2 | 24 | 0 |
| *L. tigrinum* diploid | 2 | 76 | 0 |
| *L. tigrinum* diploid | 4 | 203 | 0 |
| *L. tigrinum* diploid | 6 | 100 | 1 |
| *L. tigrinum* diploid | 8 | 100 | 7 |

The Addington, one Hurricane, the two Mosquito and the eight *L. tigrinum* tetraploids have been confirmed as such by pollen grain size and by root tip chromosome counts. The chimeral tetraploid Hurricane and Mosquito plants were first identified as diploids by pollen grain size, but in later years each bore flowers with unmistakably large pollen grains and other tetraploid flower characters.

In addition to these colchicine-induced tetraploids, a spontaneous tetraploid *L. amabile* plant was discovered in the lily breeding plots of the Horticulture Division. We are indebted to Mr. D. F. Cameron for directing attention to this plant.

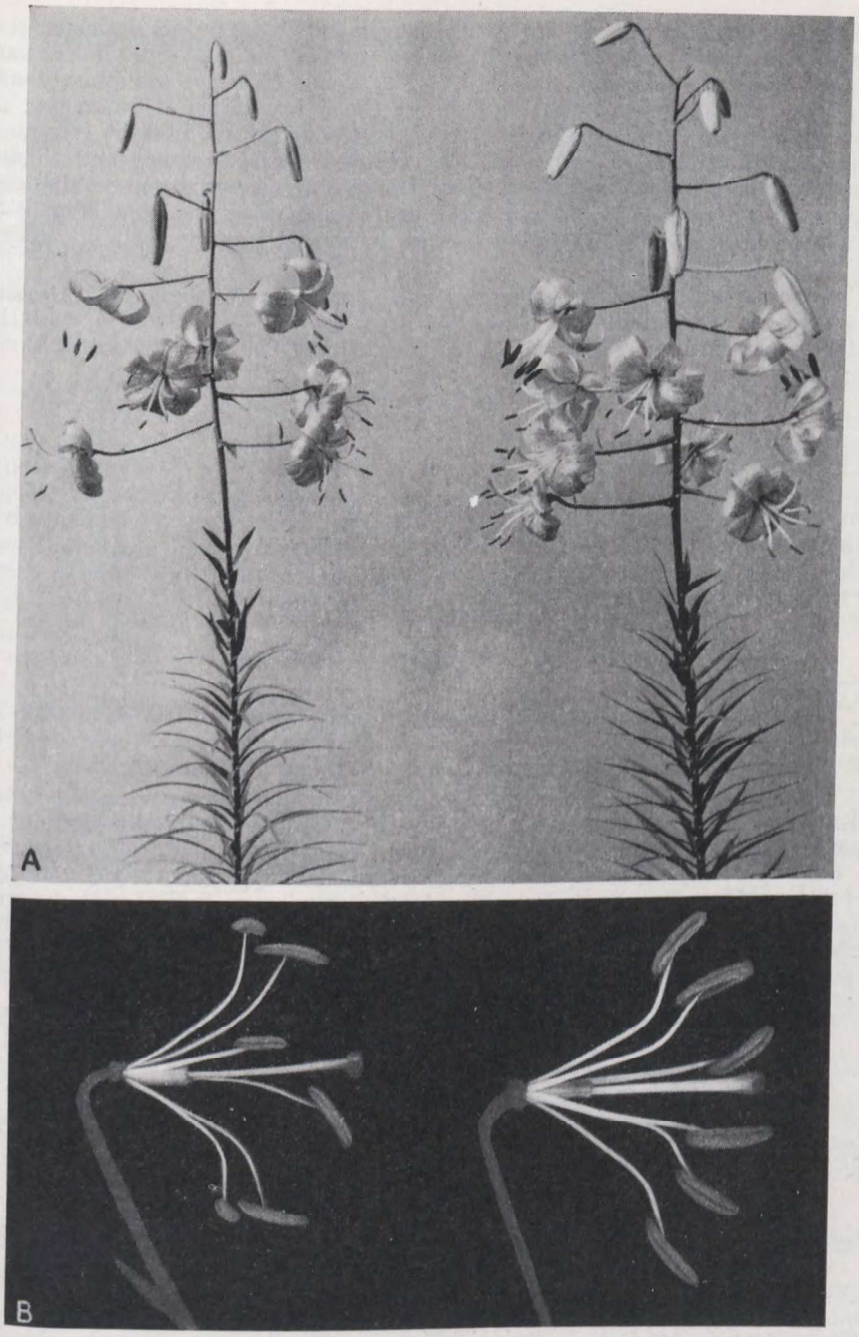


Fig. B-2—A. Left, diploid; right, tetraploid plant of the lily variety Mosquito. The flowers of the tetraploid are no larger than those of the diploid but the stem is stouter, and the leaves, because of their increased thickness, are straighter. B. Left, essential organs of diploid *L. amabile;* right, tetraploid, showing increased size of parts.

The flowers of the tetraploids are not markedly larger in diameter than those of their diploid counterparts. However, most of the individual flower parts do show a definite increase in size (Fig. B-2). The anthers are sometimes longer and always broader; the filaments stouter; the ovary larger in diameter; the stigma larger; the style stouter, and the petals and sepals thicker, sometimes broader but not much longer. The leaves are longer, broader, and thicker. Because of their thickness the leaves of tetraploids do not droop to the same extent and they appear to make a more acute angle with the stem (Fig. B-2). The stems of the tetraploids are stouter, an important improvement in varieties with weak stems.

The tetraploid clones are being multiplied for testing in the garden. Crossing and selfing the tetraploids have thus far been limited, but it does appear that the tetraploids are not more self- and cross-compatible than the same diploid varieties.

### Pansy

Tetraploids of three pansy varieties were produced by placing a drop of 1·0 or 2·0 per cent aqueous solution of colchicine three times at 24-hour intervals on the terminal bud of young plants. The flowers on the tetraploids were markedly smaller than those of the same diploid variety. The petals were thicker, ruffled and somewhat pleated. The tetraploids were completely self- and cross-unfruitful, and for that reason were discarded.

### Salvia

Tetraploid plants of *Salvia splendens* Sello., varieties Blaze of Fire and Harbinger, were produced by placing seeds on filter paper moistened with 0·2 or 0·4 per cent aqueous colchicine solution for 24 and 48 hours.

Tetraploid salvia plants have larger, broader and shorter leaves, stouter stems and markedly larger flowers than the diploid varieties. The flower spike of the tetraploid is shorter and more compact than that of the diploid. The tetraploids are only sparingly self- or cross-fruitful, and this very definitely limits their usefulness. However, limited crossing in the greenhouse indicates that certain tetraploids are reasonably fruitful when pollinated by diploids. The resulting triploids have not been compared with diploids and tetraploids but this will be done in 1954. An attempt will also be made to produce triploid seed by natural crossing in the field.

***Acknowledgment***

The writers wish to express their appreciation to Mr. E. C. Bradley who carried out many of the treatments and who did much of the very considerable checking of stoma and pollen grain size in the search for tetraploid plants and sectors.

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## RUST RESISTANCE INHERITANCE IN BLACK CURRANTS

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In the 1934-48 Report, limited data were presented to indicate that resistance to rust was due to a single dominant factor. Further information was obtained on resistance to rust, *Cronartium ribicola* A. Fisch., 1951 and 1952.

Four backcross populations from the resistant varieties Crusader and Coronet crossed with the susceptible varieties Kerry and Magnus were pricked out into flats in 1951. Natural infection on the small seedlings was heavy in 1952, and the plants were readily scored on the basis of the presence or absence of rust. The results are presented in Table B-3.

TABLE B-3.—SEGREGATION FOR SUSCEPTIBILITY TO RUST IN FOUR BACKCROSS PROGENIES OF BLACK CURRANTS

| Cross | Number of seedlings resistant | Number of seedlings susceptible |
|---|---|---|
| Crusader × Kerry | 178 | 169 |
| Crusader × Magnus | 166 | 175 |
| Coronet × Kerry | 186 | 122 |
| Coronet × Magnus | 170 | 162 |
| Observed | 700 | 628 |
| Expected (1 : 1) | 664 | 664 |

$\chi^2 = 3 \cdot 90$ P (for one degree of freedom) $= 0 \cdot 05$

Using the grouped data from all four families the $\chi^2$ test does not indicate a close agreement with expectation on the single factor basis. However, if the Coronet × Kerry family is omitted, the ratio becomes 514 resistant: 506 susceptible; $\chi^2 = 0.063$, corresponding to a value for P of 0.8 and indicating good agreement with expectation.

Unfortunately, it is not possible to explain with certainty the reason for the marked deviation from expectation of the Coronet × Kerry family. The plants were destroyed in the process of scoring and they could not be re-examined at a later date to determine if some of the susceptible seedlings had escaped infection. It is known from previous experience that seedlings in the same group, presumably subjected to equal infection at the same time, may differ by as much as a month in the date on which they first show symptoms. A further 150 plants of each of the above families were set out in the field in the spring of 1952. Rust infection in this plantation was light in 1952 and 1953, but at the first opportunity they will be observed carefully to determine if the Coronet × Kerry progeny segregates in the same manner as the other three.

## INHERITANCE OF FLOWER COLOR IN TETRAPLOID ANTIRRHINUM

The inheritance of flower color in tetraploid greenhouse antirrhinum is explainable for the most part on the basis of the scheme described by Wheldale (5) and Scott-Moncrieff (3). The gene Y is necessary for the production of color; in its absence the flower is pure white. This gene when present alone induces the formation of yellow in the lips of the flower and ivory in the tube. The gene I inhibits the formation of the yellow color and the whole flower becomes ivory, with the exception of a yellow patch on the palate common to all

colors except white. A red color is produced in the lips of the flower by the gene L, and this is extended to the tube by the gene T. The red color is intensified by D, and changed to magenta by the gene B. The presence of the yellow and the red colors together results in a bronze flower color. Yellow and magenta together give crimson. Also, modifying genes vary the intensity of the different colors.

The genes Y, I, T and B are completely dominant. The gene L and possibly the gene D are incompletely dominant and are quantitative in effect. The incomplete dominance of L is responsible for the intermediate flower color of the diploid and the tetraploid hybrids from crosses between red and ivory varieties. The incomplete dominance of D is suggested by the marked difference in the shade of pink of two $F_1$ hybrids from crosses between a red variety and two unrelated ivories. If the red and one ivory are homozygous D, and the other ivory is homozygous d, the difference between the two $F_1$'s could be the difference between the duplex and the quadruplex condition of D. Further crossing will be required to determine this.

A very nice color segregation is obtained in the $F_2$ from the cross red (YYYYIIIILLLL) $\times$ ivory (YYYYIIIIllll). The four shades of red and one of ivory corresponding to the quadruplex, triplex, duplex, simplex and nulliplex condition of the gene L are easily recognizable. The color of the $F_1$ between a bronze (YYYYiiiiLLLL) and an ivory is indistinguishable from that of the $F_1$ between a red and an ivory because of the complete dominance of I. However, the $F_2$ of the bronze $\times$ ivory cross segregates for four shades of bronze and one of yellow in addition to the red and ivory segregates of the red $\times$ ivory $F_2$.

The weakening of the red shade associated with the duplex condition of L is seen also in the red $\times$ yellow, bronze $\times$ yellow and magenta $\times$ yellow crosses. A further manifestation of this effect is found in the triploids from crosses between red or ivory tetraploids with diploids of the opposite color. The $F_1$ from a red tetraploid $\times$ ivory diploid (LLl) is deeper colored than the $F_1$ from an ivory tetraploid $\times$ red diploid (Lll).

The securing of quantitative data in autotetraploids requires large populations and may not be very rewarding. Mather (2) has pointed out that autotetraploids have no hard and fast segregation expectation for any gene. Segregation, which is dependent upon the way in which the eight chromatids of the first meiotic division separate into four pairs during gamete formation, is governed by several cytological events. These include the degree of multivalent formation, the number and position of chiasmata and the mode of disjunction of the separating chromosomes of a multivalent configuration. The simple expectations of random chromosome or chromatid segregation are ideal conditions which rarely if ever occur. The actual condition probably lies somewhere between these two.

In 1953, an $F_2$ population from the cross red $\times$ ivory tetraploids selfed (significant genes LLll $\times$ LLll) was grown in the field. The observed segregation for flower color is given in Table B-4. Included for comparison are the values expected on the basis of random chromosome and random chromatid segregation (Haldane, 1).

The observed results do not agree with either assumption although they are closest to those expected on the basis of random chromosome segregation. The discrepancy is understandable when multivalent formation, chiasma location and mode of disjunction are considered. The meiotic behavior of the parental hybrid was not studied but it is likely to resemble the series of intervarietal tetraploid snapdragon hybrids examined by Sparrow, Ruttle and Nebel (4) in which an average of 5.05 quadrivalents per cell was observed. If the gene L is so located that a chiasma may occur between it and the cent-

TABLE B-4.—OBSERVED AND CALCULATED $F_2$ FLOWER COLOR SEGREGATIONS IN AUTOTETRAPLOID ANTIRRHINUM

| — | Quadruplex LLLL (red) parental color | Triplex LLLl (red) | Duplex LLll (red) $F_1$ color | Simplex Llll (red) | Nulliplex llll (ivory) parental color |
|---|---|---|---|---|---|
| OBSERVED (918 plants) | 16 | 172 | 476 | 225 | 29 |
| CALCULATED— | | | | | |
| Random chromosome segregation (1:8:18:8:1) | 25·5 | 204·0 | 459·0 | 204·0 | 25·5 |
| | $\chi^2=11·83$ | P=0·02 | | | |
| Random chromatid segregation (9:48:82:48:9) | 42·2 | 224·8 | 384·1 | 224·8 | 42·2 |
| | $\chi^2=57·78$ | P=<0·001 | | | |

romere, and if adjacent chromosomes in a multivalent association sometimes go to the same instead of to the opposite pole at first anaphase, the opportunity for further discrepancies is presented. Without many more data than are available it is not possible to calculate the net result. However, the observed segregation ratio is skewed towards the duplex-nulliplex end, indicating an excess of recessive gametes over expectation. Mather (2) has shown that such an excess is the result of the cytological events discussed.

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## SEED PRODUCTION FOLLOWING SELFING OF SOME LILY VARIETIES

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Genetic information is conspicuously lacking in the genus Lilium, mainly because of lack of interest on the part of lily breeders and the difficulty of producing homozygous lines for genetic study. Both of these are associated with the reproduction of most lilies by vegetative means. On the one hand the plant breeder is not forced to produce pure breeding lines, and, on the other hand, most lily varieties are very heterozygous and, therefore, not good subjects for the geneticist. The production of homozygous lines is complicated by the high incidence of self-incompatibility in the genus.

Notwithstanding these complications, a program was initiated in 1951 in an attempt to secure information on the inheritance of flower color in the group of lilies descended from Miss Preston's original cross, made in 1929, between *L. Davidi* var. *Willmottiae* and a *L. dauricum* seedling. The ancestry of the varieties used is given by Cameron (1).

While very little genetic information has been secured so far, the data on seed production are presented for the information of lily breeders. Most of the varieties in the group under study produce a few or no seeds on selfing. Therefore, the effect of α-naphthalene acetamide (2) and pollination in the bud stage were investigated. The hormone was applied as a 1·0 per cent lanolin paste to a wound at the base of the ovary made by tearing off a petal. The bud pollinations were made two or three days before the buds would normally be expected to open.

The use of α-naphthalene acetamide had no effect on the seed formation of the self-fruitful variety Mosquito which set a large amount of seed, following selfing, on both treated and untreated flowers. There was also no effect on the highly self-unfruitful varieties Grace Marshall, Lyla McCann, Addington (39-08-01), Hurricane, Typhoon and 37-12-01, (a sister seedling of Coronation). Hormone treatment did result in a definite increase in the seed production of Edna Kean, Coronation and Spitfire, although in none of these varieties did seed production approach that of Mosquito. A reduction in seed formation accompanying the use of α-naphthalene acetamide was not observed.

The populations grown from the seed produced by selfing the above varieties, both with and without hormone treatment, exhibited segregation for plant and flower color characters. This indicates that these seeds are not apomictic.

The pollination of Addington, Coronation and Hurricane at the bud stage resulted in seeds only when pollination was accompanied by hormone treatment. Then, seed production was about equal to that from pollination at anthesis.

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2. Emsweller, S. L. and N. W. Stuart. Use of growth regulating substances to overcome incompatibilities in Lilium. Proc. Am. Soc. Hort. Sci. 51: 581-589. 1948.

## CHROMOSOME MORPHOLOGY IN SOME "STENOGRAPHER" AND "FIGHTER AIRCRAFT" LILY VARIETIES

The "Stenographer" lilies are the offspring of a cross made by Miss Isabella Preston in 1929 between *Lilium Davidi* var. *Willmottiae* and a male parent described as "an unnamed seedling of the umbellatum type", and in another place as "an unnamed seedling of *L. Thunbergianum* × *L. dauricum*". *L. Thunbergianum* is reported to be a hybrid between *L. dauricum* and *L. concolor*.

The "Stenographer" lilies tend to resemble *L. Davidi* var. *Willmottiae* in their outward or downward facing flowers with strongly recurved corolla segments. The "Fighter Aircraft" varieties are open-pollinated seedlings of the Stenographers. With the exception of Mosquito, they have flowers that are cup-shaped and erect, distinctly star-shaped, with narrow pointed petals and a decidedly waxy sheen. These characters are all typical of *L. concolor*.

The present study was undertaken in an attempt to make a more accurate determination of the parentage of the Stenographer and Fighter Aircraft groups. Stewart (1) demonstrated that it is possible to distinguish most Lilium species by the morphology of their somatic chromosomes. Using Stewart's technique, idiograms were prepared of the chromosome complements of the Stenographer varieties Edna Kean, Grace Marshall and Lyla McCann, and of the Fighter Aircraft varieties Hurricane, Mosquito and Spitfire, open-pollinated seedlings of

Edna Kean, and of Typhoon, an open-pollinated seedling of Lyla McCann. The clones of *L. Davidi* var. *Willmottiae* and the male parent used by Miss Preston in the original cross have been lost. In their place, bulbs of *L. Davidi* var. *Willmottiae, L. dauricum,* and *L. concolor* var. *coridion* were obtained from commercial nurseries.

Schematic idiograms of the putative parents and of representatives of the Stenographer and Fighter Aircraft groups are presented in Plate B-I. The photomicrograph of a metaphase plate of Mosquito (Fig. B-3) illustrates the type of material from which these idiograms were prepared.

Fig. B-3—Metaphase plate from root-tip squash of Mosquito lily (× 700). The idiograms in Plate B-I were prepared from material of this kind.

The absence of the exact parents of the Stenographer lilies made it difficult to draw definite conclusions. However, on the basis of the presence or absence of chromosome types that are diagnostic for the different species, certain conclusions appear warranted.

1. The presence in the Stenographer varieties of the morphologically distinguishable A, B, D, F and G chromosomes of *L. Davidi* var. *Willmottiae* (see Plate B-I) and the A, B, F and G chromosomes of *L. dauricum* is confirmation that these two species entered into the parentage of this group. The secondary constriction in the long arm of the C chromosome of *L. dauricum* was not observed in any of the Preston hybrid lilies. This constriction was seen only rarely in the *dauricum* plant examined and according to Stewart (1) it is not a constant feature of this species. Either the secondary constriction in the C chromosome occcurs so infrequently that it was not observed in the Preston hybrids or the *dauricum*-type seedling used by Miss Preston did not have this constriction in its C chromosome.

2. The failure to identify the B and K chromosomes of *L. concolor* in the Stenographer lilies suggests that the male parent was not a *Thunbergianum-dauricum* hybrid.

3. The finding in the Fighter Aircraft group of only those chromosome types already identified in the Stenographer lilies indicates that the pollen parents of the Fighter Aircraft lilies were Stenographer lilies.

Interspecific hybrids in this genus provide an excellent opportunity to demonstrate the morphological relationship between similar chromosomes in different species. A direct comparison is difficult when the chromosomes are in different plants. When they are combined in one plant, as in the Stenographer lilies, the relative lengths may be readily compared. Differences are particularly evident in the A and F chromosomes of Grace Marshall and Edna Kean.

***References***

1. Stewart, R. N. The morphology of somatic chromosomes in Lilium. Am. J. Bot. 34: 9-26. 1947.

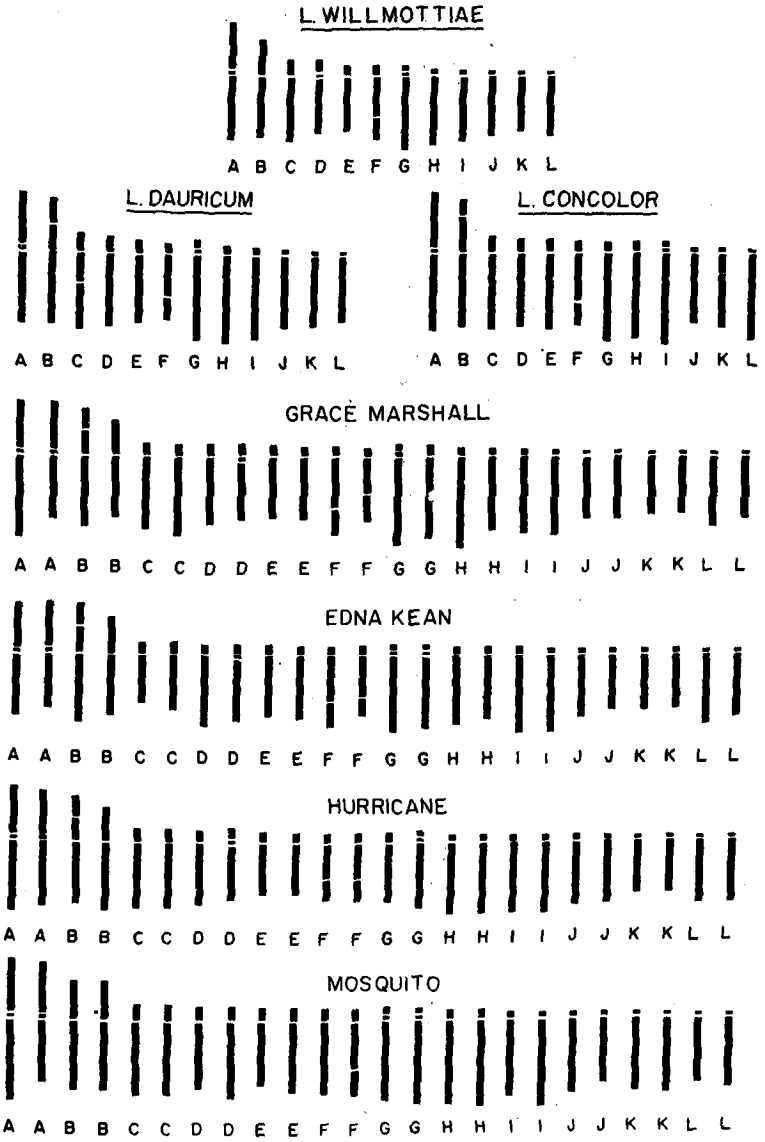



Plate B-I—Idiograms of the somatic chromosome complements of the putative parents of the Stenographer lilies and of representatives of the Stenographer and Fighter Aircraft varieties. The distinctive A, B, D, F and G chromosomes of L. *Davidi* var. *Willmottiae* and the A, B, F and G chromosomes of *L. dauricum* are seen in all the descendents. The readily identifiable B and K chromosomes of *L. concolor* were not found in any of the varieties examined, indicating that this species did not enter into their parentage.

# CHROMOSOME NUMBERS IN ROSE VARIETIES

*G. W. R. Walker and A. W. S. Hunter*

A survey of chromosome numbers in rose varieties was begun in 1949 to provide information for the rose breeding program. The chromosome counts were made either on root tips from rooted cuttings growing in pots in the greenhouse, or on leaf and petal squashes from plants growing in the rose gardens of the Horticulture Division. The root tips were fixed in a chrom-acetic-osmic fixative, usually 2 BD; embedded; sectioned, and stained in iodine-crystal violet. The leaf and petal squashes were usually pre-fixed in a saturated solution of paradichlorobenzene for two hours; washed in water for one-half hour; fixed in 3 parts absolute alcohol to 1 part glacial acetic acid for 24 hours, and macerated and stained in acetic-lacmoid according to the schedule of Darlington and La Cour (1).

The chromosome counts reported in Table B-5 supplement those published in an extensive list by Wylie (3). The classification follows Miss Wylie's and the varieties listed by her are marked with an asterisk. Information concerning the parentage of most of the varieties may be found in Modern Roses IV (McFarland, 2).

TABLE B-5.—LIST OF CHROMOSOME NUMBERS IN ROSE VARIETIES

| Variety | Chr. No. (2n) |
|---|---|
| TEA ROSES— | |
| Anna Olivier | 14 |
| Mme Tillier | 14 |
| HYBRID PERPETUAL ROSES— | |
| *Captain Hayward | 28 |
| *Frau Karl Drushki | 28 |
| *Mrs. John Laing | 28 |
| HYBRID TEA ROSES— | |
| Break o' Day | 28 |
| Charles Mallerin | 28 |
| Chief Seattle | 28 |
| Christopher Stone | 28 |
| Chrysler Imperial | 28 |
| *Condesa de Sástago | 28 |
| Crimson King | 28 |
| Dainty Bess | 28 |
| Douglas MacArthur | 28 |
| Ellinore Le Grice | 28 |
| Fantasia | 28 |
| Jackman's White | 28 |
| Joanna Hill | 28 |
| Lily Pons | 28 |
| Mary Margaret McBride | 28 |
| *Mme Caroline Testout | 28 |
| New Yorker | 28 |
| *Peace | 28 |
| Phyllis Gold | 28 |
| Pink Princess | 28 |
| Red Robin | 28 |
| Rubaiyat | 28 |
| Shades of Autumn | 28 |
| Vanderbilt | 28 |
| V for Victory | 28 |
| Ville de Paris | 28 |
| DWARF POLYANTHA, HYBRID POLYANTHA AND FLORIBUNDA ROSES— | |
| Betty Prior | 21 |
| *Chatter | 28 |
| *Cocorico | 28 |
| *Donald Prior | 28 |
| Eutin | 21 |
| *Fashion | 28 |
| Fortschritt | 21 |
| *Frensham | 21 |
| Gay Heart | 28 |
| Golden Salmon Supérieur | 14 |
| *Goldilocks | 28 |
| *Independence | 28 |
| *Karen Poulsen | 28 |
| Katharina Zeimet | 14 |
| *Kirsten Poulsen | 21 |
| Madge Prior | 21 |
| Mandarin | 28 |
| Ma Perkins | 28 |
| Mrs. R. M. Finch | 28 |
| Orange Triumph | 21 |
| *Paul Crampel | 14 |
| Permanent Wave | 21 |
| Poulsen's Bedder | 21 |
| Poulsen's Pride | 21 |
| Red Ripples | 28 |
| Summer Snow | 14 |
| Verdun | 14 |
| *Vogue | 28 |
| World's Fair | 28 |
| HYBRID MUSK ROSES— | |
| Violacée | 28 |
| HYBRID RUGOSA ROSES— | |
| Algonquin | 28 |
| *Belle Poitevine | 14 |
| Carmen | 14 |
| *Carmenetta | 28 |
| Double Red | 14 |
| F. J. Grootendorst | 14 |
| George Will | 14 |
| Grootendorst Supreme | 14 |
| Hansa | 14 |
| *Mme Georges Bruant | 14 |
| Mrs. John McNab | 14 |

TABLE B-5.—LIST OF CHROMOSOME NUMBERS IN ROSE VARIETIES—*Concluded*

| Variety | Chr. No. (2n) | Variety | Chr. No. (2n) |
|---|---|---|---|
| *Rose à Parfum de l'Hay | 21 | Isabella Preston | 14 |
| Semi White | 14 | Langford | 14 |
| Sir Thomas Lipton | 14 | Mabelle Stearns | 28 |
| Souv. de Philemon Cochet | 14 | Prairie Belle | 21 |
| Tetonkaha | 14 | Ross | 14 |
| Wasagaming | 14 | | |
| Wright's Hybrid | 14 | GALLICA ROSES— | |
| | | Cardinal de Richelieu | 21 |
| HYBRID SPINOSISSIMA ROSES— | | Flammula | 28 |
| Harison Lemon | 28 | Mme Tiret | 14 |
| Orinda | 28 | | |
| Poliarchus | 28 | MISCELLANEOUS ROSES— | |
| | | Betty Bland | 14 |
| HYBRID WICHURIANA ROSES— | | Félicité et Perpétue | 14 |
| Chatillon Rambler | 14 | Hiawatha | 14 |
| Dorothy Perkins | 14 | July Glory | 14 |
| Mary Wallace | 21 | Kazanlik | 35 |
| *New Dawn | 21 | Mrs. F. W. Flight | 14 |
| Yvonne | 14 | Nascapee | 21 |
| | | Patricia Macoun | 14 |
| HYBRID SETIGERA ROSES— | | Thalia | 14 |
| Baltimore Belle | 14 | Woolley Dods | 35 |
| Doubloons | 28 | | |

*Reported by Wylie (3).

### *References*


1. Darlington, C. D. and L. F. LaCour. The Handling of Chromosomes. 2nd ed. Geo. Allen and Unwin Ltd., London. 1950.
2. McFarland, J. H. Modern Roses IV. J. Horace McFarland Co., Harrisburg, Pennsylvania. 1952.
3. Wylie, Ann P. Chromosomes of garden roses. Am. Rose Ann., pp. 36-66. 1954.


## CHROMOSOME NUMBERS IN APPLES

Somatic chromosome counts were made in 1951-53 on 53 apple varieties and species growing in the Horticulture Division plantings at Ottawa. Included were varieties or species used in, or intended for, breeding purposes and colchicine induced polyploidy, new varieties introduced by this and other experiment stations, and varieties recently acquired for testing.

All the counts reported were from leaf squashes. The most satisfactory of the several techniques tried was to pre-fix very small leaves from the tips of rapidly growing shoots in a saturated aqueous solution of paradichlorobenzene for 2 hours, wash in water 30 minutes, fix in 3 parts absolute alcohol to 1 part glacial acetic acid for 24 hours, and macerate and stain in acetic-laemoid according to the schedule of Darlington and La Cour (1).

The varieties and species examined are listed in Table B-6. All are diploids with the exception of Hibernal and Withington Fillbasket which are triploids.

TABLE B-6—LIST OF CHROMOSOME NUMBERS IN APPLE VARIETIES AND SPECIES

***Diploids***

| | | |
|---|---|---|
| *Anis | *Geneva[1] | *O-294[1] |
| Bancroft[1] | Herring's Pippin | *O-2016[1] |
| *Beautiful Arcade | Hume[1] | *Parades[3] |
| *Bechtel's Crab | Joyce[1] | Patricia[1] |
| *Blanc Sur[3] | Lawfam[1] | *Patten Greening |
| *Calville Blanc | Linda[1] | Petrel[1] |
| *Chamuzat[3] | Lobo[1] | *Red Melba (Pate strain) |
| Charlamoff | *Macross[1] | *Red Melba (Platt strain) |
| *Churchill[2] | Melba[1] | *Riboude[3] |
| Cortland | *Merton Prolific | *Sandow[1] |
| *Court Pendu Rouge[3] | Milton | Spartan[2] |
| Duchess of Oldenburg | Newtosh[1] | *Trail Crab[1] |
| Edgar[1] | *No Pip | Tremlett's Bitter |
| Elmer[1] | *O-272[1] | *Yarlington Mill |
| Emilia[1] | *O-274[1] | Yellow Bellflower |
| Fireside | *O-277[1] | |
| *_Malus astrosanguinea_ (Spaeth.) Schneid. | | _Malus robusta_ No. 5[1] |
| _Malus prunifolia_ (Willd.) Borkh. | | _Malus Sieboldii_ (Reg.) Rehd. |

***Triploids***

| | |
|---|---|
| Hibernal | Withington Fillbasket |

* New determination.
[1] Originated by Horticulture Division, Ottawa.
[2] Originated by Experimental Station, Summerland, B.C.
[3] Very late flowering French Variety.

The only variety requiring particular comment is Hibernal. Dermen (2) remarked that this variety "has been somewhat of a cytological anomaly". Lincoln (4) from root-tip counts, and Vaarama (5) from counts at meiosis, reported Hibernal to be a tetraploid; whereas Einset and Imhofe (3) and Dermen (2), from stem tips, found it to be a triploid. Dermen suggested, from analogy with some other species, that Hibernal may exist in two forms—the triploid variety itself and a tetraploid seedling of it, virtually indistinguishable from the variety. This tetraploid could have been formed by the fertilization of an unreduced egg cell of the triploid by a pollen grain from a diploid apple.

The present study does little to solve the problem. An attempt to trace Lincoln's material failed. The tree from which Vaarama secured his material was propagated from scions reported to have come from the Central Experimental Farm, Ottawa, by way of a nursery in Finland. The only shipment of this variety to Finland recorded in our files was in 1929. At that time there were two Hibernal trees in our orchards, and it is not known from which tree the scions were taken. At the present time all the Hibernal trees at Ottawa are propagated from one of these two trees and all are triploids.

Scions were secured in 1951 through Dr. O. Meurman, State Horticultural Institution, Piikkio, Finland, of the exact tree used by Vaarama. Three trees were successfully grown from these scions. Leaf squashes from stem tips yielded nothing but triploid counts. Dr. Vaarama (personal communication, August 15, 1953) confirmed that there could be no doubt about the identity of the scions, nor about the accuracy of his count which was made on very well fixed second metaphase material. The possibility exists that we are dealing with a cyto-chimera. Vaarama made no somatic chromosome counts, and we have not yet been able to study meiosis in the trees grown from the scions from Finland. Until this has been done or until Hibernal has been shown to exist in two distinct forms, one triploid and the other tetraploid, the puzzle must remain unsolved.

***References***

1. Darlington, C. D. and L. F. La Cour. The Handling of Chromosomes. 2nd ed. Geo. Allen and Unwin Ltd., London. 1950.
2. Dermen, H. Ploidy in the Hibernal apple. J. Hered. 40: 162-164. 1949.
3. Einset, J. and Barbara Imhofe. Chromosome numbers of apple varieties and sports. Proc. Am. Soc. Hort. Sci. 50: 45-50. 1947.
4. Lincoln, F. B. Chromosome counts on Hibernal and Northwestern Greening apples. Proc. Am. Soc. Hort. Sci. 37: 217. 1940.
5. Vaarama, A. Meiosis and polyploid characters in the tetraploid apple variety Hibernal. Hereditas 34: 147-160. 1948.

## CHROMOSOME NUMBERS IN CHRYSANTHEMUM SPORTS

*G. W. R. Walker*

The species from which are derived the garden chrysanthemums of England and Japan and the greenhouse chrysanthemums of North America are all hexaploids (2n=54). Most chrysanthemum varieties are also hexaploids but, as shown by Emsweller (3), Dowrick (2) and Shimotomai (4), some are aneuploids with more, and sometimes fewer, than the hexaploid number of chromosomes. Many chrysanthemum varieties have arisen as sports. Dowrick demonstrated that in English varieties related sports frequently differ in chromosome number.

Chromosome counts of related sports of North American varieties have not been reported. Therefore, in August, 1953, a survey was begun on the varieties available in the collection of the Horticulture Division, Central Experimental Farm, Ottawa. Root tips were pre-fixed in a 0.2 per cent aqueous solution of colchicine for 3 to 4 hours; washed in water for 20 minutes; fixed in 3 parts absolute alcohol to 1 part glacial acetic acid for 24 hours and stained in acetic-lacmoid according to the schedule of Darlington and La Cour (1).

The varieties examined to date and their origins are listed in Table B-7.

TABLE B-7.—CHROMOSOME NUMBERS IN CHRYSANTHEMUM SPORTS

| Variety | Chromosome number | Parent |
|---|---|---|
| | (2n) | |
| Bronze Buckeley | 54 | Sport of Mrs. William Buckeley. |
| Deep Pink Buckeley | 55 | Sport of Mrs. William Buckeley. |
| Masterpiece | 57 | |
| Bronze Masterpiece | 57 | Sport of Masterpiece |
| Yellow Queen | 58 | Sport of Orchid Queen |
| Deep Pink Orchid Queen | 57 | Sport of Orchid Queen |
| William Turner | 61 | |
| Bronze Turner | 60 | Sport of William Turner |

These incomplete results do not include the parent variety in each case. However, determinations were sufficient to indicate that chromosome number differences are associated with sporting in North American varieties. It is not surprising, in view of their relationship, that they should resemble English varieties in this respect.

The results to date also confirm Dowrick's and Shimotomai's observation of a positive correlation between chromosome number and inflorescence size. The inflorescence size of the varieties examined increases from the top to the bottom of the list in Table B-7. The Buckeley varieties are pompons; the Masterpiece decorative, the Queens incurved standards, and the Turners are large-flowered exhibition types.

*References*

1. Darlington, C. D. and L. F. La Cour. The Handling of Chromosomes. 2nd ed. Geo. Allen and Unwin Ltd., London. 1950.
2. Dowrick, G. J. The chromosomes of Chrysanthemums, II: Garden varieties. Heredity 7: 59-72. 1953.
3. Emsweller, S. L. Breeding of ornamental plants. Proc. Am. Soc. Hort. Sci. 51: 565-574. 1948.
4. Shimotomai, N. Zur karyogenetik der gattung Chrysanthemum. J. Sci. Hiroshima Univ. Ser. B. 2: 1-100. 1933.

## CHROMOSOME NUMBERS IN TWIN PLANTS OF ASPARAGUS

*A. W. S. Hunter*

Twin plants with other than the normal number of chromosomes have been reported in many genera. Therefore, when twins were observed in 1940 during the course of colchicine treatment of asparagus seedlings, a search was instituted in the hope of discovering tetraploid plants. The seed used was the variety Eden, an Ottawa selection from the Elmira variety. It was produced in the same seed block in two different years. The seedlings examined in 1940 were grown from 1940 seed, and those examined in 1948 were grown from 1947 seed.

A marked difference in the number of twin seedlings in the two lots is shown in Table B-8.

TABLE B-8.—FREQUENCY OF TWIN SEEDLINGS GROWN FROM SEED OF EDEN ASPARAGUS PRODUCED IN TWO DIFFERENT YEARS

| Lot No. | Year seed produced | Number of seedlings examined | Number of twin seedlings | Twins per 100 seedlings |
|---|---|---|---|---|
| A-15 | 1940 | 1,922 | 5 | ·26 |
| O-43 | 1947 | 2,448 | 24 | ·98 |
| Total | | 4,370 | 29 | ·66 |

The frequency of twinning in this material falls within the range reported for the Mary Washington variety by Randall and Rick (1). Most of the twins were of the type referred to by these authors as "conjoined multiple seedlings". Twenty-four had twin roots and shoots and were joined at the hypocotyl. Only one had a double shoot and single root. The condition of four pairs was not noted. This material differs from that of Randall and Rick in which "the multiple seedling possessing a double shoot and single primary root is the type most frequently encountered".

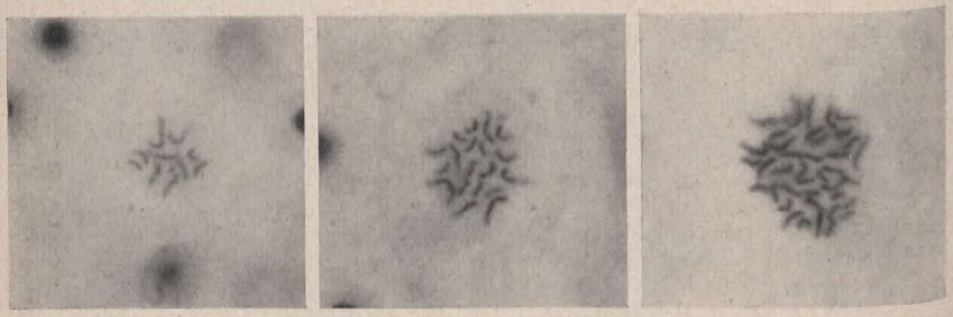


Fig. B-4—Asparagus root-tip metaphase plates. Left, haploid (10 chromosomes); center, diploid (20 chromosomes); right, tetraploid (40 chromosomes) × 1700.

The members of the pairs were planted separately in small pots. Chromosome counts were obtained from 21 pairs. Root tips were fixed in 2 BE, sectioned, and stained with iodine-crystal violet. One diploid-tetraploid pair and one haploid-haploid pair were found. The remainder were all diploid-diploid. The diploid-tetraploid pair were both males. The haploids, although now six years old, have remained small and have not flowered. The sex of the other twin plants was not determined.

***Reference***

1. Randall, T. E. and C. M. Rick. A cytogenetic study of polyembryony in *Asparagus officinalis* L. Am. J. Bot. 32: 560-569. 1945.

## MYCORRHIZA IN THE BLUEBERRY

*M. MacArthur*

Material examined was *Vaccinium angustifolium, V. brittonii* and *V. myrtilloides* from Tower Hill, N.B., two lots of unnamed blueberries from Danford Lake, Que., and greenhouse-grown seedlings from native New Brunswick blueberries.

No root hairs were found on any plants, adult or seedling.

*Adult plants.*—Mycorrhizas were not in mantle form, but one-tenth to one-twentieth of the epidermal cells of the finer rootlets in the adult collections were invaded. Larger roots had sloughed off the epidermis, which was replaced by periderm. The internal hyphae, maximum diameter 8 microns, exhibited form differences. Most conspicuous was a dense 'knot' completely filling the cell. In many cells, the internal coils were being digested. Of two external hyphal types, the first was dark, sterile or empty, and septate. Clamp connections at the septa indicate a Basidiomycete. These sterile hyphae did not appear to penetrate the epidermis and were probably epiphytes. The second, sparsely septate, filled with protoplasm, irregular in diameter, narrowed as it penetrated the epidermal cell. These latter hyphae were continuous with the internal filament, coil or 'knot'. No encapsulation was found in the invaded cells of any adult plant.

In addition to the fungal coils, many epidermal cells had single to branching attenuate hyphae invading contiguous cells. Such hyphae had no discernible septations or external connections, but the external portion may have been broken off in preparation. The central cylinder, including the xylem, was sparsely invaded by slender filaments, easily seen in longitudinal section.

*Seedlings.*—For the seedling experiments some non-afterripened seed was treated for fifteen minutes, including evacuation for five minutes, in 1:1000 corrosive sublimate and planted in sterilized soil, five parts ground peat to one part sand. Untreated seed was planted in both sterilized and non-sterilized soil. Germination began in two and one-half weeks. Untreated seed in non-sterilized soil produced the largest number of seedlings; next, untreated seed in sterilized soil, and least, treated seed in sterilized soil. For two months the stem portion remained in the cotyledon stage, so the flats were moved to a warmer house and watered more frequently. True leaves then appeared.

Seedlings were examined bi-weekly. At the second examination many cells with coils were found in the root epidermis of the controls. Only two were found during the winter in all seedlings from untreated seed in sterilized soil, and one was found in the third lot, seedlings from treated seed in sterilized soil. After the first month every control seedling examined was infected, but with

the exceptions mentioned no endophyte was found on plants in sterilized soil whether or not the seed had been treated. Occasionally the fungus was found below the epidermis, but not in the central cylinder. Non-penetrating hyphae were found in all flats, and the flats were exposed to air-borne infection.

Root systems in the sterilized soil had some abnormalities. Protoplasm in some cells was discolored and long roots ceased growth early, but side-root growth was prolific. Roots in the control were much healthier, and cells between epidermis and central cylinder were packed with starch grains.

At four months, besides one to several hyphae, fruiting bodies were found in some epidermal cells of approximately one-third the controls. The bodies were dark brown, globular, smooth-surfaced, 7 to 8 microns in diameter, usually one to a cell, frequently two and occasionally up to five. They were attached to a lighter brown basal cell. These fruiting bodies were borne on short hyphal branches, off-shoots from a non-septate filament that appeared to decrease in diameter and taper to a point. The color was in the outer coat; the interior was a whitish, more or less solid mass at the time observed. Encapsulated hyphae were found also in the control only. When the seedlings had been growing for two months, a few epidermal cells appeared to be filled with encapsulated masses; on the other hand, at four months a cell contained one to two masses but these did not fill the cell. Encapsulation is one method of suppressing the invader; digestion, another, has been mentioned. Hyphal connections were found in the first but not the second type of encapsulation. The almost completely intracellular endophyte was not found on the root-stem transition portion, stem, cotyledons or leaves. Therefore, it is not systemic.

Soil sterilization destroyed the fungus and it does not appear to be seed-borne. Root and top growth was poorer in sterilized soil. Sterilization may have made the substrate unsuitable and certainly such soil had fewer fungi. With spring, growth in all lots became static, possibly indicating the need for a rest period, but one month at 32°F. was not sufficient to force them into new growth.

The experiment indicated that mycorrhiza are not necessary for early growth of lowbush blueberry seedlings.

# NUTRITION AND SOIL MANAGEMENT STUDIES

*H. Hill and H. B. Heeney*

## MICRONUTRIENT OR TRACE-ELEMENT STUDIES

Studies dealing with the effects of trace elements on the growth of horticultural crops have been conducted by this Division for several years. The main phase of the studies has been the determination of growth characters and the foliage symptoms resulting from the deficiency of a specific element in plants grown under controlled nutritional conditions. Symptoms of boron deficiency of the apple, turnip, celery, cauliflower, cabbage, corn, table beet, tomato, spinach, carrot and garden pea have been described and effective control measures established (2, 3, 6, 7). Similarly, symptoms and control measures of manganese and magnesium deficiencies of a range of crops have been determined (2, 5, 7). Although this knowledge has been useful for diagnoses when the deficiencies were such that visible symptoms were present, it is realized that yield and quality may be decreased by a threshold deficiency lacking in those visible plant growth symptoms. There is also a need for the determination of annual crop requirement before the crop is planted. Further information is required on deficiency symptomology and physiological reactions produced in plant metabolism by such elements as zinc and molybdenum.

During the last five years the main trace-element studies have had the following objectives:

1. A study of symptomology and physiological reactions of zinc and molybdenum deficiencies in horticultural plants.

2. The determination of deficiency and critical levels of zinc and molybdenum in the plant.

3. The investigation of a bioassay method of analyzing soils and plants to determine the need for applying zinc, copper, molybdenum and magnesium.

### Molybdenum Deficiency

This element is known to be especially important in the production of cauliflower and broccoli on acid soils. The characteristic deficiency disorder known as "whiptail" has been reported in field production in Prince Edward Island, New Brunswick, Quebec and Ontario. The need of leguminous plants for this element has also been demonstrated. So far our work has included a study of deficiency symptoms in cauliflower, broccoli and corn. Plants were grown in two-gallon pyrex jars and procedures as outlined by Hewitt and Jones (4) were designed to eliminate molybdenum from all sources.

#### *Observations on Broccoli and Cauliflower*

During the early stages of growth, the symptoms began as a mottled chlorosis of the older leaves. The chlorotic tissue was first noted at the base of the blade and gradually spread upwards along the margins. Many of the younger leaves showed a marked cupping effect starting at the tip and then progressing until the whole margin was curled upwards. The cupped leaves were brittle and tattered readily. Later, the chlorosis was severe, affecting all the



52626—6

foliage with the exception of the cotyledons which remained dark green. The margins of many of the chlorotic leaves became necrotic, and the laminae rapidly withered and dropped off. In some cases mature leaves that had appeared relatively turgid became water-soaked and collapsed overnight. At this stage, and before the occurrence of whiptail symptoms, the chlorotic condition of the younger leaves largely disappeared. These leaves became elongated, developed a narrow wavy outline, and brownish withered areas appeared between the veins. When these necrotic areas dropped out all that remained was the midrib of the leaf with small areas of lamina projecting on either side of the principal veins. Other leaves with completely defective laminae developed, and plants assumed the typical whiptail symptoms. The growing point died and no flowers developed (Plate C-I).

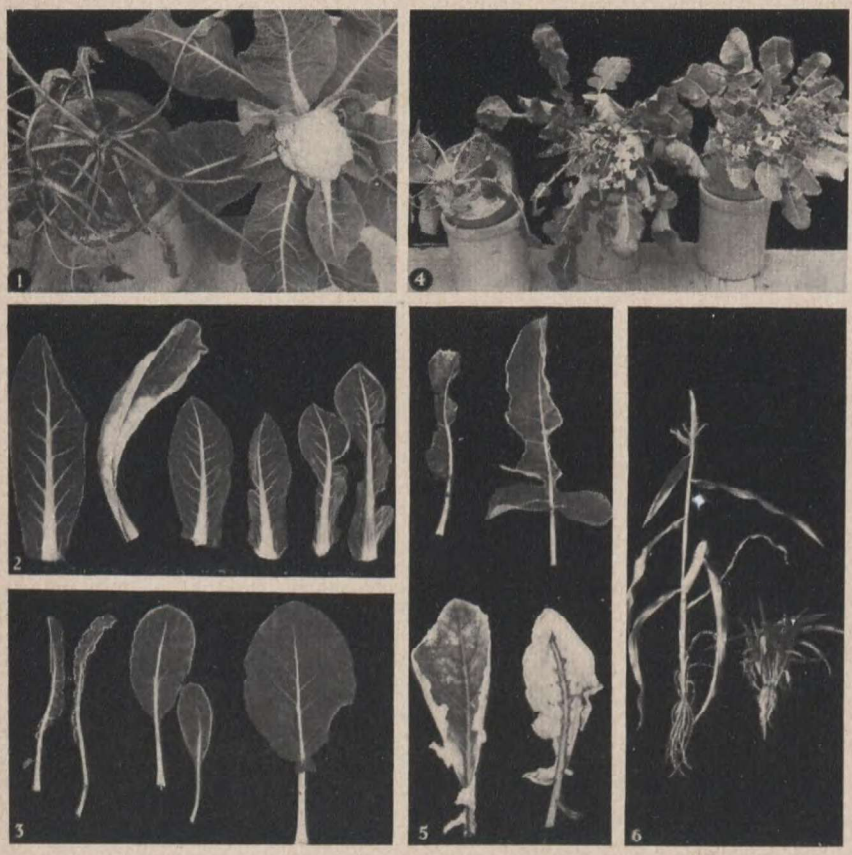


Plate C-I—Molybdenum deficiency symptoms in cauliflower, broccoli, and sweet corn.—Fig. 1. Left, severe whiptail symptoms; right, normal cauliflower. —Fig. 2. Cupped or moccasin leaves of cauliflower.—Fig. 3. Left, defective laminae; centre, mottled chlorosis; right, normal leaf of cauliflower.—Fig. 4. Left, severe whiptail symptoms; centre, defective laminae and growing point; right, normal broccoli.—Fig. 5. Top, defective laminae; bottom, chlorosis and necrosis of broccoli leaves.—Fig. 6. Marked stunting and rosetted habit of growth compared with normal sweet corn.

The comparative effect of molybdenum deficiency on the growth of cauliflower and broccoli is recorded in Table C-1.

TABLE C-1.—EFFECT OF MOLYBDENUM DEFICIENCY ON THE FRESH AND DRY-MATTER YIELDS OF CAULIFLOWER AND BROCCOLI

| Molybdenum treatment | Cauliflower | | | Broccoli | | |
|---|---|---|---|---|---|---|
| | Fresh wt. plant top | Dry wt. plant top | Wt. of curd | Fresh wt. plant top | Dry wt. plant top | Wt. of curd |
| | gm. | gm. | gm. | gm. | gm. | gm. |
| Minus | 121 | 16 | ..... | 122 | 16 | ..... |
| Plus | 1,462 | 185 | 227 | 1,175 | 135 | 199 |

The relation between visual symptoms and the molybdenum content of cauliflower and broccoli are shown in Table C-2. Molybdenum content was determined by chemical analysis and by a bioassay method which is described later in the text.

TABLE C-2.—RELATION BETWEEN VISUAL SYMPTOMS AND MOLYBDENUM CONTENT OF CAULIFLOWER AND BROCCOLI

| Molybdenum treatment | Leaf symptoms | Molybdenum[1] in blade | | Molybdenum in petiole | | Molybdenum in plant | |
|---|---|---|---|---|---|---|---|
| | | Chemical analysis | Bio-assay | Chemical analysis | Bio-assay | Chemical analysis | Bio-assay |
| CAULIFLOWER— | | | | | | | |
| Minus | chlorotic | ·020 | ·032 | ·014 | ·015 | ·010 | ·052 |
| | necrotic | ·014 | ·032 | ·023 | ·015 | ·010 | ·011 |
| | *normal*[2] | ·014 | ·022 | ·036 | ·125 | ·260 | ·238 |
| Plus | normal | ·360 | ·408 | ·210 | ·268 | ·290 | ·289 |
| BROCCOLI— | | | | | | | |
| Minus | chlorotic | ·050 | ·058 | ·040 | ·041 | ·054 | ·055 |
| | whiptail | ..... | ..... | ·020 | ·013 | ·010 | ·013 |
| | normal[2] | ·060 | ·033 | ·050 | ·030 | ..... | ..... |
| Plus | normal | ·498 | ·488 | ·280 | ·279 | ·504 | ·495 |

[1]Molybdenum content as p.p.m. dry weight.
[2]Apparently normal.

Severe symptoms of deficiency were associated with levels of 0.01 to 0.03 p.p.m. dry weight, while control plants had levels from ten to thirty times that found in deficient tissues. A more detailed study of intermediate and excess levels will be necessary in order to establish the critical content. With minor exceptions, a good relationship was found between the chemical and bioassay methods of analyses.

Cauliflower plants and soils from commercial fields were also analyzed by the bioassay method. Some plants in one area were showing molybdenum deficiency symptoms. Plants with varying visual symptoms, apparently normal plants from the same area, soil in which these were growing, treated soil, and various tissues of completely normal plants from a second area were analyzed for molybdenum content. This material was provided by E. Terasme, Ontario Agricultural College, Guelph, who is conducting an investigation of the occurrence and control of trace element deficiencies in commercially produced Ontario crops. The relation between visual symptoms and the molybdenum content of plants and soils is shown in Table C-3.

TABLE C-3.—RELATION BETWEEN VISUAL SYMPTOMS AND MOLYBDENUM CONTENT OF PLANTS AND SOILS FROM COMMERCIAL FIELDS

| Area | Treatment | Symptoms | Analysis of | Mo. in tissue[1] | Mo. in soil[2] |
|---|---|---|---|---|---|
| 1 | nil | severe whiptail | leaves | 0·04 | 0·04 |
| 1 | nil | cupped moccasin | leaves | 0·08 | |
| 1 | nil | undev. crowns | crowns | 0·04 | |
| 1 | nil | nil | blades | 0·81 | |
| 1 | nil | nil | midribs | 0·72 | |
| 1 | nil | nil | ..... | ..... | 0·11 |
| 1 | sodium molybdate 2 lb./ac. | nil | ..... | ..... | 0·51 |
| 2 | nil | nil | blades | 1·8 | |
| 2 | nil | nil | midribs | 1·3 | |
| 2 | nil | nil | crowns | 2·2 | |

[1]Molybdenum in p.p.m. dry weight.
[2]Molybdenum in p.p.m. soil.

Table C-3 shows a consistently wide difference in plant molybdenum content between normal and affected plants. The molybdenum content of the soil is also related to plant condition.

***Observations on Sweet Corn***

Further studies are necessary to determine the early deficiency symptoms of corn, for the control plants that received molybdenum exhibited a chlorotic condition which was later corrected by increasing the magnesium concentration in the nutrient solution. The early seedling symptoms that developed on the minus molybdenum plants may have been partially due to an insufficient magnesium supply. The symptoms described in the following refer to those occurring during the later stages of growth.

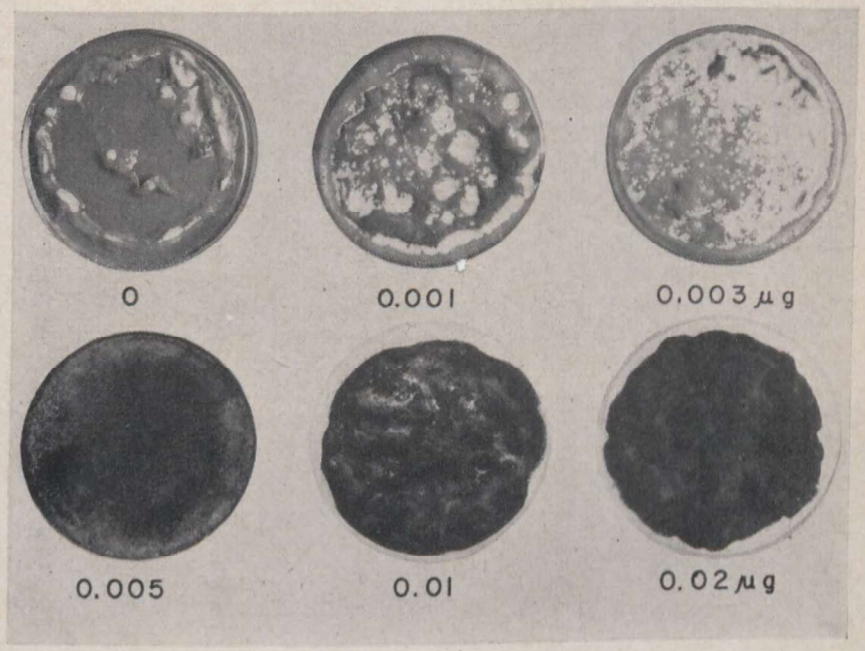
Plants not receiving molybdenum were extremely stunted, reaching not more than one foot in height at flowering time. Any tassel flower parts that formed were diminutive, and although filaments formed, anthers were lacking. The plants had a rosetted habit of growth for internodes were much shortened thus closely spacing the leaves (Plate C-I). In general, the leaves were narrower than normal; the leaf margins tended to curl upwards producing a wavy outline or, in more extreme cases, a cupping effect.

## Bioassay Method of Determining Molybdenum, Copper, Zinc and Magnesium in Soils and Plants

The need for a more critical method of determining trace-element requirement other than by the occurrence of definite plant growth symptoms has been apparent for some time. Chemical analysis of soils has not proved too satisfactory since it has been difficult so far to obtain a soil extracting solution that will reproduce the extracting properties of the plant roots. Moreover, the quantities extracted are so small that the chemical methods lack sensitivity. A bioassay method for some elements has been developed and has found favor in Continental Europe and in England. A laboratory has been set up in this Division to explore the method as a means of assessing soil requirement and plant content. The bioassay figures included in this report were obtained by this method.

The method is based on the requirement of the fungus *Aspergillus niger* (Mulder's M strain) for all the trace elements needed for normal growth. An increase of any one of these elements from deficiency to sufficiency levels results in a specific quantitative increase in growth and sporulation of

the fungus. In using *Aspergillus niger* as a test organism, a definite quantity of soil or plant material to be tested is added to a culture of the fungus containing all the necessary nutrients other than the one to be determined. The fungus is allowed to grow for five to six days at a constant temperature. By reference to a standard growth series employing dry weight yields of the fungus, the amount of the element present in the test substance, the plant or soil, is thus determined (Plate C-II).



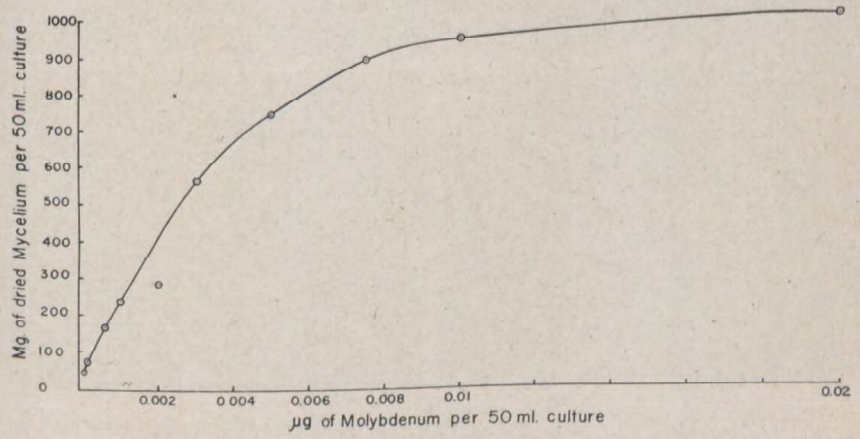




Plate C-II—Bioassay method of determining certain trace elements.—Top: Relative growth of *Aspergillus niger* (M) in standard solutions containing a range of molybdenum from 0·0 to 0·02 micrograms per 50 millilitres of culture solution.—Bottom: Dry weight of *Aspergillus niger* (M) after 5½ days at 26°C. in relation to molybdenum supplied in standard cultures.

## Zinc Deficiency

Zinc deficiency symptoms and growth responses to the application of zinc have been reported in the commercial production of various tree fruits in the Okanagan Valley, British Columbia (8), although no definite diagnosis of such deficiency has yet been reported from eastern fruit areas. Deficiency symptomology of a number of horticultural crops has been studied employing the same methods as referred to for molybdenum.

***Observations on Apple (McIntosh and Malus robusta 5)***

The first symptoms appeared on the foliage as a fading of the color in the interveinal areas of the leaves at the tips of the shoots. The disappearance of chlorophyll was followed by a more distinct yellowing, with the veins and a narrow area of tissue on either side remaining green or even becoming intensified in color. This symptomatic pattern is quite similar to that caused by iron deficiency. The less intense mottled symptoms which sometimes occurred might also be confused with those of manganese deficiency. During the first year of deficiency treatment, growth was appreciably reduced and leaves were smaller in size without, however, reaching the stage that has been referred to as "little leaf". Late in the growth cycle, buds in the leaf axils broke, and the resulting very small leaves produced a feathered effect on the shoots.


Plate C-III—Zinc deficiency symptoms of the apple.—Fig. 1. Chlorotic interveinal areas of *Malus robusta* 5 foliage.—Fig. 2. McIntosh leaves in second year of treatment showing diffuse type of chlorosis.—Fig. 3. "Little leaf" symptom on McIntosh in second year of treatment. Small, rosetted, chlorotic leaves compared with normal shoot.—Fig. 4. Failure of lateral buds to break and dense tufts of very small chlorotic leaves at terminals of McIntosh shoots in third year of treatment.

In the second year of deficiency treatment, chlorosis was intensified; leaves were small, brittle in texture, and length of shoot growth was much reduced. Some of these very short shoots ended in whorls of leaves markedly chlorotic to almost white. Such leaves were narrow, with the margins curled upwards.

By the spring of the third year of deficiency treatment there was a marked failure of any but the terminal leaf buds to break. This resulted in the occurrence of dense tufts of very small chlorotic leaves at the branch terminals (Plate C-III). During the second and third years the zinc content of the foliage from deficient and zinc-treated trees was determined with results as shown in Table C-4.

TABLE C-4.—ZINC CONTENT OF APPLE FOLIAGE IN RELATION TO ZINC TREATMENT AND SYMPTOMS

| Treatment | Leaf symptoms | Zinc content in p.p.m. dry weight | |
|---|---|---|---|
| | | Chemical analysis | Bioassay |
| SECOND YEAR— | | | |
| Zinc | normal | 10·7 | |
| Nil | chlorotic | 8·0 | |
| Nil | rosetted | 6·4 | |
| Nil | normal | 8·2 | |
| THIRD YEAR— | | | |
| Zinc | normal | 16·8 | 16·8 |
| Nil | normal | 15·4 | 14·2 |
| Nil | rosette + little leaf | 3·9 | 4·0 |

Bould *et al* (1) have reported a zinc content in leaves of less than 3 p.p.m. in association with deficiency symptoms, while leaves from apparently healthy trees from the affected area contained about 10 p.p.m. Woodbridge (8) found that the zinc content in affected leaves varied from 3 to 22 p.p.m., and in healthy leaves from 6 to 40 p.p.m. In the data of Table C-4, the zinc content between normal-appearing leaves and leaves showing marked symptoms differs widely, although both samples were from the same tree.

While zinc deficiency in apple orchards in Eastern Canada has not yet been definitely diagnosed, symptoms resembling those described have been noted in the varieties Delicious, Spy and Sandow growing on a high-lime soil at the Horticulture Substation, Smithfield, Ont. The average zinc content of affected foliage was 7.1 p.p.m. with a variation of 4 to 11 p.p.m. Foliage from trees not showing symptoms had an average zinc content of 16.6 p.p.m. with a variation of 8 to 30 p.p.m. Thus, trees showing symptoms had a foliage zinc content in that range associated with zinc deficiency.

***Observations on Tomato***

Growth was markedly reduced and stunted, but the foliage was initially darker green than plants receiving zinc. Four weeks after seedling plants were subjected to deficiency treatment they developed an interveinal chlorosis of the older leaves. At eight weeks this chlorosis had also involved the younger top leaves. The leaflets were distorted, became down-curled, and coiled into a compact mass. Necrotic flecks appeared on the underside of the younger leaves and on all areas of the older leaves. The older leaves became completely necrotic and dried up. The stems and petioles also showed marked necrotic lesions in the advanced stages of the deficiency. Although some floral parts developed, no fruit set (Plate C-IV).

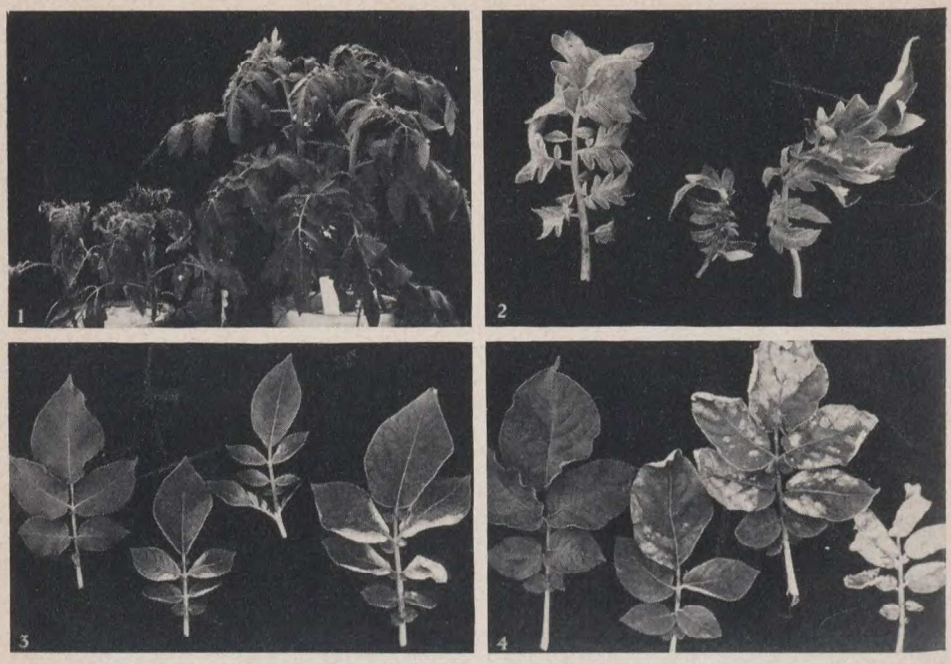


Plate C-IV—Zinc deficiency symptoms in the tomato and potato.—Fig. 1. Marked stunting and distortion of leaves compared with a normal potato plant.—Fig. 2. Distortion and chlorosis of tomato leaves under zinc deficiency.—Fig. 3. Leaves from top of potato plant. Golden yellow chlorosis at base of lower leaflets.—Fig. 4. Progressive development of water-soaked and necrotic areas in the potato leaf under a deficient zinc treatment.

***Observations on Corn***

Symptoms were first observed as a fading of color and the appearance of necrotic flecking on the older leaves. As growth proceeded, a banded interveinal chlorosis appeared, quite similar to that produced by magnesium deficiency. Newly developed leaves showed a severe interveinal chlorosis, or an almost white area at the base. The necrotic areas on the older leaves enlarged and merged, finally encompassing the entire leaf. The plants were severely stunted; the leaves became distorted and curled upwards.

***Observations on Potato***

Symptoms first appeared as a golden-yellow chlorosis at the base of the lower leaflets at the top of the plant. This symptom progressed leaflet by leaflet upwards from basal to topmost leaflet of an affected leaf. On other leaves scattered bright yellow spots occurred. These varied from pinpoint up to one centimeter in diameter. As the deficiency symptoms progressed, the chlorotic spots became surrounded by an area at first water-soaked in appearance but which later dried up and necrosed. Necrotic areas merged until the leaves at the top of the plant were completely necrosed. Sometimes this leaf necrosis was accompanied by stem lesions (Plate C-IV).

While the extreme stages of zinc deficiency in such plants might be diagnosed correctly by growth symptoms, intermediate deficiency stages could be easily confused with symptoms produced by other factors.

In these studies many plant samples have been taken for the determination of zinc content, but the analyses have not yet been completed. It is hoped that the data presented herein and those accumulated from future studies may lead to the establishment of critical standards of zinc content in the plant or plant part.

The chemical analyses reported in the preceding were determined by the Chemistry Division, Science Service.

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## RELATIONSHIP OF SOIL TESTS FOR PHOSPHORUS AND POTASSIUM TO CROP YIELD AND FERTILIZER REQUIREMENTS OF THE TOMATO AND POTATO

Although current and past research indicates soil analysis to be the logical tool for fertility diagnosis, the use of soil test values as a basis for fertilizer recommendations has too often proved unsatisfactory. It is submitted that failure to correlate soil test values with yield response is largely responsible. In many instances the present use of soil analysis has the weakness of inadequate or complete lack of data to ensure correct interpretation since the validity of various chemical methods has frequently been determined in the laboratory without the benefit of suitable field experiments.

Probably the most satisfactory approach to the problem of efficient estimation of crop fertilizer requirement is found in the work of Bray (1) in which plant response is the measure of effectiveness. Bray has shown satisfactory correlations between soil tests for phosphorus and potassium and crop response to these nutrients added as fertilizer. He used a modified interpretation of Mitscherlich's Law of Diminishing Returns in which the Mitscherlich constant was not accepted but was replaced with an experimentally developed constant ($c_1$) applicable only to a given crop and locality.

***Results with Canning Tomatoes***

Field and laboratory investigations relative to the production of canning tomatoes in Prince Edward County, Ontario, were conducted during a four-year period. The study (2), designed to establish correlation tables between soil test values and crop response to fertilizer, included soils of varying texture and reaction.

Bray's method for adsorbed and easily acid soluble phosphorus (1) as well as one employing 1·0 per cent solution of $K_2CO_3$ (3) as extractant was used to obtain estimates of available soil phosphorus. Potash in the soil was determined as that extracted by neutral normal ammonium acetate. Yields from plots lacking either phosphorus or potash were expressed as a percentage of those from plots receiving both phosphorus and potash. Adequate amounts of nitrogen were supplied in all cases.

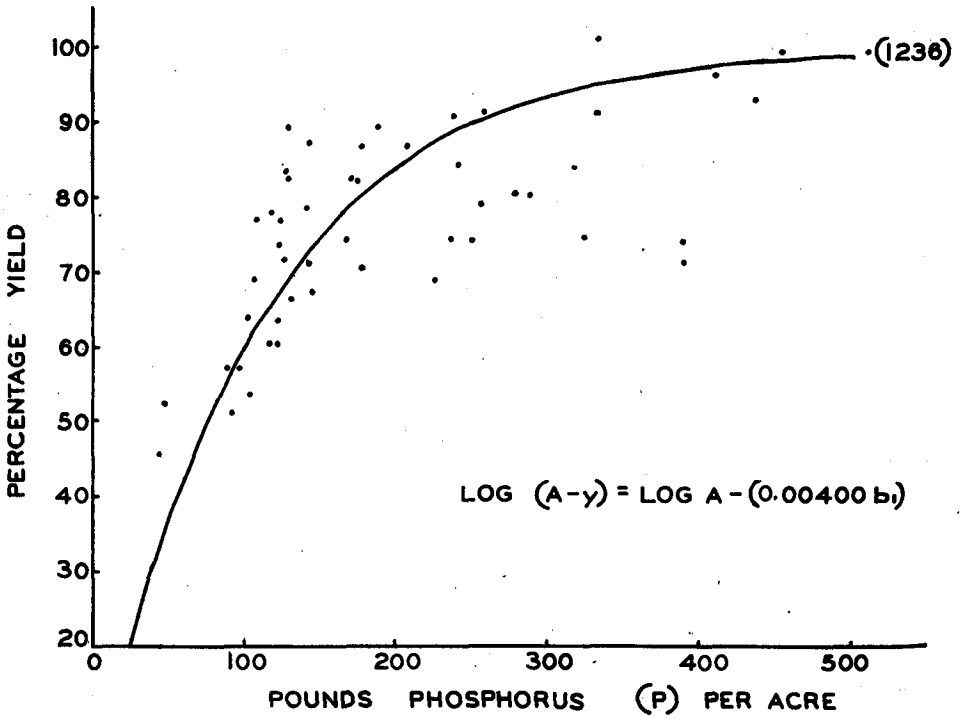


Fig. C-1—Relationship between soil phosphorus by the Bray method of analysis and percentage yield of the tomato canning crop in Prince Edward County.

TABLE C-5.—SCHEDULE OF PHOSPHATIC FERTILIZER REQUIREMENTS FOR 95 PER CENT OF MAXIMUM YIELD OF TOMATOES IN PRINCE EDWARD COUNTY

| Soil test (Bray) lb.P/ac. | Per cent yield without P ($c_1$=·00400) | Phosphorus requirement lb. $P_2O_5$/ac. (c=·00366) |
|---|---|---|
| 40 | 30·8 | 312 |
| 80 | 51·1 | 268 |
| 100 | 60·2 | 246 |
| 140 | 71·0 | 202 |
| 180 | 79·3 | 159 |
| 240 | 87·2 | 93 |
| 280 | 90·6 | 49 |
| 300 | 91·8 | 28 |
| 310 | 92·4 | 17 |
| 320 | 92·9 | 6 |

The phosphorus studies indicated, as shown in Fig. C-1, that the percentage yields plotted against the soil test values by the Bray method resulted in a curvilinear relationship similar to that for the Law of Diminishing Returns. The data over the five-year period indicate that on these soils it is preferable to use the Bray method of soil phosphorus analysis instead of the $K_2CO_3$ method. This provided a basis for predicting the percentage yield to be expected from various soil test values using the equation:

$$\text{Log } (100-y)=2-.004\ b_1,$$

where y is the expected percentage yield and $b_1$ is the soil phosphorus by the method of Bray (1). The relationship between the soil tests for phosphorus and the percentage yield of the tomato crop obtained from the average curve shown in Fig. C-1 is presented in Table C-5. The constancy of the $c_1$ values upon which these are based indicates that the Bray method of soil analysis provides a reliable index of the phosphorus status of Prince Edward County soils, and it may be used to predict relative expected yield increase from phosphatic fertilization. This soil test percentage yield relationship does not in itself permit prediction of the quantity of phosphatic fertilizer required to give maximum yield. Some data on this problem are presented in Table C-5. The data, which are tentative, will probably be slightly modified with further experimentation. The equation currently in use to give these data is based on a $c_1$ value of 0.004 and a c value of 0.00366 and is

$$0.004\ b_1+0.00366\ x=1.2996,$$

where $b_1$ is the soil phosphorus in pounds of phosphorus per acre by the Bray method and x is the pounds of $P_2O_5$ per acre required to give 95 per cent of the maximum yield. Indications are that maintenance requirements of phosphatic fertilizer are all that are required if the soil tests above 250 pounds of P per acre.

The results bearing upon the relationship between soil tests for exchangeable potassium and crop response to potassic fertilizers indicate that this method of soil potassium determination does not bear any consistent relationship to crop requirement in this area. Data over a three-year period indicate that while the average $c_1$ constant changes little from year to year, there is a strong suggestion of a negative relationship between the soil test value for exchangeable K and the individual values of the $c_1$ constant obtained each year. This indicates that for this area at least some other method of soil potash determination must be used before the soil test percentage yield relationships can be applied to potash in this area. Work is continuing in this direction using several different methods of potash determination.

***Results with Potatoes***

Using the same techniques, studies with potatoes were conducted in the Guelph, Ont., area and at the Central Experimental Farm, Ottawa, for the past five years. Exchangeable soil potassium was estimated using neutral normal ammonium acetate as the extractant, and soil phosphorus was estimated using the methods of Truog (4), Bray (1), and Hockensmith (3). The results indicate that only with the Truog phosphorus was there any relationship whatsoever between soil phosphorus and percentage yield. The results show con-

siderable variability in the calculated $c_1$ values from the different phosphorus and potash trials. There was, however, enough uniformity between the means for the different years to consider giving some tentative consideration to the results.

TABLE C-6.—ANNUAL MEAN $C_1$ VALUES FOR PHOSPHORUS AND POTASH POTATO TRIALS AT OTTAWA AND GUELPH

| | Potash trials (Exchangeable soil K) | | Phosphorus trials (Modified Truog soil phosphorus) | |
|---|---|---|---|---|
| Year | Guelph | Ottawa | Guelph | Ottawa |
| 1949 | ..... | ·00802 | ..... | ·00861 |
| 1950 | ·00732 | ..... | ..... | ·00797 |
| 1951 | ·00761 | ·00839 | ·01404 | ·00711 |
| 1952 | ·00759 | ·00769 | ·01182 | ·00953 |
| 1953 | ·00584 | ·00814 | ·01045 | ·00937 |
| Mean | ·00709 | ·00806 | ·01210 | ·00852 |

TABLE C-7.—EXPECTED PERCENTAGE YIELD BASED ON SOIL TEST VALUE AND MEAN ANNUAL $C_1$ VALUES FOR PHOSPHORUS AND POTASH

| Soil potash (Exchangeable K) lb.K/ac. | Expected per cent yield without added potash | | Soil phosphorus (Truog) lb.P/ac. | Expected per cent yield without added phosphorus | |
|---|---|---|---|---|---|
| | Guelph | Ottawa | | Guelph | Ottawa |
| 40 | 46·2 | 52·4 | 40 | 67·7 | 54·4 |
| 60 | 60·5 | 67·2 | 60 | 71·7 | 69·2 |
| 80 | 71·0 | 77·4 | 80 | 89·6 | 79·2 |
| 100 | 78·8 | 84·4 | 100 | 94·1 | 85·9 |
| 150 | 90·2 | 93·8 | 150 | 98·5 | 94·7 |
| 200 | 95·5 | 97·6 | 200 | 100·0 | 98·0 |
| 250 | 100·0 | 100·0 | 250 | ..... | 100·0 |

The annual mean $c_1$ values for both phosphorus and potash studies in the two areas as well as the general means are given in Table C-6. While it is apparent that the variation between the annual $c_1$ means is generally not very great, the considerable variation of $c_1$ values within each year does not permit the use of the general mean except for tentative evaluation of soil test percentage yield relationships. It should be noted, however, that the general $c_1$ values vary considerably between Ottawa and Guelph. These differences stress the importance of limiting the use of a mean $c_1$ value to a given experimental area. The expected percentage yields of plots lacking potash or phosphorus fertilizers at various soil test levels based on the general equation:

$$\text{Log } (100-y)=2-c_1b_1,$$

are given in Table C-7. These data may be used to tentatively estimate the expected potato crop response to either potash or phosphorus fertilizers in these areas. The data are, however, subject to revision with further field experimentation. Because of the unreliability of the $c_1$ constants obtained, no work has been conducted with potatoes on relationships of the soil to fertilizer requirement. This phase of the study will require further work.

The experiments were conducted co-operatively with the Chemistry Division, Science Service. Soil analyses were by the Chemistry Division.

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## RELATIONSHIP BETWEEN PLANT COMPOSITION AND PLANT GROWTH, YIELD AND QUALITY

Analysis of the soil and determination of plant composition have both been employed in the diagnosis of nutritional disorders and for estimation of fertilizer requirement. While plant and plant-part analyses have been made for many years, lately more emphasis has been directed towards determining "critical" levels associated with optimum crop production.

The relative merits of soil and plant analysis will not be discussed in detail but certain observations may be considered. The outstanding shortcoming of plant tissue testing of annual crops is that the crop has first to be partially grown whereas soil testing provides information on what should be added in preparation for growing the crop. However, plant tissue tests may be employed to indicate whether or not fertilizer side dressings are required during the annual vegetable crop growing period. This is especially true for the element nitrogen, since the greater part of the nitrogen in soil is associated with organic matter. Even if a fertility diagnosis of other elements may sometimes be too late to be of use for a particular current crop, it may be used in suggesting a change in fertilizer practice for the succeeding year on the same or a neighboring field.

Greater scope is possible with tissue or plant analysis tests on such perennial crop plants as tree or bush fruits, for corrective treatments may be applied thereon in successive years. In fact, plant analysis offers a considerably greater basis of accuracy for fertilizer recommendations than soil analyses with any deeply rooted perennial crop. Since roots of fruit trees are widely dispersed in the soil profile, it is difficult to determine from what specific portion of the profile they may be drawing most of their nutrients.

Considerable work has been conducted at the Central Experimental Farm on a number of horticultural crops by one of two methods of analysis; (1) that level of nutrient extracted from the fresh tissue by a two per cent solution of acetic acid or (2) that level contained in the dried, ground and ashed plant material. Established or tentative levels associated with the occurrence of deficiency symptoms and with satisfactory production and crop quality are tabulated in Table C-8. Those relationships considered to be firmly established are designated in this table by an asterisk.

TABLE C-8.—ESTABLISHED AND TENTATIVE CRITICAL LEVELS FOR VARIOUS HORTICULTURAL CROPS

| Portion sampled and date or stage | Nutrient | Levels in deficient plants | | Levels in normal plants | |
|---|---|---|---|---|---|
| | | F.W.B.[1] | D.W.B.[2] | F.W.B. | D.W.B. |
| | | p.p.m. | %[3] | p.p.m. | % |
| BEANS | Mn | ....[4]... | 0·0045 | ..... | 0·012 |
| Matures leaves at harvest. | | | | | |
| BROCCOLI | Mo | ..... | 0·0130–0·05 p.p.m. | ..... | 0·28–0·5 p.p.m. |
| Petioles before heading time. | | | | | |
| CABBAGE | N | ..... | ..... | 500 | ..... |
| Midribs of leaves | P | ..... | ..... | 180 | ..... |
| subtending head | K | ..... | ..... | 4800 | ..... |
| at heading time. | Mo | ..... | 0·014–0·07 p.p.m. | ..... | 0·9–2·3 p.p.m. |
| CARROT (Muck soil) | *N | 55–550 | ..... | 600–650 | ..... |
| Middle third of | *P | 15–60 | ..... | 125 | ..... |
| petioles in mid- | *K | 650–3000 | ..... | 6000 | ..... |
| August. | | | | | |
| CAULIFLOWER | N | ..... | ..... | 500 | ..... |
| Midribs of leaves | P | ..... | ..... | 180 | ..... |
| subtending head | K | ..... | ..... | 5000 | ..... |
| at heading time. | Mo | ..... | 0·015–0·13 p.p.m. | ..... | 0·21–0·3 p.p.m. |
| CELERY | N | ..... | ..... | 400 | ..... |
| Middle third of | P | ..... | ..... | 180 | ..... |
| mature petioles. | K | ..... | ..... | 5200 | ..... |
| | *Mg | 34 | ..... | 75 | ..... |
| | Ca | ..... | ..... | 700 | ..... |
| PEA | N | <70 | ..... | 800 | ..... |
| Stem and petioles | P | 15–46 | ..... | 156–500 | ..... |
| at flowering. | K | 2000–4000 | ..... | 7600 | ..... |
| POTATO (Muck soil) | *N | <200 | ..... | >200 | ..... |
| Petioles, third | P | ..... | ..... | 70 | ..... |
| from apex just | *K | <3000 | ..... | 3500–4000 | ..... |
| before full bloom. | | | | | |
| POTATO (Mineral soil) | N | <800 | ..... | 1200–1400 | ..... |
| | K | ..... | ..... | 5000 | 6·0 |
| Petioles, third from apex just before full bloom. | | | | | |
| Laminae, third | P | ..... | <0·3 | ..... | 0·35 |
| from apex just | K | ..... | ..... | ..... | 3·5 |
| before full bloom. | | | | | |
| ONION (Muck soil) | *N | ..... | ..... | 200–400 | ..... |
| Middle third of | *P | <30 | ..... | 75–100 | ..... |
| foliage, mid-July. | | | | | |
| SPINACH | N | ..... | ..... | 800 | ..... |
| Top of plant at | P | ..... | ..... | 200 | ..... |
| midseason. | K | 3900 | ..... | 7800 | ..... |
| | *Mn | ..... | 0·0008 | ..... | 0·0025 |
| TOMATO | N | ..... | ..... | 1100–1400 | 2·4 |
| Petioles, third | P | ..... | ..... | >70 | 0·27 |
| from apex just | K | ..... | ..... | 3500 | 5·0–6·0 |
| before full bloom. | | | | | |
| Laminae, third | N | ..... | ..... | ..... | 3·4 |
| from apex just | P | ..... | ..... | ..... | 0·27 |
| before full bloom. | K | ..... | ..... | ..... | 3·0 |
| APPLE | *N | ..... | ..... | ..... | 2·1 |
| Leaves, mid- | P | ..... | ..... | ..... | 0·15–0·24 |
| portion of new | *K | ..... | ..... | ..... | 1·7 |
| growth, terminal | Mg | ..... | 0·05–0·2 | ..... | 0·15–0·25 |
| shoots, mid-July. | Mn | ..... | ..... | ..... | 0·006–0·015 |
| | Zn | ..... | 0·001 | ..... | 0·0015–0·003 |

TABLE C-8.—ESTABLISHED AND TENTATIVE CRITICAL LEVELS FOR VARIOUS HORTICULTURAL CROPS—*Concluded*

| Portion sampled and date or stage | Nutrient | Levels in deficient plants | | Levels in normal plants | |
|---|---|---|---|---|---|
| | | F.W.B.[1] | D.W.B.[2] | F.W.B. | D.W.B. |
| | | p.p.m. | %[3] | p.p.m. | % |
| APPLE..... Fruit, mid-July. | B | .....[4]..... | 0·0003–0·001 | ..... | 0·0016–0·003 |
| BLACK CURRANT.... Leaves from fruiting wood, mid-June. | N | ..... | ..... | 600–800 | 2·7–3·3 |
| | P | ..... | ..... | ..... | 0·31–0·37 |
| | K | ..... | ..... | 4500–5000 | 2·5–2·6 |
| | Mg | ..... | ..... | ..... | 0·26–0·3 |
| STRAWBERRY..... Leaves from primary runners, mid-June. | *Mn | ..... | 0·0023 | ..... | 0·0137 |
| RASPBERRY..... Leaves from non-fruiting growth, September. | N | 150 | 2·4 | 800–1000 | 3·4–3·7 |
| | P | 46 | 0·11 | 300–400 | 0·25–0·35 |
| | K | 450 | 0·5 | 4000–5000 | 1·8–2·6 |
| | Mn | ..... | 0·0015 | ..... | 0·012 |

[1]On fresh weight basis: two per cent acetic acid soluble nutrients expressed as p.p.m. of the fresh material.

[2]On dry weight basis: total nutrients expressed as per cent of the dried material.

[3]As per cent, except where stated otherwise.

[4]Indicates that no value has been determined.

*Indicates firmly established critical levels.

***Phosphorus Content of Potato Plants in Relation to Yield and Phosphorus Concentrations in Nutrient Solutions***

Table C-8 indicates that the rachis or petiole of many vegetable crops was the particular plant part selected for analysis. Also more analyses have been on that fraction of the constituent extracted by two per cent acetic acid. Nevertheless, neither potatoes nor tomatoes have shown a consistent or reliable phosphorus to yield relationship with such analysis on this particular portion of the plant. A specific difficulty has been the association of a relatively narrow range of phosphorus values with wide yield increases. To clarify this situation, that is, the plant part and the phosphorus fraction most closely related to yield, a greenhouse pot culture study with potatoes was conducted.

*Petioles.*—Relationship between either soluble or total phosphorus and 5 to 20 p.p.m. levels of phosphorus in the nutrient solutions was lacking, even though there was a significant increase in yield with each increase of phosphorus supply within this range. The phosphorus content showed a marked progressive increase when the nutrient solutions contained 30 to 75 p.p.m., but the yield increase was only 12 per cent and not significant.

*Leaf blade or entire plant top.*—Throughout the entire range of phosphorus levels in the solution both leaf blades and total plant top showed a progressive increase of soluble phosphorus. A continuous relationship (Fig. C-2) was obtained between the total phosphorus content in the leaf blades or entire plant top and the phosphorus supply, and the total phosphorus content provided a wider range of values at the lower levels of phosphorus than the soluble phosphorus determinations. The determination of total phosphorus in the leaf blades provided the best relationship index between yield and the phosphorus content of the plant. Indications are that the total phosphorus content of leaf blades should probably be not less than 0.35 per cent.

On the basis of these results the total content of the ashed leaf blades will now be employed to establish critical levels.

The results of this study will be found in greater detail in "Phosphorus Content of Potato Plants in Relation to Yield, and to Phosphorus Concentrations in Nutrient Solution" by H. Hill, A. B. Durkee, H. B. Heeney and G. M. Ward, which will appear in a forthcoming issue of the Canadian Journal of Agricultural Science.

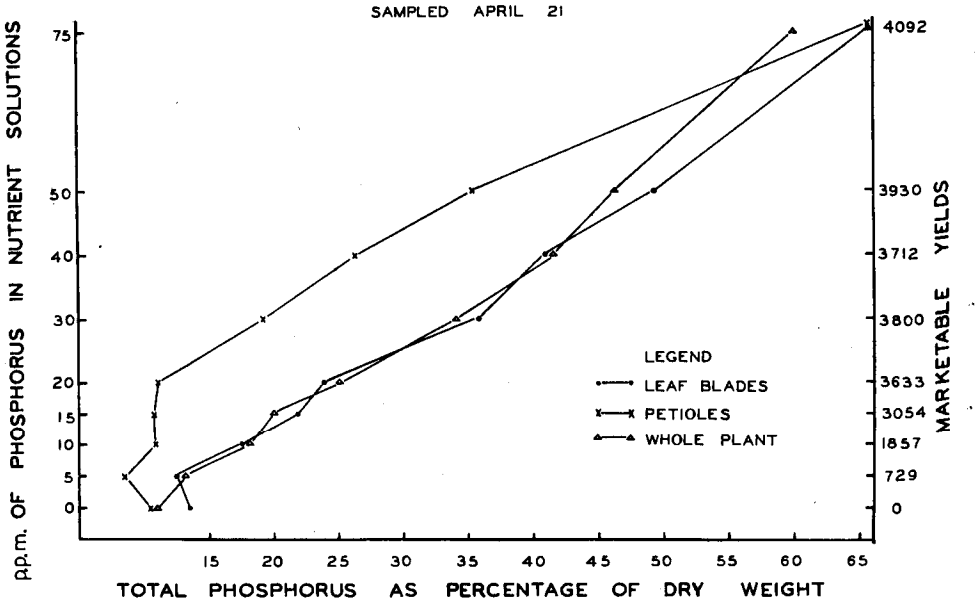


Fig. C-2—Relationship between phosphorus supplied, total phosphorus in various tissues, and yields of pot-cultured potatoes.

***Factors Affecting Potato Quality***

Past research has indicated that the factors affecting potato quality, especially the blackening of cooked potatoes, are of a complex interacting nature. In a study of this problem some effects of the application of fertilizer on potato tuber quality have been noted. The application of muriate of potash was accompanied by an absorption of chlorine and a reduction of dry matter in the tuber. While an application of 100 pounds of $K_2O$ in the form of KCl reduced the dry matter only a fraction of 1 per cent, an application of 300 pounds reduced the dry matter percentage in excess of 2 per cent. There was an apparent relationship between a reduction of dry matter in the tuber and the chlorine content. In some cases there was actually an increase in dry matter with increased potassium when the chlorine levels were very low. Cooking trials revealed, however, that while texture ratings were lowered with the application of KCl, the color of the cooked tubers was improved.

In an attempt to obtain further information on the effect of potassium on tuber quality, potatoes were grown in the greenhouse with nutrient solutions at five different levels and with two sources of potassium, potassium chloride and potassium nitrate.

There was a very discernible progressive decrease in graying or blackening of the cooked tubers as the potassium supply was increased either as muriate or nitrate of potash. When treatments receiving the same amount of potassium but with varying levels of chlorine are compared, discoloration increased with increased levels of chlorine.

These studies indicate that while large amounts of muriate of potash may decrease potato dry matter, an insufficient supply of potassium will increase the tendency of potatoes to discolor upon cooking. Where the potassium requirements of a soil are such that larger quantities are necessary, it might be well to apply a part of the fertilizer to the previous crop in the rotation so that chlorine absorption might be lowered. Workers who have recognized the importance of chlorine content in the reduction of dry matter have recommended this practice in Europe.

***Relationship Between Nitrogen Content and Storage Quality of the McIntosh Apple***

Over a period of years a study was made of the relationship between the analysis of foliage sampled in mid-July and the subsequent storage quality of McIntosh and Spy apples. In this study a highly significant negative correlation was obtained between the foliage nitrogen and fruit quality. In the Spy variety a marked decrease in quality occurred with foliage nitrogen above 1.9 to 2.0 per cent and a like decrease of quality occurred in the McIntosh variety with foliage nitrogen above 2.0 to 2.1 per cent. A much smaller positive relation appeared between foliage potassium and fruit quality. The data between potassium levels and storage quality suggest that quality may be impaired if potassium levels fall below 1.7 per cent. These foregoing relationships, considered reliable for nitrogen and potassium, are now being used to make fertilizer recommendations for growers' orchards.

The question then arose whether the nitrogen content of the fruit itself could be employed as an index of fruit quality and whether such data could also be employed to determine orchard nitrogen requirement.

To explore this possibility a study was conducted in 1952-53 with a group of thirteen trees that had received differential nitrogen applications. Total nitrogen was determined on the foliage in mid-July. Total nitrogen, soluble nitrogen and protein nitrogen were determined on apple pulp at harvest time. Harvested samples were stored at 32°F. for quality grading and storage behavior in mid-January.

TABLE C-9.—THE RELATIONSHIP BETWEEN FRUIT QUALITY RATING AND THE NITROGEN CONTENT OF THE LEAVES AND FRUIT OF THE McINTOSH APPLE

| Fruit quality rating | Leaf nitrogen | Fruit pulp | | |
|---|---|---|---|---|
| | | Total nitrogen | Soluble nitrogen | Protein nitrogen |
| | % | % | % | % |
| 68 | 2·37 | ·028 | ·0105 | ·0186 |
| 63 | 2·22 | ·028 | ·0101 | ·0195 |
| 63 | 2·23 | ·027 | ·0118 | ·0188 |
| 62 | 2·35 | ·032 | ·0108 | ·0161 |
| 62 | 2·30 | ·029 | ·0127 | ·0220 |
| 61 | 2·24 | ·026 | ..... | ..... |
| 60 | 2·46 | ·037 | ·0170 | ·0185 |
| 59 | 2·49 | ·043 | ..... | ..... |
| 54 | 2·54 | ·037 | ·0169 | ·0189 |
| 53 | 2·49 | ·039 | ·0210 | ·0188 |
| 51 | 2·47 | ·032 | ·0148 | ·0178 |
| 50 | 2·44 | ·045 | ·0243 | ·0196 |
| 43 | 2·63 | ·042 | ·0279 | ·0226 |

The relationships between analytical data and fruit quality are shown in Table C-9. Fruit quality decreases with progressive increases of leaf nitrogen or total or soluble nitrogen in the fruit pulp. No relationship is apparent between protein nitrogen in the fruit pulp and the fruit quality rating. When the relationship between foliage nitrogen and quality and the relationship between total and soluble fruit pulp nitrogen are compared, some evidence of a more regular relationship using the fruit pulp nitrogen is shown.

These studies offer some evidence that analysis of fruit nitrogen, especially the soluble fraction, offers a means of estimating fruit quality. Considerably more such data will have to be obtained to establish constant, critical relationships.

Some of these results will be found in greater detail in "Foliage Analysis as a Means of Determining Orchard Fertilizer Requirements" by H. Hill. Rept. XIII Int. Hort. Congr. 1: 199-214. 1952.

The chemical analyses in these studies have been conducted mainly by the Chemistry Division, Science Service, Ottawa.

## RASPBERRY SOIL MANAGEMENT

A deficiency of soil moisture during the fruiting period is frequently the main limiting factor in raspberry yields, therefore conservation of soil moisture is necessary. Because of the scarcity of barnyard manure some other method of maintaining organic matter and conserving soil moisture is also of importance.

In a comparison of two mulch types of management with the standard management, the following average annual yields for 1951-53 were obtained:

1. Clean cultivation from early spring to harvest, cover crop of fall rye, 15 tons of manure per acre and 9-5-7 fertilizer at 700 lb. per ac. Yield: 2819 lb. per ac.

2. Sawdust mulch maintained to a depth of 4 inches with ammonium sulphate surface applied at 300 lb. per ac. at any mulch application, and an annual application of 9-5-7 fertilizer at 700 lb. per ac. Yield: 4,118 lb. per ac.

3. Straw mulch maintained to a depth of 4 inches with ammonium sulphate surface applied at 150 lb. per ac. at any mulch application, plus an annual application of 9-5-7 fertilizer at 700 lb. per ac. Yield: 2,252 lb. per ac.

The sawdust mulch has been much more effective in weed control than straw mulch, which latter may introduce weed seeds. When the sawdust is applied over the whole area (as it was in these trials) instead of being confined to the row areas, raspberry sucker growth is greatly increased between the rows and constitutes a removal problem. In an attempt to overcome this disadvantage it may be possible to confine the sawdust mulch to the row area and plant the intervals to perennial rye grass to be kept closely mowed. The effect of such amendment on yield is yet to be determined. A plot with the foregoing treatment will be laid out in an attempt to show whether under these conditions sawdust mulch still tends to increase yields over other forms of management.

During the years of the trial the soil moisture level was adequate under all treatments at the 12-inch depth as indicated by the Buoyoucous moisture blocks. In 1953 additional blocks were placed at a depth of 6 inches, and it was noted that the moisture level at this depth in the clean cultivated plot was less than 50 per cent available during the periods July 22 to August 4, and August 24 to September 8. Moisture was adequate at 6 inches in both the mulched plots throughout the season.

The sawdust mulch plot has shown a marked increase in soil organic matter at 6-, 12- and 18-inch depths, while with the other two treatments only relatively slight increases are recorded to 12 inches. Total soil nitrogen has also increased to a greater depth in the sawdust mulch plot.

As for winter injury, the plot with the sawdust mulch has shown little injury to date while the two other plots have so far been rather seriously injured at least once.

The studies will be continued with the addition of the plot row-treated with sawdust mulch and perennial rye grass sown between the rows.

## THE APPLICATION OF FERTILIZERS IN SOLUTION FORM

Increasing interest is being shown in the possibility of applying fertilizers in solution either as a substitute for, or a supplement to, dry fertilizers applied to a soil.

Both liquid and completely soluble dry fertilizers have been employed for specific purposes and have been applied by different methods. Some of these are discussed in the light of experimental evidence.

### *Transplanting or Starter Solutions*

Liquid or soluble fertilizers with a relatively high phosphorus content such as 10-30-10, 15-30-15, 10-52-17 and 7-14-7 have been employed for some time by tomato growers at the time the plants are set out in the field. They have been employed to a lesser extent in the same way in the production of such crops as cabbage and cauliflower. The general method of application has been to dissolve approximately 5 pounds of the fertilizer in 50 gallons of water and to apply one half-pint of this solution in the planting hole.

Comparisons between employing water only for this purpose as compared with a starter solution have in some cases shown that the starter solution increases the total yield but invariably results in the more marked effect of causing early development and ripening of fruit. In such a comparison a 6 per cent increase in total yield but a 20 per cent increase in ripe fruit at the first date of picking has been obtained.

Analysis of plant petioles, sampled three weeks after planting, have shown a marked effect of the starter in increasing the phosphorus content in the plant. The content of soluble phosphorus in plants receiving a starter was in three successive years 196, 172 and 150 p.p.m. compared with 68, 72 and 85 in those plants receiving water only when transplanted. An ample supply of available phosphorus at the time of transplanting is very important for quick induction of an extensive root system, and it is considered that the increased level of phosphorus in the plants supplied by the starter is the main reason for earlier fruit maturity.

The fact that such transplanting solutions quickly assure a relatively high level of phosphorus in the plant suggests that greater use should be made of this treatment in setting out annual ornamental material or in transplanting perennial material. In this way a root system will be established more quickly and transplanting set-back will be appreciably reduced. The same types of soluble fertilizers have been employed to advantage in watering flats of annual flowers awaiting transplanting out-of-doors or for watering flats of such vegetables as tomatoes and cabbage.

### *Fertilizers Applied as Foliage Sprays*

The extent to which foliage sprays can be economically employed as a main source of fertilizer depends to a considerable extent upon the elements involved. A distinction in this respect should be made on the basis of the two main groups of elements—the major and the trace elements.

The reasons for considering these two groups separately are based upon the following facts.—The concentration of the different trace elements found in plant tissue or removed by a crop is of the order of one one-hundredth to one one-thousandth of that of the major elements. Even if there is practically no supply available to the plant from the soil the amount of trace element a plant must secure from an applied source is quite small. This is important since the maximum quantity that can be applied as a spray or sprays is limited by the concentration of the salt that can be used without having a caustic effect on the growing plant. Thus if a 400-bushel crop of potatoes removes 175 pounds of potassium but only 1 pound of boron, it is possible to supply the total boron requirement in the form of foliage sprays. A concentration of 2½ pounds of borax in 100 gallons may be used without causing injury and three sprays will supply the total requirement. On the other hand a concentration of a potassium salt greater than 10 pounds in 100 gallons is liable to cause foliage burning, and three sprays will supply only about 18 pounds of actual potassium. While the total requirement of trace elements can be applied as foliage sprays it is possible to supply only a small fraction of the total requirement of a major element such as potassium in this way. It has been shown by other workers that as much as 7 per cent of the phosphorus requirement of developing tomato fruit was supplied by a single foliage spray, and 40 per cent from four applications. When apple trees were sprayed with diammonium phosphate it was found that from 2 to 3 per cent of the phosphorus content of the plant was derived from the foliage spray.

Even though the actual percentage of the applied fertilizer absorbed by the plant may be considerably greater when applied as a foliage spray, the total amount that may be applied is limited, and the application of such major elements can only be considered as emergency or supplemental treatments where a quick response is desired and where a slight increase in plant concentration is sufficient.

Deficiencies of trace elements in the plant are more frequently due to unavailability than to an actual deficiency of the element in the soil. When such elements are added to certain soils they are quickly converted to an unavailable form, so that trace elements in general as well as the element magnesium have been found more effective when applied as foliage sprays.

In the foliage application of the major elements the greatest attention has been given to nitrogen. Nitrogen has been applied in the form of urea, a commercial form of which is marketed under the name "Nugreen". When used in apple orchards at a concentration of 5 pounds in 100 gallons the green color of the leaves is quickly intensified. The effect is transitory and three to four sprays are necessary if they are to be relied upon as the main source of nitrogen. The opinion is held that foliage sprays of nitrogen should be considered emergency supplementary treatments rather than supplanting soil applications. There has been some evidence that foliage sprays of urea have been successful in increasing fruit set and their use may also result in a more precise control of nitrogen level in the tree.

Less extensive studies have been conducted with urea or complete fertilizer foliage sprays in the production of vegetables. However, with vegetables also the effects are transitory and successive applications at weekly intervals are required if sprays are to constitute the major source of applied nutrients.

One or two foliage sprays during a period when soil nitrification is low or when side dressings of dry fertilizer are unavailable to the plant because of low soil moisture should prove a special and immediate benefit.

# ORNAMENTAL HORTICULTURE

## OUTDOOR ORNAMENTALS

*R. W. Oliver*

The ultimate purpose of ornamental horticulture is to help the individual raise his standard of living by using plants to provide beauty and comfort to his home surroundings. Our task is to determine the best plants and the most efficient methods by which they can be grown both by the commercial nurseryman and amateur gardener, then to make this information available through demonstration and literature.

As demonstration is the best form of instruction, the ornamental grounds are maintained as an open park where people can see various plants arranged for landscape effect, or study large collections of horticultural varieties to evaluate the characteristics of each. This great attraction to visiting thousands is, as well, a stimulus to their desire for more information which is furnished through correspondence and the distribution of literature. In the five-year period covered by this report approximately seven thousand letters were answered, and thousands of bulletins and pamphlets were distributed dealing with some phase of ornamental horticulture.

While it is felt that this policy best fulfils the ultimate objective, public demand for information means that the greater part of the staff's time and of the available ground area are thus absorbed, leaving a lesser part for actual experimental work.

The work can be divided into three main phases.—(1) Testing newly introduced species and varieties to evaluate their usefulness under local conditions; (2) Origination, through breeding, of new varieties with superior characteristics; (3) Conducting experiments in propagation, nutrition and other phases of plant cultivation that will assist both commercial and amateur growers.

### Trees and Shrubs

In the past 65 years (1888-1953) most known woody ornamental plants indigenous to the temperate zone and sufficiently hardy to succeed at Ottawa have been tried out on the grounds. Up-to-date information concerning these has been presented in two bulletins, "Deciduous Trees and Conifers", 1953, and "Ornamental Shrubs and Woody Climbers", 1954.

The hedge collection started in 1889 has been maintained and a few new ones added recently. Information on hedges has also been brought up-to-date in a new bulletin, "Hedges for Canadian Gardens", 1953.

In recent years there has been a fairly rapid natural decline of the trees planted 60 or more years ago. This seems to be the life span of several species when grown on light sandy soil under open park-like conditions. Norway and silver maples, mountain ash, American elm and Scots pine particularly seem to have reached the stage where they can no longer throw off the attacks of wood-rotting fungi and boring insects. Consequently, much new planting has been done and much more is planned to effect necessary replacements and changes demanded by new buildings and road alterations. Form of planting must also change so as to be seen from faster moving traffic.

***New Introductions***

Descriptions of three worthy woody plants introduced during the past few years but not included in the aforementioned bulletins, are:

*Juniperus scopulorum* Smithers.—A very upright columnar form of the native western red cedar. It came in a lot of natural seedlings collected and forwarded by F. V. Hutton, Dominion Experimental Station, Prince George, B.C. The attractive blue-green foliage is carried on perpendicular branchlets creating a very vertical planting note. It will be distributed to the nursery trade as soon as sufficient stock can be propagated.

*Parthenocissus radicantissima.*—Closely resembles *P. Engelmanii* but has smaller, more refined foliage. Unfortunately it seems loath to attach itself to masonry at the start, but makes an excellent bank or fence cover. It was sent from Alnarp, Sweden, at the request of M. B. Davis, who had been attracted to it on his visit to that country in 1946.

*Salix purpurea nana.*—A dwarf blue-leaved form of the purple willow, now very popular. The foliage is very fine in texture and attractive in color. The slender, graceful branches are always in motion making it an attractive shrub when cut back each year. It should also make a good hedge plant.

***Propagation***

No large-scale experimental work in the propagation of trees and shrubs has been carried on through this period. However, the general practical work of propagation in the nursery together with small scattered experiments have provided the following summary of information:

*Rooting softwood cuttings.*—The so-called growth-promoting chemicals as indolbutyric acid and naphthylacetamide will stimulate the rooting rate of softwood cuttings of most genera and species that root naturally. Some of these are *Buxus, Caragana, Deutzia, Forsythia, Genista, Hydrangea* and *Philadelphus.* Therefore, they are useful in developing better-rooted plants that will have more chance of surviving the first winter. They are, however, of very little value with such species as *Cotoneaster, Cotinus, Malus* and *Syringa* that do not root easily.

*Rooting Conifers.*—Cuttings of the coniferous genera, *Chamaecyparis, Taxus* and *Thuja,* respond favorably to these chemicals as do *Juniperus chinensis* and *J. communis.* Other junipers do not respond, and in our trials *Picea Abies* has been definitely negative. We have had no practical success in rooting other species of *Juniperus, Picea* or *Pinus* with or without chemical treatment.

*Media.*—The particular medium--sand, peat, vermiculite or sandy soil—in which softwood cuttings are "stuck" or hardwood cuttings are stored does not seem to be important. Proper moisture and oxygen balance within the medium determine the success. More moisture must be supplied to sand than to soil or vermiculite. Provided foliage on the cuttings can be kept turgid by atmospheric humidity, root development is best if the medium is kept on the dry side.

Quality of root systems does depend on the medium. Sand if held on the dry side produces very stocky, brittle, white roots. The addition of peat tends to darken the roots and increase fiber.

*Time of Collection.*—At Ottawa, December is the best month for taking hardwood cuttings of deciduous trees and shrubs for propagation. Then the wood is fully ripened. In earlier months the quantity of stored carbohydrates is lower; in later months the wood is partly desiccated. The best storage temperature was 35 to 40°F. in a medium half sand and half moistened peat.

Callus formation during storage does not seem to have much connection with root formation. In fact, excessive callusing seems to obstruct root formation.

Conifer cuttings are also best taken in December. The most practical method is to "stick" them in sand in a cool greenhouse with bottom heat 5 to 10°F. above air temperature and to maintain turgidity by shading with cheesecloth, frequently syringed. They are then ready for planting in a cold frame in April or May.

If rooted in a closed propagating frame at higher temperature they root more quickly but must be potted in February or March, an extra labor requirement.

*Air-layering.*—During the summers of 1952 and 1953 an adaptation of the old greenhouse method of "air-layering" was practised for the propagation of *Cotinus coggygria, Euonymus alata, E. europaeus* and *Syringa* hybrids.

In mid-June branches of wood of the previous season were slit part-way through, just below the base of the new season's growth. Sphagnum moss from which surplus moisture had been thoroughly squeezed was then wrapped around the wounded branch with a strand or two of moss holding the slit slightly open. Moss formed a pad about three-quarters to one inch thick around the branch for a distance of 2½ to 3 inches. An 8-inch plastic square was wrapped around the moss and firmly tied with raffia. In 1952 various plastics were used as the moisture conserving wrap. Since polyethylene alone was successful, this material was used to wrap all cuttings in 1953.

Quite satisfactory results were obtained if all surplus moisture was squeezed from the moss. In eight weeks 50 per cent of properly prepared layers produced roots. Leaving too much moisture in the moss—a strong human tendency—resulted in bark rotting.

*Seed Germination in the Rose.*—In past years the rose breeding program has been hampered by uncertain and slow germination in various rose species. Experimental work here has not given conclusive results with all species. However, it would appear that rose seeds should be left in the hips and stored at 40°F. until ready to sow.

Seeds of continuously blooming garden roses are best sown in a warm greenhouse when slightly immature. Once these seeds have matured and dried they, just as other species, require stratification. Seeds of such species as *R. canina* and *R. spinosissima* germinate more freely after stratification for three to four months at 40°F. than when stored dry over winter. After stratification, germination was more uniform at 50°F. than at higher temperature, though even the best lots continued to germinate over two seasons.

## Roses

In spite of careful protection, winter losses to Hybrid Tea varieties are always severe under Ottawa conditions. Open winters, as were two of the last five, seem to do more damage than really cold ones. In such winters the heat-absorbing dark covers increase thawing and freezing. They also make comfortable winter quarters for field mice, which seem to prefer rose bark to any poisoned bait yet discovered.

Fiberglass blankets are excellent insulators for winter protection of individual plants. The white color reflects the heat of the sun, an added advantage. The material is expensive, however, for thorns tear it so that it can be used only two years. Also, when working with it long leather gauntlets must be worn, for the glass fibers are very irritating to the skin.

Because of winter losses the turnover of varieties in the garden is quite rapid. However, this provides the opportunity to try out new varieties of merit soon after their introduction.

***Climbers***

No new climber introduced in the last five years has proved so hardy as the older ones, hence none has been worth mentioning. Nevertheless, Elegance has produced blooms of excellent quality and is an attractive golden-apricot color.

***Hybrid Teas***

The Hybrid Tea group originated by the Brownells of Little Compton, Rhode Island, have proved somewhat hardier than the class as a whole. Out of twenty-seven plants (three in each of nine varieties) only two have been killed in the last three years, whereas over the whole range of Hybrid Tea varieties the loss was over 25 per cent. While the Brownell varieties are very floriferous they lack quality compared with the others and consequently are mainly useful for informal bedding. In this group we like the varieties:

Break of Day..... Buff orange shades
Shades of Autumn..... Coral red and gold blend
V for Victory..... Yellow with pale edge

Of the new good quality Hybrid Teas tried in our garden since 1949 the following proved excellent:

4.5* Barnaby—A very fine cream, originated by the late H. M. Eddie of Vancouver.
3.7 Chas. Mallerin—Very fine crimson.
7.3 Chief Seattle—Scarlet with gold reflex.
19.6 Diamond Jubilee—Golden apricot, particularly fine form in bud.
13.3 Eclipse—Fine golden yellow with long bud; very strong, erect stems.
6.2 Helen Traubel—Very full, rounded form. Glowing golden rose color.
12.0 Peace—Pale cream-yellow with rose edge. Very large blooms; flops badly in our sunny garden.
3.3 Lodestar—Another rose-gold blend like Helen Traubel but different in form.
7.3 Tawny Gold—Color true to name; form very firm.

*The figures before the variety name represent the average number of blooms per plant during July and August, 1953.

***Hybrid Polyanthas***

The last five years have convinced us that for garden purposes in this district—color per square yard per week—the newer Hybrid Polyantha or Floribunda roses are far superior to others. The following are excellent hardy varieties tried out during the last five years:

44.0 Chatter—Dull crimson, fine for bedding.
*55.1 Else Poulsen—Tall, single, deep rose-pink.
*190.2 Eutin—Tall, smaller crimson flowers in large clusters.
36.3 Fashion—Excellent, coral-apricot, hardy bedder.
*128.5 Fortschritt—Fine apricot-white, for bedding.
24.6 Goldilocks—The best of the yellows we have tried.

83.0 Joyous—Very good deep rose-pink.
47.4 Mrs. R. M. Finch—Excellent, hardy, shell pink to rose.
58.6 Red Ripples—Bright crimson bedder.
*56.0 Snowbank—The best white we have grown.
*Varieties not new to our garden but still among the top ten.

The much higher figures for bloom on this list than for Hybrid Teas in the preceding indicates the extra show obtained from the Hybrid Polyanthas.

## Herbaceous Perennials

The two open winters 1949-50 and 1952-53 with little snow protection and much ice over the low areas caused heavy damage to the perennial borders and variety collections. This decreased the show from perennials in 1950 and 1953 but at the same time provided the opportunity and challenge to replant with new varieties.

### *Garden Chrysanthemums*

The open winters and variable summers have convinced us that garden chrysanthemums cannot be considered reliable perennials at Ottawa. Very few varieties will survive the average winter and these only in sheltered positions where they are covered with snow. Date and quality of bloom vary from year to year according to the temperature and cloudiness at bud initiation time in July. Therefore, they cannot be counted on for a main fall garden show as had been hoped.

New plants must be grown yearly from cuttings started in a greenhouse or from small divisions taken from old plants in spring. This involves considerable labor and groups garden chrysanthemums with those plants that require special attention rather than with hardy perennials.

### *Hemerocallis*

Eighteen new varieties of Hemerocallis have been added in an attempt to keep up with the best of the great flood of material being brought out by amateur plant breeders in the United States. No addition has produced anything better than the varieties recommended in the bulletin, "Herbaceous Perennials", 1952. The results have shown however, that so far as this plant is concerned recommendations must be based on Canadian trials, for many varieties highly esteemed by the American Hemerocallis Society are not sufficiently hardy here.

### *Iris*

In the last three seasons 168 new varieties of garden iris have been added to the collection. This includes excellent collections of varieties of their own origination from Mrs. Jean Stevens of Wanganui, New Zealand, and Mrs. Olive Murrell of Orpington, Kent, England. Many other additions have been made through the generosity of various directors of the Canadian Iris Society to whom we are very grateful.

Most of these new varieties have not proved themselves here sufficiently for us to recommend them generally. However the following new varieties of Canadian origination have been particularly impressive:

Algiers (Bickle)—Excellent, tall, deep rose blend.

Elizabeth of England (Miles)—Light blue self of excellent quality.

City of Stratford (Miles)—Large, deep violet-purple of very fine texture.

Forse's Gold (Forse)—Very large, deep, clear, gold self. Outstanding in our garden but shows water marks on heavier soils.

Vice Regal (Miles)—Deep red-violet with prominent, bright orange beard.

The iris collection was rearranged in 1952 into separate sections for old-fashioned varieties, Canadian originations, British and New Zealand varieties, and a general collection. This should be of more interest to the rapidly growing number of iris enthusiasts than having the collection arranged alphabetically as previously.

***Peony***

Thirty-two new varieties have been added to the peony collection. Of these we particularly like Jocette, a rose-colored single; the semi-double shell pink Rare China, and the very large fully double white Louise Lossing, a Canadian origination. Another Canadian of great promise is Donna Jean, a compact fully double red-flecked white, originated by Mr. Wm. Browne of Elora.

## Rock Garden

One of the most interesting features of our grounds is the new rock garden constructed during 1947 to 1952. The older portion of the planting has developed well so that it is beginning to have some character. Public interest has been great and the comments very favorable.

A great variety of planting material has been tried out. In 1947 and 1948 seeds of species and botanical varieties, which we felt might produce suitable rock garden material but had not been tried here previously, were obtained from botanic gardens throughout the northern hemisphere. A few plants of each sort were set out as the rock work progressed and observations were made on their behavior. This resulted in much botanically interesting material, but only a few plants could be considered worthy ornamentals under our conditions. Other new material was secured from commercial nurseries.

Much material was killed out during the first or second winter; much was not worth growing; much more was untrue to name, expected in seed from species growing in close proximity. The worst example was in *Dianthus*. Forty-four lots with different names were planted. Thirty-six were new to our garden. The result was a lot of mixed up, washed out lavenders, mostly showing some characters of *D. plumarius* or *D. gratianopolitanus* (caesius). The only new ones worthwhile were *D. inodorus*, which forms lovely mossy tufts of foliage with small white rather insignificant flowers, and *D. zonatus*, much taller with broad leaves and deep rose-red flowers.

Other similarly badly mixed genera were *Alyssum, Aethionema, Anemone, Arabis, Armeria, Campanula, Erysimum, Penstemon, Phyteuma, Saxifraga, Silene* and *Veronica.*

Of the rock plants tried over the last five years that are new to our garden the most worthy are:

*Achillea ageratifolia.*—Tufts of silver gray pinnatifid foliage with slender 6- to 8-inch stems bearing white flowers in June.

*Achillea Clavennae.*—Similar to preceding but taller, 10 to 12 inches.

*Achillea serbica.*—Low mats of finely toothed leaves not pinnatifid, white flowers, 8 to 10 inches.

*Allium Ellisii.*—Broad leaves with large globular heads of pink flowers.

*Antennaria microphylla.*—Close creeping silky gray mat of fine leaves. Small white flowers on slender 10- to 12-inch stems.

*Anthemis carpatica.*—Low tufts of gray-green foliage with many 6-inch stems bearing 1½- to 1¾-inch flowers with white rays.

*Arabis albida* Jean Brodie.—Received from Mrs. Jean Brodie, Garden Editor of the Toronto Star. The deepest rose-colored *Arabis* we have grown.

*Aster alpellus* Triumph.—An *A. alpinus*×*Amellus* hybrid. The large lavender-blue flowers make a good show in late June.

*Artemesia* Silver Mound.—Good for foliage only and described by its name.

*Artemisia* Silver King.—This, too, is a good foliage plant but more useful for a perennial border as it is 24 to 30 inches tall.

*Callianthemum angustifolium.*—Tufted gray pinnatifid foliage with white flowers on 8-inch stems.

*Campanula marchesetti.*—A large-flowered form similar to *C. rotundifolia.*

*Campanula sub-pyrenaica.*—A taller form comparable to *C. persicifolia* but with firmer, dark green foliage and wide flaring bells.

*Dianthus deltoides* Little Jock.—Dark red dwarf form of the species.

*Dianthus deltoides* Wisley.—Very dark red, large-flowered form of species.

*Dianthus deltoides* Tiny Rubies.—Compact tufts of gray foliage; 6-inch stems bear small, fully double, deep rose carnations.

*Eriophyllum caespitosum.*—Flat, coarse mats of gray-green foliage, covered with three-quarter-inch yellow daisies. Inclined to be tender.

*Lavandula* Summerland.—Can be used to better advantage in the perennial border; quite hardy at Ottawa; from the Experimental Station, Summerland, B.C.

*Phlox subulata* Schneewitchen.—An excellent white mat when in bloom with good, neat foliage later.

*Phlox subulata* Apple Blossom.—A lovely pale pink.

*Tulipa praestans* Fusilier.—A spring flowering bulb but such an excellent scarlet blaze in the rock garden that it should not be missed.

The list contains, of course, only a few of the many effective plants. The majority are discussed in more detail in the bulletin, "Herbaceous Perennials".

## Annual Flowers

Since 1948 we have grown many more annual flowers than in the preceding ten years, trying out each year 50 to 100 varieties from among the best offered by various seed houses. These have been planted in formal and informal bed arrangements rather than the former single field rows in cultivated ground. The new arrangement is much more popular with visitors. It enables them to choose combinations of varieties and colors that please them and to avoid those that do not.

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A list of the best would be monotonous for it would simply repeat names of the All America Selections found in various garden magazines for the last five years. However, the following few have been outstanding in our garden and can be recommended whole-heartedly:

*Ageratum* Blue Cap.—Uniform edging plant, 4- to 6-inch height.
*Alyssum* Carpet of Snow.—Almost flat mats of clear white.
*Cleome* Pink Queen.—Tall plant, blooms over a long period.
*Cleome* Helen Campbell.—Good white, not so tall as preceding.
*Centaurea* Blue Gem.—Good color, medium height.
*Cosmos* Dazzler.—Deep red, large flower.
*Cosmos* Fiesta.—Not so tall as others, orange color.
*Dimorphotheca aurantiaca.*—Mixed colors, dependable all season.
*Eschscholtzia* Carmine King.—True to color, which is unusual.
*Godetia* Kelvedon Glory.—Very good crimson.
*Lobelia* Crystal Palace.—Tall variety, vivid indigo-blue.
Marigold Flash.—Semi-double orange-bronze, 15 to 18 inches.
Marigold Glitters.—Carnation-flowered yellow, 27 to 30 inches.
Marigold Naughty Marietta.—Single gold with mahogany band, 18 to 21 inches.
Marigold Redhead.—Semi-double orange-mahogany, 18 to 21 inches.
Marigold Tangerine.—Covered with flat double orange flowers, 12 to 15 inches.
Marigold Sunkist.—Excellent orange pompon for bedding, 8 to 10 inches.
Marigold Yellow Pigmy.—Excellent gold pompon for bedding, 8 to 10 inches.
Pansy Coronation Gold.—True gold self for bedding.
Pansy Swiss Giant White.—Clear white self for bedding.
Pansy Ullswater.—True bright blue with navy face.
*Petunia* Admiral.—Excellent royal blue, tall bedder.
*Petunia* Ballerina.—Large frilled rose-red flowers.
*Petunia* Cheerful.—Small flowered but the best clear rose.
*Petunia* Comanche.—Large frilled deep red.
*Petunia* Elks Pride.—Tall bedder with deep plum-purple bloom.
*Petunia* La Paloma.—Large frilled white bedder.
*Petunia* Rose Charm.—Numerous very large magenta flowers.
*Petunia* Snow White.—Small flowered white bedder.
*Phlox Drummondii* New Globe.—Low mounds in various colors.
*Phlox Drummondii* Red Glory.—Tall, clear, deep red, with white eye.
*Salvia* Blaze of Fire.—Old but reliable scarlet of medium height.
*Scabiosa* Blue Moon.—Excellent form, good pale blue.
*Scabiosa* Coral Moon.—Excellent form, good rose.
*Tithonia* Torch.—Tall stiff plants with firm bright orange daisies.
*Verbena* Sparkle.—Low plant with deep red, white-eyed flowers.
*Verbena* super giant Royal Blue.—Tall erect, true color.
*Zinnia* Floradale Scarlet.—Very large bright bloom.
*Zinnia* Salmon Gem
*Zinnia* Rosebud.—Excellent pompon.

***Relation between Seeding and Blooming Dates***

At more northerly locations annual flowers are frequently outstanding as a color show. Growth and bloom are also accelerated by long daylight. In 1949 several of the Experimental Stations were asked to record in their 1950 and 1951 reports the dates of seeding, germination, bedding out and bloom of various annuals. It was felt that analysis of such data might establish some relationship between latitude and number of days between seeding and bloom.

Information from Normandin, Que.; Ottawa, Harrow and Kapuskasing, Ont.; Morden, Man.; Indian Head, Sask.; Lethbridge and Beaverlodge, Alta., and Prince George, B.C., on the 30 most common annuals was tabulated. These data provided the following general information:

1. Most annuals seeded later in the season or subjected to longer periods of daylight do bloom in a shorter number of days after seeding but do not make so much vegetative growth.

2. Seed sown outside in cool soil requires a greater number of days to blooming than seed sown indoors with plants moved out after the soil warms up.

3. Growth was slower in cloudy than in sunny areas.

4. Regular moisture supply produced bloom in fewer days than where periods of rain and drought alternated.

These points are all to be expected and were sufficient to overbalance any influence of longer daylight in northern areas.

## Bulbous Plants

***Tulips***

Work was carried on for two seasons with British Columbia vs. Holland-grown tulips for early forcing. The early work showed that when received B.C. bulbs were in a more advanced stage of bud formation than were Dutch bulbs, so that different storage treatment during summer was needed. Later work in this project is also being reported.

Outside work with tulips has consisted largely of variety testing on the basis of which the following old and new varieties are recommended:

EARLY SINGLE

Cramoisi Brillant—brilliant crimson;
*General de Wet—gold, flushed orange;
*Ibis—deep rose;
*Olympiade—golden yellow;
Sunburst—gold, scarlet markings;
*White Hawk—white.

EARLY DOUBLE

*Dante—blood-red;
Electra—cherry-red;
Orange Nassau—scarlet, orange margin;
*Peach Blossom—pale rose;
*Schoonoord—white;
*Triumphator—deep rose.

MENDEL

*Her Grace—white, rose margin;
*Krelage's Triumph—clear light red;
*White Sail—white.

TRIUMPH

Bandoeng—mahogany-edged yellow;
*Crater—deep red, stiff stem;
Denbola—rose-red, edged white;
*Edith Eddy—carmine-red, edged white;
*Elizabeth Evers—rosy, white base;
*Kansas—pure white, yellow center;
*Telescopium—red-violet, strong stem.

COTTAGE

Advance—crimson-scarlet;
*Albino—white;
*Carrara—white;
*Golden Harvest—gold;
*G. W. Leak—geranium-red, yellow base;
Inglescombe Yellow—yellow, flushing scarlet;
Marshall Haig—scarlet, yellow base;
Mongolia—large, soft yellow;
Mrs. John T. Scheepers—light canary-yellow.

DARWIN

*All Bright—clear deep red;
Blizzard—clear white;
City of Haarlem—vermilion-scarlet, blue base;
*Clara Butt—clear rose-pink;
Dory Overall—deep mauve;
*Fanny Farrar—white and rose, changing to deeper;
*Golden Age—rich buttercup-yellow;
*Insurpassable—rose-lilac;
Mr. Van Zijl—clear rose-pink, white edge;
*Margeaux—wine-red;
*Niphetos—clear yellow;
Scarlet Leader—scarlet to blood-red;
*Prunus—salmon-pink;
Queen of the Night—deep maroon;
The Bishop—clear violet;
Zwanenburg—pure white, black anthers;
Smiling Queen—satiny pink;
*William Pitt—crimson-red.

PARROT

Blue Parrot—bluish mauve;
Fantasy—pink;
Firebird—fiery red, green streaks;
*Red Champion—cochineal-red and scarlet.

LATE DOUBLE

Eros—old rose;
Symphonia—cherry-red.

BREEDER

Dillenberg—orange-scarlet, edged lighter;
Indian Chief—mahogany, flushed purple;
Louis XIV—orange-violet, paler edge.

*Suitable for indoor forcing.

Trials have also shown that where it is desired to leave Cottage, Darwin and other late flowering types in the same position for a number of years, planting 8 to 12 inches deep is more satisfactory than the customary 4 to 6 inches. At the deeper level only one new bulb develops yearly and crowding does not occur.

***Gladiolus***

A test garden for gladiolus seedlings sent in by members of the Canadian Gladiolus Growers' Council is operated. Five such gardens are maintained across Canada and are instrumental in sifting out poor seedlings before they are put on the market as named varieties. Of the 75 to 100 seedlings sent in yearly for test usually only about 10 per cent are rated "A" and considered worthy of introduction.

## ORNAMENTAL PLANT BREEDING

*D. F. Cameron*

This report deals with ornamental plant breeding between the years 1948 and 1953 in the genera *Chrysanthemum, Lilium, Malus, Rosa,* and *Syringa.*

### Awards

Since the publication of the previous Report a further number of varieties of ornamental plants developed at Ottawa have been honored with the Award of Merit from the Royal Horticultural Society in London, England.

*Lilium* × Lillian Cummings: Award of Merit, R. H. S., July 12, 1949.

*Rosa* × Agnes: Award of Merit, R. H. S., June 12, 1951.

*Syringa* × *Prestoniæ* var. Elinor: Award of Merit, R. H. S., June 12, 1951.

*Iris* × Gatineau: Award of Merit, R. H. S., May 24, 1953 after trial at Wisley.

L.39-08-01: Awarded the D. G. Griffith cup at the New York Show of the North American Lily Society, June 28, 1951, as the best unnamed new seedling in the show. This variety, described in the previous Report, was named Addington in 1952, for the Ontario county of that name. Addington (Fig. D-1) has been released to commercial lily growers.

Fig. D-1—*L.* × Addington, an Ottawa selection named in 1952.

## Chrysanthemum

In districts where early September frosts are not a problem, garden chrysanthemums are among the most useful of the colorful autumn flowering plants. Unfortunately, many of the most attractive varieties of chrysanthemums are injured by the early frosts that are frequently followed by two or three weeks of fine autumn weather.

In 1949 seed of several open-pollinated garden varieties of chrysanthemums was sown under glass. Later the seedlings were transferred to the nursery. A number of controlled crosses were made under glass in 1950, and the seedlings from these latter crosses were also grown in the nursery. Among the several hundred seedlings were several promising selections that were propagated vegetatively under glass and grown in the public grounds for comparison with the

Fig. D-2—Ch. × Lavender Rose, a new garden chrysanthemum, hardy at Ottawa.

named varieties on trial. Many of the selected seedlings produced heavy crops of bloom. Blooming season began late in August and continued through September, with several seedlings blooming on into October.

Hard or black frosts occurring at time of full bloom frequently caused a rapid discoloration of the flowers thus rendering the plants very unattractive. Yet, many seedlings in bud at the first hard frost were apparently undamaged and produced normal crops of bloom. Because of the variable behavior of these seedlings and their extreme lateness in blooming, most of them have been discarded.

Only one seedling was considered sufficiently distinctive to deserve a name. This is Ch. 49-01-01, which appeared among a group of open-pollinated seedlings of mixed parentage. This seedling has been named Lavender Rose (Fig. D-2). It is semi-single with a small yellow disk; individual flowers are 1½ to 2 inches across and are borne so profusely that the whole plant is clothed with bloom. The foliage is small, light grayish-green in color, somewhat similar to that of the variety Deanna Durbin. The plant has an open branching habit. It reaches a height of 24 to 30 inches, covers an area about 30 inches in diameter, and has remained in bloom for over four weeks. It has not been injured by frost at Ottawa and has shown good recovery from early frosts. Lavender Rose has been tested by a number of commercial nurserymen and other growers and has received much favorable comment for its hardiness and prolonged blooming period. Stock plants left in the open ground have come through three successive winters without damage; the only protection other than natural snow cover being the old stems which were left on the plant until spring. Two of these winters were open; one was severe. The test winters appear to be the open winters when protection by snow coverage is meager.

## Lilium

Prior to 1948, most of the lily varieties of *L. Davidi* extraction developed at the Central Experimental Farm, and by several other lily breeders in Canada and elsewhere, were in the orange and orange-red color band. With so many good new horticultural varieties in these colors already available in commerce, a need existed for more yellow-flowered varieties of varying height, habit of bloom and flowering season; new lilies that would also have the resistance to *Botrytis* blight possessed by the "Stenographer" and "Aircraft" groups.

In addition to the two yellow-flowered varieties, Coronation and Sovereign, several yellow-flowered seedlings under number were available in the experimental gardens at Ottawa. Most of these seedlings were described briefly in the Progress Report, 1934-1948, pp. 142-143, and are shown in the genealogy, p. 145.

In 1948 a number of exploratory controlled crosses were made in the garden involving seedlings or named varieties of this group. Several seed capsules were harvested, but a number of crosses failed to set fruit. Lilies of the later-flowering *Henryi*-Havemeyer-*Aurelianense* group were also crossed and a small lot of seed was obtained from these.

The following year the breeding program was confined mainly to eight different seed and six pollen parents. Crosses that had not been attempted in 1948 were made and some crosses that had yielded little or no seed were repeated. Most of these crosses were made in the greenhouse, using plants that had been forced. Seed was obtained from sixteen different crosses. Attempts at self-pollinating Coronation and two numbered seedlings were unsuccessful.

Lily breeding under garden conditions in 1948 and 1949 was hampered by strong winds that removed the protecting paper bags. Not only were the bags frequently damaged or carried away but in many cases the inadequately protected inflorescence itself was also damaged or broken, and thus several good capsules were lost. To minimize this loss and to obviate the use of paper bags in protecting the stigmas of flowers selected for breeding, a new technique was tried under both garden and greenhouse conditions.

***New Techniques***

Two sizes of waxed paper soda straws were cut to suitable 3- to 4-inch lengths. With one end folded over, these were slipped over the stigma and style of the bud that had been forced open and emasculated. The flower segments were then held together by an elastic band for a day or two, or until the flowers would have opened naturally, as indicated by bud swelling. At this time the stigma is usually receptive. The straw was then removed long enough to apply the pollen, but was replaced immediately. These soda straws offer little resistance to the wind and usually remain in place until both floral parts and style wither and fall. This technique has been in use since 1950.

Several hundred seedlings from the 1948 and 1949 crosses flowered for the first time in 1951. Several from the yellow-flowered members of the 1948 Preston group had upward facing yellow flowers, but none among them was of outstanding merit. Forty of the lot from the 1949 crosses were very promising. These were selected for further observation and include considerable potential breeding material.

***New Yellows***

Certain crosses involving the variety Sovereign, Sovereign × L. 43-02-01, Sovereign × L. 42-06-01, L. 37-10-01 × Sovereign, L. 42-06-01 × Sovereign, yielded a greater proportion of desirable seedlings than all others combined. Among the seedlings selected from these crosses are clones with flowers ranging from downward to outward to upward facing. The flower form ranges all the way from the Martagon type through open bowl to almost flat. These represent many shades of yellow—from light yellowish-lime to deep orange-yellow, with only a few of the seedlings showing the red wash or streaks that sometimes appear in the variety Sovereign. Flower texture is usually heavy, and most of the Sovereign and other seedlings selected have well placed flowers on plants of good constitution.

The lighter yellow-flowered selections are expected to become very popular among lily growers because of their bright unusual colors. The upward or outward facing members of this group have a greater garden value than the pendulous type, for the flowers of the former are displayed prominently and to much better advantage.

***Popular New Lilies***

A group of lilies which is becoming more popular every year are the late flowering *Lilium Henryi, Sargentiae, myriophyllum* v. *superbum* (*sulphureum*), *leucanthum* v. *centifolium, regale,* × princeps, and various hybrids involving two or more of these species. Dr. E. F. Palmer, Vineland, Ont., is one of the several outstanding lily breeders working with this group of lilies in the three countries: Canada, Britain and U.S.A.

In 1925 a French lily breeder, Monsieur E. Debras, of St. Jean-de-Braye, near Orleans, France, crossed *L. Sargentiae* with *L. Henryi*, and named the resulting hybrid *L. aurelianense*. Debras backcrossed this hybrid to each parent

and crossed the resulting progenies. Ottawa received seed of this parentage in 1939 where it was then grown. Two of the resulting seedlings have been used in plant breeding here: L. 39-85-04, which somewhat resembles its *L. Sargentiae* ancestor, but with a prominent rich apricot colored throat and the outside of the floral segments being stained pink; and L. 39-86-01, with semi-reflexed flowers, light orange in color (Tangerine Orange: R. H. S. 9), lighter at tips; more like its *L. Henryi* parent in habit, but almost completely lacking the papillae which are so prominent in this species. This seedling, L. 39-86-01, was named Simcoe in 1953.

Both of these seedlings have been used in a number of crosses since 1948. Simcoe has not produced seed with any pollen so far employed, but its pollen used on L. 39-85-04 and on other trumpet lilies produced some very attractive seedlings, most of which failed to survive the 1952-53 winter. From a cross between a yellow-flowered Centifolium lily received from a source in the United States and pollen of L. 39-85-04, a lot of about fifty seedlings was grown, twelve of which flowered in 1952 and others in 1953. Among these are several promising seedlings, including two which are light yellow and trumpet shaped. Others are semi-trumpet with coloring varying from very pale green or pale buff to white with prominent orange centers. These seedlings appear fairly hardy at Ottawa.

The cross which resulted in these seedlings has been repeated, and a larger population of seedlings is being grown. Some of the better seedlings from this and other crosses have been used as seed parents, using pollen of outstanding yellow or colored Aurelianense varieties from Dr. E. F. Palmer of Vineland, Ont.; Mr. J. E. H. Stooke of England, and Mr. Carleton Yerex, Newberg, Oregon, U.S.A. As pollen parents they have been used on lilies selected for their yellow color or other desirable characteristics.

From the several crosses made in this phase of the lily breeding program, it is hoped that a number of good yellow trumpet lilies will result; lilies with the necessary degree of hardiness to enable them to be grown where they now last but a season or two.

### Malus

With the object of developing flowering crabapples to meet certain definite needs, a few crosses were made in this genus, using in each case one or two of the Rosybloom crabapples. The variety Sissipuk blooms about a week or ten days later than most of the other Rosybloom crabapples. Therefore, this variety was crossed with other forms of *Malus* to obtain a wider range of late-flowering varieties, and to fill the gap in bloom between the end of the blooming season of the other Rosybloom varieties and the beginning of the Sissipuk bloom.

From these and other crosses small populations of seedlings are being grown and it will be several years before any selections can be made.

Two double-flowered varieties, Dorothea and Katherine, were obtained from the Arnold Arboretum for use in plant breeding.

### Rosa

Before 1948 a large number of hardy shrub roses were developed at Ottawa from controlled crosses, or as selections from open-pollinated seed of species hardy at Ottawa. These varieties of roses were described in the 1934-48 Report.

Crosses were made in 1948 between various roses in an attempt to produce climbing roses with a greater degree of hardiness than the climbing hybrid tea and other large-flowered climbing roses commonly grown. Attempts were made to combine hardiness with a recurrent habit of bloom. Hardiness and the climbing habit were expected from the use of roses such as the *R. setigera*

hybrids, Langford and Doubloons, and from the *R. Helenae* seedling, Patricia Macoun. Two unnamed climbing seedlings, R. 30-19-06 and R. 30-19-07, were also used. These were from the same cross as R. × Langford (*R. setigera* × polyantha pompon var. Aanchen Müller). Recurrent bloom and improved flower quality and color were expected from the use of hybrid polyantha varieties such as Donald Prior, Else Poulsen, Eutin, Goldilocks and the hybrid tea, Crimson Glory and others.

The work was repeated and extended in 1949 and 1950, when a larger number of crosses involving other parent material were made. The resulting seed, together with some open-pollinated seed, was sown in bottles and subjected to a period of low temperature, following the technique recommended by Barton (1) and Crocker and Barton (2). Since hardiness is one of the qualities sought in the rose breeding project, these seedlings were tested by leaving them in an open cold frame covered with evergreen boughs. An open winter during both 1951-52 and 1952-53 caused heavy losses to much ornamental plant material, and only a few rose seedlings survived. These survivors were lined out in the nursery where they receive no winter protection other than that afforded by the natural snow cover. They are still in the nursery and no selections have yet been made.

Various hardy roses, both species and hybrids, have been obtained from Canadian and European sources, and it is planned to explore the breeding potentialities of a larger number of hardy forms.

***References***

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2. Crocker, W. and L. V. Barton. After-ripening, germination and storage of certain Rosaceous seeds. Contr. Boyce Thompson Inst. 3: 385-404. 1931.

## Syringa

***Syringa hyacinthiflora***

By crossing the pale, early-flowered variety Peggy with Vestale, one of the good white varieties of *S. vulgaris*, it was hoped to combine earliness with lighter color or white to extend the color range of the *S. hyacinthiflora* group. Thirteen plants from this cross were planted out in the nursery in 1953 along with a number of seedlings from such crosses as Norah × *S. alba grandiflora*. These seedlings have not flowered yet.

***Late Blooming Syringa***

The late flowering hybrid S. × Fountain (p. 151, 1934-48 Report) is one of the very attractive varieties that has been used extensively here in an effort to develop new forms of late blooming lilacs. S. × Fountain was crossed with its unnamed sister seedling, S. 33-11-07, which has darker but more sparse bloom, and between a number of other late blooming species and hybrids. Some of the seedlings from these crosses have flowered in the nursery but no selections have yet been made.

# FLORICULTURE RESEARCH

*A. P. Chan*

## Greenhouse Roses

***Evaluation of Watering Methods***

In the experiments on watering methods the variety Better Times was used. All methods employed were practical but each had its advantages and drawbacks. From the standpoints of low initial investment and operational ease, the Skinner Superior Nozzle system is the most desirable. Sufficient water pressure and volume are the two main requisites for its successful operation.

The constant water level system requires a level, water-tight bench, soil possessing good structure, and frequent leaching to keep soluble salts low. This method requires the least labor but precision in operation is very exacting and errors can be costly. The Revere Copper Pipe system is satisfactory if the water supply is fairly clean. The gravel culture method is the most efficient, but at the same time it is the most costly because of the initial investment of water-tight benches, solution reservoir and pumping apparatus.

Table D-1 shows that the effects on production are not very uniform. The gravel culture system is especially low, but planting of these plots was delayed for a month because the pumps were not installed. However, the production increased appreciably in the second year. In the two-year records, the stem length averaged 1 to 3 inches less than other plots. This is quite serious because roses are sold on the basis of stem length. Two nutrient solutions "WP" and "CH" were used.

TABLE D-1.—EFFECT OF WATERING METHODS ON PRODUCTION OF ROSES

| Method of watering | Flowers/plant/year | | Average stem length (in.) | |
|---|---|---|---|---|
| | 1948–49* | 1949–50 | 1948–49 | 1949–50 |
| Skinner Superior Nozzle | 16·7 | 24·5 | 21 | 19 |
| Constant water level | 18·6 | 27·0 | 20 | 19 |
| Revere | 18·6 | 26·9 | 19 | 19 |
| Gravel culture (WP) | 11·8 | 22·0 | 18 | 17 |
| Gravel culture (CH) | 13·6 | 24·8 | 18 | 17 |
| Manual overhead | 17·2 | 26·6 | 21 | 19 |

*September to May.

***Gradual Knife Pruning versus Cut-back After Drying***

In the experiment on knife pruning versus drying-off and cutting back, the varieties Happy Day and Starlite were used. Because of the longer cutting period during the time that the plants are in production, the knife pruning method consistently gave better production as indicated in Table D-2.

TABLE D-2.—EFFECTS OF KNIFE PRUNING AND CUT-BACK

| Variety | Method | Flowers/plant/year | | Average stem length (in.) | |
|---|---|---|---|---|---|
| | | 1948–49 | 1949–50 | 1948–49 | 1949–50 |
| Happy Day | knife pruning | 24·3 | 30·6 | 20 | 18 |
| | cut-back | 18·4 | 28·5 | 21 | 18 |
| Starlite | knife pruning | 24·9 | 37·7 | 17 | 15 |
| | cut-back | 23·5 | 33·6 | 17 | 15 |

***Blindness in Roses***

The first phase consisted of obtaining a picture of the developmental anatomy of both flowering and blind rose shoots.

In collecting stem tip samples the usual technique of pinching to make lateral buds assume a terminal position was not in itself adequate. A large number of shoots were pinched; samples were collected periodically but at close time intervals to obtain all developmental stages. Such was not obtained from the successive collections, for buds treated (pinched) at one time in this manner did not all begin to differentiate at the same time. Thus buds collected at any

particular date from the time of pinching would be in different morphological stages. Further work indicated that the subtending leaf of the axillary bud directly below the pinch can exert an inhibiting effect. This can be avoided by removing the leaf or simply bending the petiole downward.

The stem tips were collected, microtomed and stained with a triple-stain (safranin-haematoxylin-aniline blue). Slide examination is not yet complete.

When blind shoots are obvious it is not possible to force reversion to flowering shoots. Flowering shoots were grafted successfully to blind shoots but the blind shoots did not go on to form flowers. If the blind shoot was at a less advanced stage, i.e., just approaching blindness, flower formation after grafting might be possible. However, as yet there are no means of determining the early stages of blindness.

## *Carnations*

### *Effects of Watering Methods on Production*

The results of the first-year crop indicated no distinctly superior method. Highest yields with constant water level were consistent, but the increase was not more than one flower per plant. Gravel and sand cultures gave consistently high average production.

### *Second-Year Production*

The plants used in the studies on watering methods were retained for a second year of growth. No special pruning was practiced. Table D-3 shows the production figures during the second year. The varieties Northland and Virginia seem to be more adaptable than Wm. Sim.

TABLE D-3.—CARNATIONS: FLOWERS PER PLANT IN SECOND YEAR

| Method of watering | Northland | Wm. Sim | Virginia |
|---|---|---|---|
| Constant water level | 12·9 | 10·2 | 16·3 |
| Gravel (WP solution) | 12·5 | 8·6 | 15·0 |
| Gravel (CH solution) | 12·5 | 8·8 | 13·8 |
| Nelson Master Nozzle | 12·6 | 9·6 | 14·1 |
| Manual overhead | 11·9 | 9·8 | 14·1 |
| Sand culture | 11·4 | 11·0 | 15·1 |

### *Timing the Production*

Timing the peak flowering periods is important in rose and chrysanthemum crops. To regulate flowering periods of carnations is very difficult, but the problem is receiving a great deal of attention.

In 1951 our work confirmed the difficulty. Shoots were pinched and tagged first on June 2, then others at five-day intervals to August 31. Time of flowering from the pinched shoots was recorded as the day ready for cutting. It was hoped that this would give at least an indication of when to pinch for particular flowering dates. Unfortunately, the pattern was too scattered to be of value. For example, shoots arising from a pinch on June 2 may flower any time from October to late December. The key factor seems to be plant position of the pinched shoots. Fundamentally, this is determined by the number of times the plant has been pinched. The factors of season, variety, and nutrient levels also play important roles.

The 1952 continuation work was on the recently introduced Yoder varieties. Although it was planned to obtain a peak production for Mother's Day by planting early in January, this was not possible because the cuttings arrived late. They were benched directly on February 27, and divided into three blocks. Block A was given a single pinch; Block B was not pinched at all, and Block C was given multiple pinches (standard method). The unpinched plants flowered in late June and early July. The single pinch flowered in July and August. The multiple-pinched plants began production in October. The flowering dates varied considerably with variety. However, the no-pinch and single pinch plants were quite uniform in development.

A second experiment of three plantings, June 2, 8 and 20, was set up to peak at Christmas. These plants were single-pinched July 5, 10, 15 and 20. In summary, once again variety was an important factor. The June 2 planting with pinches made on July 5 and 10 all flowered before December with the exception of two slower growing varieties (Neptune and Jupiter). In general, the plants in the June 20 planting and pinched July 15 flowered in early December.

Plots with a peak production in mid-December flowered heavily again in late May and June. This means that the crop missed the next big holiday flower demand.

The 1953-54 experiments are essentially a repetition of these tests. However, it was found that nitrogen levels at the time of planting can upset timing schedules very easily. Without showing any visible signs of typical nitrogen deficiency, carnation plants can be checked in growth to such an extent that flowering periods are delayed by four weeks. Also, some varieties had higher than normal temperature requirements.

The 1954-55 experiments are designed to elucidate these points.

#### *Mineral Nutrition*

The nutritional studies have shown that carnations will grow well over a very wide range of nutrient levels. Two well-defined symptoms were noted. Potassium deficiency is shown by a bleaching of the leaf tips. It first appears as a blotching effect and gradually bleaches to a bright yellow straw color. Potassium deficiency is accentuated by nitrogen levels. A medium level of nitrogen produces a correspondingly less severe condition. Low nitrogen is indicated by stunted growth, a grayish cast over the foliage, but most specifically by leaf shape. Plants grown under low nitrogen levels have narrow straplike leaves and are straight and stiff. At optimum nitrogen levels the leaves are wider, thicker, and the tips are curled. The relationship between nitrogen, potassium and phosphorus levels with stem stiffness has not been established.

## Poinsettias

#### *Air-expressed California Cuttings*

Most small growers find it difficult to propagate poinsettia cuttings. Usually the difficulty is referable to inferior stock plants and poor techniques in handling stock plants and cuttings. To investigate the possibilities in rooted cuttings from California, arrangements were made for air-express shipments during August and September, 1949 and 1950. The results of these trials indicated that the high temperatures prevailing in August and the numerous necessary transfer points combined to make the importation of California cuttings impractical. Losses in some shipments were as high as 65 per cent. In early September the losses were reduced but not enough to make the practice a sound one. It appears that the last transfer (Toronto) is the most

critical. Thus growers in Toronto have successfully imported cuttings from California, but losses mount with shipment east of Toronto. However, a southern Ontario firm has recently begun large scale selling of small poinsettia plants, and this is the small growers' best source.

#### *Precision Method of Poinsettia Growing*

The results of a series of experiments set up to devise a procedure for a precision method of growing poinsettias that any grower can follow have been published (Can. Florist 45. Sept. 1950).

The results may be summarized as follows:

1. Vigorous cuttings are possible only when stock plants are grown in large containers (soil minimum, 1 cu. ft.).
2. Later propagation is recommended. Instead of propagating in June, the first shoots should be pinched. Propagation may be started on July 15 and continued to Sept. 1.
3. Later panning dates are recommended to keep plants short. Best period is Sept. 15 to Oct. 1.
4. Frequent fertilizing (particularly nitrogen and potassium) is necessary for both stock and young plants.

### *Chrysanthemums*

#### *The Effect of Mineral Nutrition on Flower Bud Initiation*

When year-round programs of chrysanthemum production were introduced, flower bud initiation in plants grown for the winter crop presented a very real problem. It was thought that some of the reasons for the failure of these plants to set flowers were low light intensities coupled with high nutrient levels, particularly nitrogen. A gravel culture set-up with a wide range of nutrient levels which were in turn raised and lowered at various photoperiods failed to show any distinct effects. The flower bud initiation was checked by hand sectioning fresh stem tips eight days after short photoperiodic treatment began. All varieties in the various plots showed signs of the onset of flowering.

These plants were followed to the flowering stage, and it was found that altering the nutrient levels did not affect the time of flowering. In later experiments, other factors were studied.

#### *Factors Affecting Flower Bud Initiation*

Flower bud initiation in the year-round flowering program is usually no problem provided that the proper photoperiods and temperatures are maintained. The winter-grown crop, however, presents serious difficulties. Then it is sometimes difficult to get flower buds to set. Experiments were set up to determine the responsibility of low light intensity, plant nutrition, plant size (physiological age), temperature and light quality.

Eight varieties: Gold Coast, Masterpiece, Vibrant, Encore, Popcorn, Highbrow, Little America, and Shasta, representing the principal response groups, were chosen for the experiments. Reducing the available light intensity by 30 per cent did not cause the plants to remain vegetative.

In experiments on size (or age) of plant and the degree of vegetativeness, the results showed that the older the plants the more easily flower bud initiation took place. In addition, plants with a hard type of growth produced by starvation levels of nutrients did not set flower buds more readily than plants with a highly vegetative, lush type of growth.

During the winter months there is generally more water vapor in the greenhouse atmosphere and it was considered a possibility that this vapor may filter out some of the essential parts of the light spectrum. Accordingly, a preliminary experiment was set up to study the effects of supplementing the natural light with artificial illumination from certain bands of the spectrum. Red, blue and near ultra-violet lights were tried without success.

Fig. D-3—Effect of temperature on flower bud development in chrysanthemum, Masterpiece variety; l. to r., 48, 60 and 65°F.

The temperature during and prior to the induction photoperiods was also studied. Temperature requirements between varieties differed considerably (Fig. D-3). For example, Grand Slam was very sensitive to low temperature (48 to 50°F.) both prior to and during the induction period, while Masterpiece was the most tolerant of low temperatures. Current studies, not yet completed, indicate that chrysanthemum varieties have certain temperature requirements. Both low and high temperatures during the dark period can exert profound effects on the behavior of chrysanthemums in flower initiation and development.

***Modern Pot 'Mums***

The modern pot 'mum is characterized by its short compact growth (Fig. D-4). It is a pot plant tailored to suit modern compact living quarters. In general it is produced by limiting the vegetative growth, accomplished by growing the plants under short-day conditions immediately or soon after potting. Thus, as soon as they are potted, the plants are placed in an environment conducive to flowering. This, however, is not always satisfactory because some varieties do not produce enough flowers under this method. A brief long-day period improves the flower bud count but the height is often excessive. While highly satisfactory plants can be grown most of the year through selection of proper varieties and

manipulation of day-length and pinch dates, the Christmas crop presents difficulties. This holiday season requires red and white colors mostly. Unfortunately, there is no suitable red variety, and some of the white ones are a little difficult to grow in December.

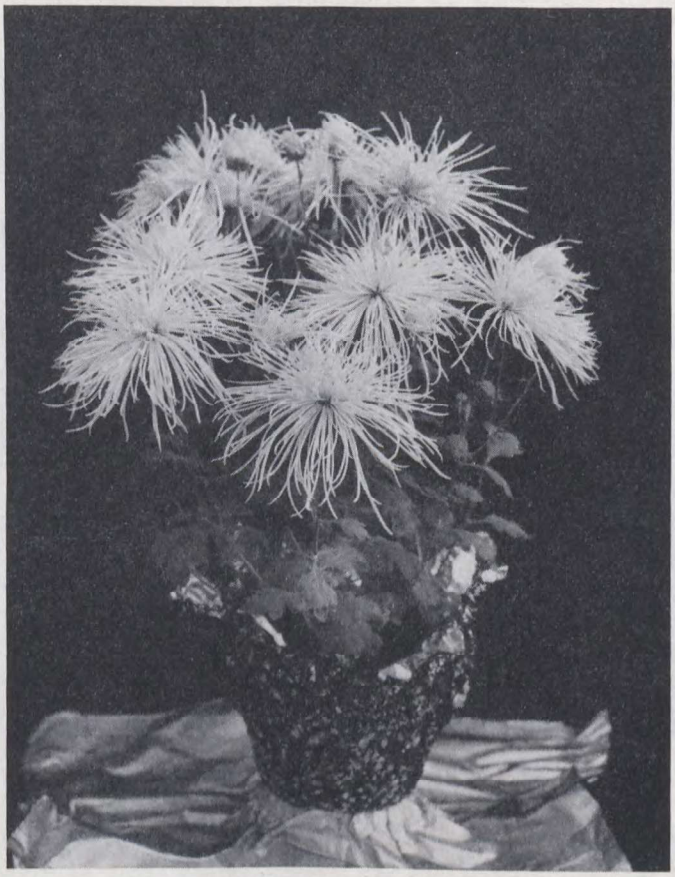

**Fig. D-4—Modern pot 'mum, variety Queen's Lace, grown for Easter market.**

Briefly, the standard method recommended is as follows:

1. Use midseason varieties, but the best are Bonnafon de Luxe, Wilson's White, Queen of Pinks, Granite Slate, Indianapolis Sports and Shasta.
2. Rooted cuttings are potted five to a 6-inch pot.
3. The cuttings are pinched and grown under short day-length immediately.
4. For winter months pot the cuttings and grow under long day-length for seven days; then under short day-length; pinch and continue under short day-length until flowering. This is the method recommended for handling garden varieties to be flowered for Mother's Day sales.

In the search for a suitable red variety for the Christmas crop, 13- and 14-week varieties were tried (in contrast to the midseason varieties of 9- and 11-week response groups). Several varieties (Poinsettia, Christmas Star and Claret)

satisfied the color requirements, but the problem was how to produce short plants with these late varieties. Delayed pinches, or pinches made after short days were in effect, would normally correct the condition, but these late varieties with their long flower development period did not react. At present, the only solution seems to be in plant breeding.

### *Wedgewood Iris*

The work on Wedgewood iris consisted of experiments on the effects of bulb size, spacing and night temperature on forcing for cut blooms. A preliminary test was also made on the effects of heat curing of iris bulbs on time of flowering. These results have been published (Can. Florist 47. Sept. 1952). The results are summarized in Tables D-4 and D-5.

TABLE D-4.—THE EFFECTS OF HEAT CURING ON WEDGEWOOD IRIS

| Bulb size | Treatment | Days to flowering | Av. stem wt. at 6 mos. | Flowers cut | Blind | Blasted | Keeping quality |
|---|---|---|---|---|---|---|---|
| cm. | | | gm. | % | % | % | days |
| 9–10 | treated | 70 | 37·5 | 96 | 2 | 2 | 3 |
| 10–11 | " | 67 | 42·6 | 96 | ..... | 2 | 3 |
| 11+ | " | 69 | 51·1 | 96 | 4 | ..... | 3 |
| 9–10 | untreated | 68 | 53·1 | 96 | 2 | 2 | 4 |
| 10–11 | " | 67 | 45·2 | 96 | ..... | 4 | 3 |

TABLE D-5.—THE EFFECTS OF BULB SIZE, SPACING AND TEMPERATURE ON FORCING WEDGEWOOD IRIS

| Bulb size | Temp. | Spacing | Days to flowering | Av. stem wt. at 6 mos. | Flowers cut | Blind | Blasted | Keeping quality |
|---|---|---|---|---|---|---|---|---|
| cm. | °F. | in. | | gm. | % | % | % | days |
| 9–10 | 60 | 2 | 37 | 30·7 | 19·0 | 19·1 | 61·9 | 3 |
| 10–11 | 60 | 2 | 37 | 39·4 | 11·9 | 9·5 | 78·6 | ..... |
| 9–10 | 60 | 3 | 37 | 30·2 | 35·6 | 13·3 | 31·1 | 3 |
| 10–11 | 60 | 3 | 40 | 42·8 | 26·1 | 6·5 | 67·4 | 4 |
| 9–10 | 60 | 4 | 37 | 37·3 | 85·0 | 5·0 | 10·0 | 3 |
| 10–11 | 60 | 4 | 39 | 40·0 | 95·0 | ..... | 5·0 | 3 |
| 9–10 | 50 | 2 | 65 | 35·0 | 90·0 | 2·3 | 7·7 | 4 |
| 10–11 | 50 | 2 | 63 | 43·0 | 71·4 | 4·0 | 23·8 | 4 |
| 9–10 | 50 | 3 | 65 | 32·6 | 97·1 | ..... | 2·0 | 4 |
| 10–11 | 50 | 3 | 63 | 45·4 | 85·7 | 11·4 | 2·0 | 3 |
| 9–10 | 50 | 4 | 67 | 35·8 | 90·0 | 10·0 | ..... | 3 |
| 10–11 | 50 | 4 | 70 | 42·8 | 100·0 | ..... | ..... | 3 |
| 9–10 | 45 | 2 | 88 | 37·7 | 95·2 | 2·4 | 2·4 | 5 |
| 10–11 | 45 | 2 | 87 | 47·8 | 97·6 | ..... | 2·4 | 5 |
| 9–10 | 45 | 3 | 84 | 40·8 | 94·3 | ..... | 5·7 | 4 |
| 10–11 | 45 | 3 | 90 | 47·0 | 91·4 | ..... | 8·6 | 5 |
| 9–10 | 45 | 4 | 87 | 44·4 | 100·0 | ..... | ..... | 4 |
| 10–11 | 45 | 4 | 82 | 47·9 | 100·0 | ..... | ..... | 4 |

### *Investigations on Various Kinds of Vermiculite*

Adverse reports on vermiculite prompted an investigation of various samples. Initial reports from growers indicated inhibition of rooting in garden chrysanthemum cuttings. Various chemical, physical and biological tests were carried out.

Vermiculite is generally considered to be chemically inert, but samples varied in pH from 7·6 to 9·6; the soluble salts from 12 to 17 ($10^{-5}$ mhos.), and the water-extracted magnesium content from 25 to 180 p.p.m. The main basis

for the wide differences seemed to be the source of the parent material. Vermiculite processed from Source 1 had the lowest pH and soluble salts; samples from Source 2 had higher, while Source 3 had the highest readings. The latter, incidentally, is not being offered for sale in Canada.

Samples with the higher pH reactions depressed germination of radish seeds greatly and beans moderately. The germinated seeds produced dark, dull green stunted seedlings. Rooted cuttings of chrysanthemums transferred to samples of high pH vermiculite wilted in two days. Root examination disclosed injury similar to typical excess fertilizer injury.

Vermiculite treated by soaking for 24 hours in 0·5 per cent $H_2SO_4$ then leached with water was successful in correcting the condition. Radish seeds germinated normally in the treated vermiculite.

Reaction on the addition of acid indicated a high magnesium content. High magnesium content would cause the high pH, but not the toxic effects directly. In other words, it is the high magnesium content in the presence of a high pH that is responsible for the toxic effects.

### *Investigations on the Effects of Bact-Vita on Ornamental Plants*

Bact-Vita is a product alleged to be food for soil bacteria and as such to improve plant growth. Several years ago (1945-46) it was tested by the Horticulture, Field Husbandry, Bacteriology and Chemistry Divisions without any positive results. In 1953 it was proposed as a greenhouse soil supplement, and this Division was requested to conduct some tests with ornamental plants.

The first test was on strips of turf 5 by 15 feet. Bact-Vita was applied at the rates of 9, 18 and 36 lb./ac. Two plots, each containing ammonium sulphate and nitrate at the rates of 1 lb./100 sq. ft. were included. All treatment plots were separated by 5-foot strips of turf. The fertilizer applications showed a response in five days. The color was dark green and the growth obviously greater. No differences were observed between treated plots and the control.

Chrysanthemums, snapdragons and carnations grown on raised greenhouse benches were tested at rates of 9, 18 and 36 lb./ac. Poinsettias also were grown in soil receiving one teaspoonful of Bact-Vita per 6-inch pan. In none of these trials was there any indication of improved plant growth, but neither were there any injurious effects. Other crops were to be included, but because of lack of positive results in the preliminary trials the remaining tests were abandoned.

### *Early Blooming of William Pitt Tulips*

*M. MacArthur and A. P. Chan*

For the past five years William Pitt tulip bulbs, source British Columbia, have been investigated as subjects for forced early bloom, and have been compared with the same variety grown in Holland. Unfortunately, it was never possible to make an exact comparison between bulbs from the two sources because of variation in arrival time and, therefore, initial developmental stage necessitating different treatments.

Generally, beginning the last week in June, bulbs were dug on three to four dates at 7- to 10-day intervals to assure early stages of flower bud development. After the first year the bulbs were shipped to Ottawa and pretreated here.

Pretreatment consisted of holding the bulbs divested of side bulbs on trays at 68°F. until at least six of ten bulbs selected at random reached (a) sepal to petal, (b) stamen, and (c) carpel formation. At these stages the bulbs were held dry at 48°F. for four weeks, then planted and returned at once to

48°F. for root and shoot development. After eleven or more weeks at 48°F. the planted bulbs were removed to dark storage at a higher temperature before benching at 65°F. (In earlier experiments bulbs were stored nine weeks and longer.)

At the first digging leaf formation was general, and it was usually possible to hold bulbs to provide the three flower stages, but with later diggings the sepals and petals and, frequently, stamens had formed. Moreover, development at digging time varied with the year and depended on climatology during new bulb formation.

Initially, the bulbs were placed at 48°F. when the earlier stages were distinguished by mere rounded meristematic protuberances on the stem tip, the very first indications of the perianth parts and some of the stamens. Examination of such bulbs after one month unplanted at cool temperature always showed continued development to at least carpel formation, but bud length was more limited than in bulbs cold stored when the meristems were more developed. For good root formation and nose extension to 4 cm. these bulbs required longer than eleven weeks planted at cool storage. When withdrawn at nine to eleven weeks, a high percentage of the bloom degenerated to the 'paper' type; the earlier the withdrawal, the greater was the number of 'paper' flowers. The abnormality is characterized by flower degeneration, the perianth drying to a tissue paper texture. In later experiments holds in cool storage were extended to twelve or more weeks.

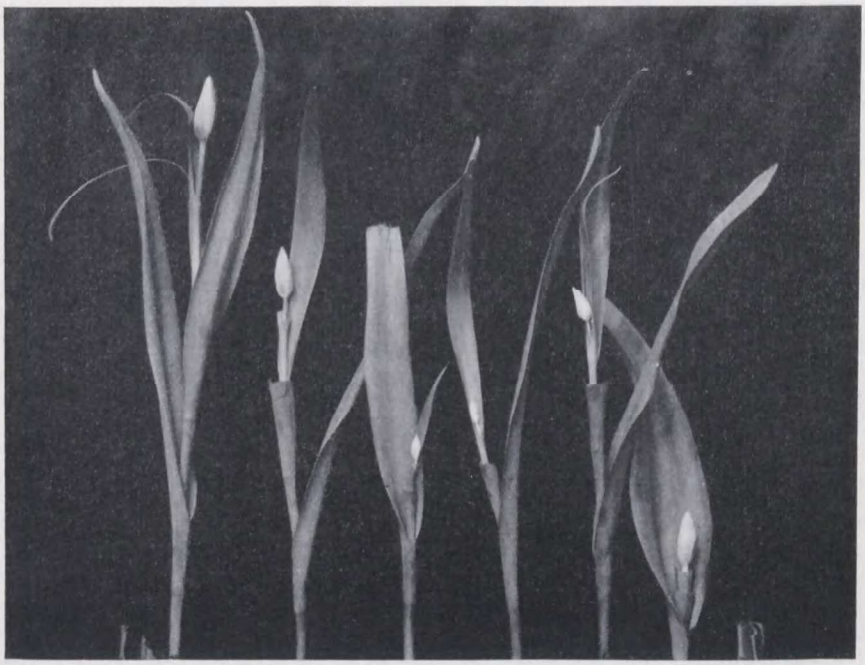

Fig. D-5—'Paper' degeneration of William Pitt tulip buds; third and fourth bud degenerated, fifth bud degenerating.

Bulbs subjected to cool storage when sepals and petals were forming produced a high percentage of 'paper' flowers, and more other abnormalities such as a bi-partite pistil, five or greenish perianth parts, and aborted or club-like stamens. Moreover, the roots of the bulbs that produced 'paper'

flowers were never so well developed as those producing normal bloom. 'Paper' flowers occurred late in plant development (Fig. D-6). No abnormality referable to 'paper' bloom was present in any bud at time of benching. Frequently the bud was visible in the neck and at times had even developed color before degeneration. Shallow flats placed on bench boards, conditions conducive to root-drying, increased 'paper' bloom markedly, and 'paper' bloom was not then limited to lots placed in cool storage at the earlier stages of bud development. Some few bulbs with normally developing visible buds were removed with masses of earth about the roots to the laboratory and watered sparsely. The buds degenerated.

A short summary of the data on the latest experiments is given in Table D-6.

TABLE D-6.—DATA ON EARLY FORCING OF WILLIAM PITT TULIPS

| Lot No. | Dug | Storage at 68°F. | Stage | Planted at 48°F. | Dug to 1st bloom | Av. cut weight | Duration of bloom | Bloom |
|---|---|---|---|---|---|---|---|---|
| | 1953 | days | | weeks | days | gm. | days | % |
| 1 x - 1 | 22–6 | 24 | a | 13 | 205 | 19·0 | 19 | 45 |
| 1 x - 2 | 22–6 | 24 | a | 14 | 205 | 21·2 | 17 | 76 |
| 1 y - 1 | 22–6 | 30 | b | 12 | 206 | 23·1 | 15 | 72 |
| 1 y - 2 | 22–6 | 30 | b | 13 | 207 | 23·8 | 14 | 78 |
| 1 z - 1 | 22–6 | 37 | c | 12 | 206 | 26·9 | 12 | 96 |
| 1 z - 2 | 22–6 | 37 | c | 13 | 208 | 28·9 | 13 | 97 |
| 2 x - 1 | 2–7 | 19 | b | 12 | 194 | 23·7 | 15 | 70 |
| 2 x - 2 | 2–7 | 19 | b | 13 | 195 | 24·2 | 16 | 86 |
| 2 y - 1 | 2–7 | 28 | c | 12 | 196 | 31·3 | 14 | 97 |
| 2 y - 2 | 2–7 | 28 | c | 14 | 196 | 30·0 | 15 | 100 |
| 3 x - 1 | 13–7 | 14 | c | 12 | 186 | 29·5 | 10 | 99 |
| 3 x - 2 | 13–7 | 14 | c | 13 | 188 | 30·0 | 12 | 97 |
| 3 y - 1 | 13–7 | 22 | c+ | 11 | 191 | 28·3 | 11 | 99 |
| 3 y - 2 | 13–7 | 22 | c+ | 12 | 191 | 29·1 | 13 | 100 |
| 3 y - 3 | 13–7 | 22 | c+ | 13 | 192 | 28·8 | 14 | 99 |

The initial holds at 68°F. included the time required for shipping. Any reduction from total (100 per cent) bloom was caused by 'paper' type of bud degeneration only. Bulbs placed in cold storage before carpel formation, stages (a) and (b) in Table D-6, had 14 to 55 per cent 'paper' flowers. Noses of bulbs cold stored at stage (a) had not protruded to 4 cm. until 14 weeks planted at 48°F. The extension of time at cold storage increased the percentage of bloom and average weight of the cut flowers, but first flowers appeared at the same time, 205 days from digging date.

Bulbs with buds at carpel stage (c) when placed in cold storage (lots 1z, 2y and 3x) had only one or two 'paper' flowers. Again it should be emphasized that only the major percentage of the buds had reached the designated stages when placed at 48°F. Days dug to first bloom indicate that lots 1z, 2y and 3x (all stage (c)) bloomed approximately the same time, for the period between digging dates of 1z and 2y was 10 days and between 2y and 3x, 11 days. Cut flowers from bulbs stored at bud stage (c) were heaviest, (b) were lighter and (a) the lightest. The cut extended over 10 to 19 days, and the most extended cuts were in lots stored at bud stage (a). Flowering began on January 12. In other years when buds were in a more advanced stage of development at digging, flowering was earlier and first flowers have occurred as early as December 23. At no time did the Holland-grown William Pitt tulips bloom so early as those grown in B.C., but no conclusions can be drawn from this because of the aforementioned differences in treatment.

*Midseason Blooming.*—That the pretreated bulbs bloom at least a month before usual midseason forcing is shown by treatment and bloom of a further lot also dug on July 13. These latter bulbs were held dry for 93 days at temperatures beginning at 68, and dropping through 62 to 55 to planting on October 14 at 48°F. The flatted bulbs were withdrawn weekly after 12 to 15 weeks and then subjected to dark storage at 52°F. for approximately one week before benching at 65°F. Benching was 33 to 28 days to bloom and blooming began February 15, a month later than the earlier forced material. The cut extended over nine to five days, the shortest cut being on the flats held 15 weeks in cold store. The cut flowers were both shorter and heavier than the early-forced bloom, but the flowers themselves were no longer, although perianth parts and also leaves were broader. First flowers appeared on these bulbs 217 to 229 days from digging, and blooming was 93 to 99 per cent. No decrease in percentage bloom resulted from 'paper' flowers.

William Pitt is a naturally late-flowering Darwin tulip, a Krelage seedling. Other Darwins had been crossed with the very early Duc van Tol tulips early in the 1900's to give the easily forced and earlier (midseason) Mendels introduced during and after 1921 (1).

The several years' work with William Pitt tulips indicate that for this variety:

1. Bud development is affected by the preceding season;

2. Warm storage after early digging does not fully compensate for the disturbed physiology of development;

3. Early forcing requires 29 to 30 weeks from leaf formation in the bud;

4. Pretreatment with cool storage before carpel formation in the bud results in a high percentage of 'paper' flowers and an extended cutting period;

5. Degeneration of flowers to 'paper' bloom occurs late in plant development;

6. Root drying has the same effect as too early cool storage;

7. Early forced plants are longer but not so sturdy as those forced for midseason blooming;

8. William Pitt, a late-season variety, can be readily forced for midseason blooming, but with difficulty and many losses for early season.

***Reference***

1. Doorenbos, J. Notes on the history of bulb breeding in the Netherlands. Euphytica 3: 1-11. 1954.

# LOW TEMPERATURE RESEARCH

*W. R. Phillips*

## Effect of Storage Temperatures

Temperature reduction prolongs the storage life of apples if the temperatures are not so low as to cause freezing injury. As a safeguard against freezing a compromise temperature of 32°F., providing a safety margin of approximately 4 degrees above the average freezing point of the apple tissues, has generally been recommended.

Recently it has been felt that this margin of safety could be reduced considerably, chiefly because of improved temperature distribution and design in cold storage plants. Hence investigations were initiated to study the comparison in storage behavior between temperatures below 32°F. with those at or above 32°F. This would form a basis for measuring the beneficial effects of lower temperatures in relation to the risk involved.

General observations including the percentage of marketable fruit and estimations of the major forms of wastage were made periodically on bulk samples of McIntosh, Cortland and Lawfam. Parallel with this, trends in sugar content, soluble pectins, pressure tests, titratable acidity and production of volatile substances were studied in detail. At intervals, samples were assessed for physiological and pathological disorders and measured for quality.

### *Observations on Bulk Samples*

In bulk samples of McIntosh, breakdown and fungal wastage tended to be more prevalent above than below 32°F. Total wastage indexes for the several storage temperatures were:

| *Storage* | *Wastage index* | *Storage* | *Wastage index* |
|---|---|---|---|
| 30°F. | 11·1 | 32°F. | 12·5 |
| 31°F. | 9·7 | 33°F. | 21·4 |

Cortland and Lawfam had very little wastage in any sample when marketed; hence, these varieties did not show comparable contrasts.

Based on the results of large-scale bulk storage experiments with McIntosh, storage life can be considerably prolonged by reducing temperatures to 32°F. Below this, the gain in storage life is not so pronounced. However, to assure benefits of the 32°F. temperature to all parts of the storage, it would be good practice to operate at, or slightly lower than, 31°F.

### *Observations on Small Samples*

McIntosh apples were examined after three, five and seven months. Such observations indicated a break-off point in the course of most trends prior to which little difference in temperature effect existed. Thus with three months' storage no differences in core flush were noted between the various storage temperatures. All were approximately index 35. After five months twice as much core flush existed at 33° F. as at either of the lower temperatures (index 160 at 33°, and 80 at 30, 31 and 32°F.). Not until seven months' storage was a contrast obtained between all temperatures, thus:

| *Temperature* | *Core flush index* | *Temperature* | *Core flush index* |
|---|---|---|---|
| 30°F. | 80 | 32°F. | 180 |
| 31°F. | 140 | 33°F. | 190 |

However, at seven months all samples were beyond marketability. These results illustrate the importance of observation time in comparing differences in storage treatment. These data also explain past discrepancies in the temperature effect on core flush and may also explain previously mentioned lack of temperature contrast in bulk samples.

Previous work demonstrated the relationship between core flush and low temperature. Core flush rarely occurs above 38°F. Considerable controversy has existed, however, on whether the condition increases progressively as the temperature is reduced below 38°F. The foregoing classifies the time-temperature relationship to core flush, and thus it would appear that most of the controversy resulted from comparative observations based on varying storage periods.

Pressure test trends also indicate a break-off point. Pressure started at 15·2 pounds at harvest, dropping in a linear fashion to 12·5±0·5 pounds at mid-February. Thereupon readings fell to 9·5±0·8 pounds within a four-week period. Pressure readings and storage temperature were not related. However, resistance to pressure and soluble pectins were conversely related. The rapid reduction in pressure after the mid-February break-point was preceded by a rapid increase in soluble pectins.

The break-point in pressure tests and mealiness were related, and mealiness was related to storage temperature. At 33°F. the apples were definitely mealy whereas those stored at 32, 31 and 30°F. had a mellow texture with no mealiness. Furthermore, mealiness onset appeared to be coincident with the core flush break-point.

Reducing sugars increased for the first three months at 31, 32 and 33°F. There was a slight deviation at 30°F. Here, reducing sugars decreased for the first six weeks, followed by a rise in concentration. The only other temperature effect was a general tendency for reducing sugars to increase more rapidly at the higher temperatures. This condition was not very clearly defined, however. Thus, reducing sugar content was not materially different at 31, 32 and 33°F. but it did assume a different trend at 30°F.

Titratable acidity appeared to decrease at a uniform rate throughout storage but storage temperature did not appear to affect the rate. One exception was that apples stored at 30, 31 and 32°F. appeared to show slight increases in acidity at the outset, whereas at 33°F. a short level phase preceded the general trend. This may suggest that at 33°F. climacteric conditions were reached more quickly than at the lower temperatures.

Volatile production, like reducing sugars, increased for the first three months. For a short time thereafter values were constant, then dropped. Different trends were assumed at the several temperatures but the relationship with temperature variation did not appear consistent or explainable by other trends. The essential difference was that no peak existed at 33°F.; for the most part these were falling or nearly level throughout. A temperature of 32°F. produced the highest peak, followed by 30 and 31°F. The foregoing suggests that above 32°F. metabolism is different from that which exists at or below 32°F. Volatile analyses were supplied by the Chemistry Division, Science Service.

The practical application of these investigations is that storage life of apples can be increased by storing at 30°F. instead of 32°F. or higher, particularly if storage life is based on core flush development. The gain per degree reduction within the normal 5 months' storage period is not so great below 32°F. as above, however. Therefore, the greatest advantage in aiming at a 31 or 30°F. temperature would be the assurance that the whole storage room is reduced to at least 32°F. From these observations it would appear that a reduction of temperature below 32° is instrumental in prolonging storage life without inducing deleterious complications.

## Effect of Storage on Bruised McIntosh Apples

It has been long conceded that careful handling of apples is necessary to avoid bruising. What is not generally known, however, is the effect of time and type of bruising. This is of great practical significance in deciding whether to grade apples upon entering storage or after their removal.

Two difficulties complicate measuring bruise damage on an experimental basis. These are (1) obtaining bruise-free material initially and (2) bruising each fruit in a sample equally. Such difficulties dictated a small-scale controlled bruising experiment.

Two types of bruising were attempted; one to simulate a pressure bruise and another an impact bruise; in other words, package and handling bruises. The former was effected by exerting a steady pressure of 17 pounds on a 0·7 sq. in. area; the latter by allowing a 0·3 lb. steel ball to hit the apple surface after rolling down a 22-inch runway of 22·5° slope. The bruised areas were marked, and the damage measured by weighing the injured tissue at a later date.

As would be expected, apple softness as measured by pressure test influenced the degree of bruising, particularly with the pressure type of bruise. Size (within limits), temperature of fruit and source had little influence on bruising damage. In all results the pressure type of bruising appeared to show more variation than the impact bruise. In maturity versus bruising susceptibility studies, later-harvested apples were more susceptible to impact bruising than earlier-harvested material. However, damage increased but little in the first three storage months in all samples bruised by either method, then stored immediately after either early or late harvest.

On the other hand, results differed after a storage period. The critical period began in late December or early January, then susceptibility increased slightly and continued to the end of storage life.

Moreover, bruising, particularly the impact type, was responsible for the onset of senile breakdown in McIntosh apples. Nevertheless, three to six weeks elapsed before the breakdown became apparent. Further storage intensified senile breakdown.

In all experiments considerable time elapsed before the damage became fully apparent. Normally, the first symptoms are merely a softened area with a slight deformity depending on the method of bruising. Browning of the soft (bruised) tissue may not occur for days or weeks. The tissue may actually dry up and the bruised area become localized. More frequently the discoloration may spread beyond the original soft area. Later still, fungal invasion, breakdown or other disorders may appear. The time lag between bruising and serious injury is of considerable practical importance.

The significance of the time lag after either type of bruise whenever applied is that apples can be graded at any time during their storage life without any great increase in injury. The significant provision is that apples graded in the later storage period should be marketed fairly quickly. If apples graded out of storage are marketed immediately they can actually be handled with lower losses from bruising, rot and senile breakdown than apples graded at harvest.

An attempt was made to calculate the length of time between actual bruising and the development of senile breakdown. Towards the end of storage life (end of January) the onset of breakdown commenced after two weeks at 32 plus one week at 68°F. As storage advanced the interval between bruising and breakdown became shorter. Thus for the major portion of the storage period the shelf life would be three weeks or longer.

## Air Purification in Apple Storages

Stored apples generate volatiles. These are detrimental for they hasten senescence and the onset of physiological disorders in the apples. Several devices have been used to absorb, oxidize or otherwise eliminate the volatiles. Paper wraps or shredded paper impregnated with mineral oil offer a common and reliable control for superficial scald, a physiological disorder induced by apple volatiles. More recently, charcoal filters and ozone have been used to a limited extent.

A disadvantage with charcoal is its inability to adsorb ethylene, the most abundant apple volatile. To overcome the disadvantage we explored ozone as an ethylene oxidant in conjunction with charcoal filters as an adsorbant. From a theoretical point of view this appeared to be worth investigating. The investigations, however, revealed obstacles that made the use of ozone impracticable. The chief obstacle was the amount of electrical energy needed. Under low humidity conditions 18 watts were required to produce 2 mg./min. In air having 90 per cent relative humidity this 2 mg. figure was reduced to 0·08 mg. The calculated amount of ozone needed to oxidize the ethylene given off by 100 bushels of stored apples is 0·1 mg./min. Thus an excess of 1000 Kw. would be required for a ten-thousand-bushel commercial storage room. Methods suggested to reduce this excessive figure were equally impracticable. It was therefore concluded that ozone does not offer a practicable solution to the apple volatile problems.

Intensive experiments were conducted on charcoal filters and their effect on the behavior of stored apples. The adsorptive capacity of various types of charcoal in relation to air movement was studied. Results suggested that the most satisfactory operating condition for our equipment was to pass air at velocities lower than 60 l.f.p.m. through coconut shell charcoal. To obtain maximum adsorptive conditions the charcoal was renewed daily.

To measure the effectiveness of this system the storage atmosphere was analyzed for volatiles and apple tissue for ethylene. Titratable acidity of the extracted apple juice, fruit quality as measured by individuals and taste panels, and soluble pectins in the tissue were estimated. Apple samples were also examined frequently and the amount and extent of both physiological and fungal disorders recorded.

In all these observations the only consistent and significant difference was the effect on the soluble pectin content. The report (2) shows primarily that volatile removal either by ventilation or charcoal adsorption reduces the extent of the soluble pectin peak normally occurring in Lawfam apples slightly after midseason.

Other trends were less consistent and significant. However, storage life as measured by pressure test and acidity loss tended towards prolongation. The best that can be said is that no harmful effects were noted. Findings on this have been published (1).

### *References*

1. Phillips, W. R. The apple volatile problem. Can. Refrig. J. 19(6): 27-28. 1953.
2. Poapst, P. A. and W. R. Phillips. Air purification and soluble pectin accumulations in Lawfam apples. Sci. Agr. 32: 109-113. 1952.

## Gas Storage

Gas storage has been under investigation at the Horticulture Division for more than 20 years. The earlier work was reported in the 1934-48 Progress Report and elsewhere.

The accumulated information has not been applied commercially for several reasons; one has been the lack of suitable commercial apple storage units. This has now been remedied in the province of Quebec, and the construction of gas storage units is almost a certainty in the near future. Similar advancement is being made in Nova Scotia.

During the earlier part of the period covered by this report the effect of temperatures between 32 and 36°F. on the development of gas storage injury was investigated. Normally, gas storage is applied at 38 to 40°F. but frequently operating gas storages at lower temperatures would fit in with a storage program. The difficulty is, however, that reducing the storage temperature below 38°F. increases susceptibility to gas storage injury.

Preliminary studies indicated that such lowered temperatures might be used if the $CO_2$ concentration was reduced below the 7 per cent recommended for 39°F. Semi-commercial trials to test these preliminary findings were then attempted.

McIntosh apples were stored in two 175-bushel gas storage rooms at 32°F. in gas mixtures (1) 5 per cent $CO_2$ and 16 per cent $O_2$ and (2) 5 per cent $CO_2$ and 5 per cent $O_2$. Because of reduced respiration rates, (1) was hard to obtain and (2) could not be obtained. The $O_2$ level in (2) could not be reduced below 12 per cent.

The gas storage injury in either room averaged 4 per cent, but was as high as 12 per cent in some samples. If the predetermined gas mixtures had been attained, the injury would undoubtedly have been increased (but see following). Thus it is obvious that gas storage of McIntosh at 32°F. would be hazardous.

In the preliminary gas storage treatment (containers with continuous ventilation) no injury had been found in duplicate samples. Possibly, therefore, the accumulation of volatiles in the gas storage room may be a causal factor in $CO_2$ injury.

Subsequent trials at 34°F. indicated that less injury was produced but it was felt that it would be a wise policy to adhere to the 38°F. minimum.

Current plans involve preliminary studies on the gas storage possibilities of new varieties including Lawfam, O-2016, Bancroft, and Toshkee. From initial findings it would appear likely that gas storage may prove a means of reducing core flush in O-2016, but further studies are needed on the other varieties.

### Carbon Dioxide Fixation in Apples

Studies in respiratory quotients on gas-stored King Edward VII apples at Ditton Laboratory, D.S.I.R., indicated that these fruits had the ability to fix carbon dioxide. This fixation process, as has been shown to exist in other material, is analogous to photosynthesis. There are two important exceptions, however, in that fixation does not utilize chlorophyll and the end products are acids rather than carbohydrates.

In studies on the carbon dioxide fixation in apples at the Horticulture Division, the procedure briefly consisted of exposing McIntosh apples to radioactive ($C^{14}$) $CO_2$ in a darkened vacuum desiccator. The $CO_2$ was generated by adding dilute phosphoric acid to a given amount of $BaCO_3$ to provide a 5 per cent concentration of $CO_2$ containing 2 millicuries of $C^{14}$. After an exposure of 18 hours to this atmosphere the apples were removed for analysis. This consisted of separating carbohydrates, acids and the protein fraction of the apple tissue. Each of these groups was then tested for radioactivity.

The percentage of radioactivity based on the calculated total was as follows:

| | |
|---|---|
| Acid (malic) | 63·8% |
| Carbohydrate | 1·6% |
| Amino acids—free | 10·1% |
| Amino acids—hydrolysate | 8·3% |
| Total | 83·8% |

These data indicate that the products of $CO_2$ fixation are mostly accounted for and consist chiefly of malic acid and amino acids. The amino acids in descending order of radioactivity were aspartic, glutamic, serine and alpha-alamine.

The trend of $CO_2$ fixation rates was measured prior to and during storage. This trend rose and fell with the respiratory climacteric shortly after harvest. These rates declined until mid-December at which time another peak occurred. This peak coincided with the peak occurring in soluble pectin, reducing sugars and other constitutents.

The ability of apples to fix carbon dioxide may explain at least one way in which $CO_2$ in gas storage prolongs the storage life of apples. Further studies along these lines may elucidate some of the aspects of acid metabolism, which has such great importance in storage physiology.

Detailed results (1, 2) of the co-operative project with the Chemistry Division, Science Service, have been published.

***References***

1. Allentoff, N., W. R. Phillips and F. B. Johnston. A $C^{14}$ study of carbon dioxide fixation in the apple. I. The distribution of incorporated $C^{14}$ in the detached McIntosh apple. J. Sci. Food Agr. 5: 231-234. 1954.
2. Allentoff, N., W. R. Phillips and F. B. Johnston. A $C^{14}$ study of carbon dioxide fixation in the apple. II. Rates of carbon dioxide fixation in the detached McIntosh apple. J. Sci. Food Agr. 5: 234-238. 1954.

## Effect of Rootstock and Stempiece on the Storage Behavior of McIntosh Apples

*W. R. Phillips and S. H. Nelson*

Work published by the Pomology Unit, Horticulture Division, has indicated definite cultural advantages in propagating apple varieties on selected rootstocks and stem builders. The type of stock selected may, however, have an influence on the storage behavior of the fruit. The purpose of these investigations was to measure this effect only, for certain present limitations preclude investigating the causal factors. Therefore, the evaluation has a direct commercial application.

Apples were harvested from trees grown on various rootstocks and stem builders under trial in the Horticulture Division orchard. An attempt was made to harvest all fruit at a starch test of 5 to 5·5. Samples of 100 randomized tree-run fruit were made up from such material and stored at 32°F. The samples were examined at intervals during storage.

***Single-worked Trees***

The first year's results confirmed those obtained some years ago. In comparison with other rootstocks, Anis produced fruit superior in storage properties. It had the greatest resistance to core flush, rots and breakdown. East Malling stocks IX and XII were as resistant to core flush as Anis but were more susceptible to fungal wastage.

East Malling I and Antonovka exhibited the poorest storage characteristics. Both were susceptible to core flush and rots and Antonovka to breakdown; also, *Malus baccata* and East Malling II were intermediate in all storage characteristics, except being slightly higher in susceptibility to rots.

With the exception of Anis, general senility had set in after four months' storage of all samples. All samples were over 80 per cent damaged after five months' storage, indicating a poorer than average storage season.

Fruit harvested in 1951 followed approximately the same pattern. McIntosh from Anis rootstock were definitely superior, the storage life being 140 days. East Malling I and II showed high susceptibility to core flush whereas East Malling IX and XII were susceptible to rots. Antonovka again rated very low, with a storage life under 120 days.

The only exception to the previous year's results was the behavior of *Malus baccata*. This time the rootstock produced fruit with the lowest storage characteristics. The rated storage life was under 110 days. Sample size difference may explain the discrepancy since only a small number of fruits were available for the first year's trial.

***Double-worked Trees***

In 1953 the fruit tested was from double-worked trees. The rootstocks were Antonovka and Anis. The stem builders on Antonovka were: Antonovka, Osman, Pioneer, Columbia, Robin and Hardy Crab; and on Anis: Anis, *M. baccata*, Hibernal, Patten Greening and Antonovka.

The whole Anis group differed very little from the Antonovka group. Quality indexes and storage disorders appeared to have greater variation within the group than between the two groups. Thus it would be reasonable to assume that the stem builder has a much more pronounced effect on storage behavior than the rootstock. However, where Anis and Antonovka were both stem builders and rootstocks, differences in storage behavior of the fruit were similar to those found earlier in the single-worked trees.

The stempieces of the double-worked trees exerted no detectable varying effects on quality, ground color or blush, but fruit from trees with stem builders Anis, Columbia and Osman were most resistant to both core flush and fungal wastage. Thus previous findings on Anis are substantiated.

The other extreme, also substantiating the 1951 findings, was *M. baccata* on Anis rootstock. This had the highest core flush rating. Hibernal and Patten Greening on Anis, and Antonovka, Hardy Crab and Robin on Antonovka were also highly susceptible to core flush.

Pioneer on Antonovka and Antonovka on Anis were intermediate in storage behavior. One very interesting feature was the better storage behavior of McIntosh apples from Antonovka on Anis rootstock compared with Antonovka on its own roots. The core flush indexes were 120 and 57 respectively.

These findings indicate, in general, that the stock on which McIntosh apples are grown—the rootstock in single-worked and the stempiece in double-worked trees—can have a profound effect on storage behavior. This effect is most marked in core flush development. The effects on rot development are also fairly consistent.

## Control of Fungal Wastage

*P. A. Poapst*

***Apples***

In an effort to find a means of controlling fungal wastage in certain varieties of apples and other fruits especially prone to such, and also to find means of curbing certain isolated instances of heavy fungal infestations in normally non-susceptible varieties, a wide selection of chemical reagents were used to treat Linda apples.

Among materials applied as an aqueous dip, the heavy-metal compounds such as bordeaux, copper-oxy-chloro-sulphate, and ferric dimethyldithiocarbamate, normally classed as orchard sprays, proved reasonably effective. These would not be feasible except where fruit is normally graded and washed on removal from storage. Acid-type materials producing fairly high hydrogen-ion concentrations were believed to damage the fruit, as judged by worsened conditions. Falling into this category were such materials as ortho-boric acid, citric acid, salicylic acid and sodium diacetate. On the other hand high pH also appeared to be damaging. Moderate success was obtained with low concentrations of the sodium and calcium salts of propionic acid but when the concentrations were increased, thus causing a rise of pH, the conditions were again worsened. It appeared that the desirable fungistat would have a pH close to neutrality.

Other materials applied by aqueous dips and producing inconsistent results were sodium silicate, sodium hypochlorite, the sodium salt of ortho-hydroxybiphenyl, sodium benzoate, formaldehyde, phenol, dehydroacetic acid and alkyldimethylbenzyl ammonium chloride. In materials not supplying a persistent effect, as in the sodium hypochlorite treatment, success varied according to re-contamination occurrence. The effective use of such agents would require periodic dosage and could be more easily practiced by supplying a gaseous-type material or one easily volatilized.

The only gaseous-type material tried on apples was ozone. The instability of the gas, coupled with the difficulty of controlling the concentration and the hazard of damaging the fruit lenticels (ozone spots), discouraged further testing.

Considerable success was experienced in controlling wastage when apple wraps, size 100 square inches, were impregnated at a weight rate of approximately 0·0055 grams per wrap of orthohydroxybiphenyl plus 0·24 grams of a glyceride oil. Exact concentrations of the active ingredient and optimum oil dilution were never worked out. Orthohydroxybiphenyl without the oil and concentrations higher than the listed dilution caused skin scalds.

Wrapping apples not normally wrapped is an additional labor charge. To escape this, tests were made where the orthohydroxybiphenyl was impregnated into carton liners, pads and shredded paper filler. These tests produced lower than moderate success and the effect appeared to be peripheral.

Sulphur dust and sulphur-impregnated wraps were completely ineffective.

***Strawberries***

The major cause of reduced shipping radius of strawberries other than the normally short shelf life is the high percentage of wastage due to fungal and bacterial causes.

Searching for a means of reducing fungal wastage, strawberries held at 75°F. were tested with perchloroethylene, trichloroethylene, peracetic acid, sodium salt of orthohydroxybiphenyl and sorbic acid. The treated and control quantities were held in separate chambers.

Perchloroethylene, trichloroethylene, peracetic acid, and the sodium salt of orthohydroxybiphenyl all increased the shelf life by at least 50 per cent. The chlorinated hydrocarbons were administered in the gaseous state at concentrations ranging from 1:10000 to 1:20000 for 24 hours on the basis of volume of liquid hydrocarbon to free air space in the container. Perchloroethylene at concentrations higher than 1:10000 damaged the fruit. The peracetic acid containing 38·5 per cent active ingredient and the sodium salt of orthohydroxybiphenyl containing 85 per cent active ingredient were employed as aqueous dips at concentrations of 0·3, 0·6 and 0·9 per cent and at 0·05, 0·10 and 0·15

per cent respectively. Both materials appeared to be equally effective at all concentrations. The peracetic acid, however, appeared to cause some bleaching of color at a concentration of 0·6 per cent and higher. Adjustment of pH of this material towards neutrality did not affect its performance in any way. Sorbic acid applied as an aqueous emulsion at 0·1, 0·2 and 0·3 per cent concentrations was completely ineffective.

All treatments other than the sorbic acid dips reduced the average mold count by the Howard Method 75·0 ± 12·5 per cent.

***Peaches***

Trichloroethylene was tested on Elberta peaches as a possible means of controlling brown rot and other mold organisms. All samples other than untreated controls were given a heavy inoculation of spores of *Monilia fructigena* and *Rhizopus* strains. Treatments and holding were carried out at both 75°F. and 40°F. with treatments and controls being stored separately. The trichloroethylene was administered at concentrations of 1:15000 to 1:25000, volume of liquid to free air space. The treating concentration was maintained for 10 hours.

Material treated and held at 75°F. showed good control for a four-day period, but tapered off to zero by the end of nine days.

Treatments made and held at 40°F. showed mainly that holding at low temperature was the best deterrent to fungal wastage in peaches.

## The Effects of Pre-harvest Sprays on the Storage Behavior of Apples

***Naphthaleneacetic Acid***

First storage investigations on the possibility of pre-harvest sprays shortening storage life were made in the crop year 1949-50. At that time, a heavy dropping year, the sodium salt of naphthaleneactic acid was in use in the McIntosh orchard. The harvested fruits from a number of trees sprayed with 20 p.p.m. "App-l-set" were set aside for casual observations in storage. For reference material an attempt was made on the basis of pressure tests and starch iodine relations to select unsprayed material of comparable maturity. Reference material was picked three days later than sprayed material.

Respiration measurements conducted at harvest time under 55°F. controlled temperature indicated slightly higher activity surrounding the climacteric on fruit from sprayed trees. Measurements varied between 15·9 and 18·4 mg. $CO_2$/Kg. hr. for treated fruit as opposed to 12·4 to 17·3 mg. $CO_2$/Kg. hr. for reference fruit. Respiration measurements at 32°F. on material withdrawn from 32°F. storage indicated that the control was more active throughout most of the storage life. Respiration varied between 4·9 and 5·8 mg. $CO_2$/Kg. hr., which was roughly 0·5 mg. higher than the sprayed fruit. That is, the sprayed fruit was more active at harvest but lower than the control during storage.

Eating quality showed a marked drop in sprayed fruit after the third week of March whereas the controls were still good for an undetermined time subsequent to the end of the month.

Terminal storage analyses of titratable acids, pressure, and soluble pectin showed that the controls exceeded the treated by 5·5 and 6·9 per cent respectively for the first two factors, and that the controls displayed a 33 per cent favorably lower level of soluble pectin accumulation.

The most outstanding difference in the keeping quality of the two treatments was in the fungal wastage. From equal wastage in both samples on December 23, wastage in the treated samples increased to 3·5 times that in the controls by May 25. Pre-harvest sprayed apples also displayed substantially more blush.

Despite the non-drop factor in the following cool season, 1951-52, the more comprehensive planned work was carried out. Sprayed and unsprayed trees were harvested in pairs over two 8-day intervals, permitting comparisons on the bases of three maturities. Detailed investigations into softening, decline of acids, respiration, and various physiological disorders revealed virtually no difference between unsprayed and sprayed fruit other than a slightly greater tendency to senile breakdown in the sprayed fruits. Blush coverage, on the other hand, was substantially higher in the fruit receiving a pre-harvest spray, a finding noted the preceding year.

***2,4,5-Trichlorophenoxypropionic Acid (2,4,5-TP)***

With the acceptance of various salts of 2,4,5-TP as suitable replacements for naphthaleneacetic acid derivatives in 1951-52, it became necessary to evaluate the effects, if any, of the newer materials on storage behavior. Four separate picks of McIntosh trees comprising controls and treatments of 20 p.p.m. foliar application were made at 8-, 13-, 17- and 22-day intervals after application. This was a heavy dropping season and insufficient material was obtained for the fourth maturity control to allow full storage investigations.

Observations prior to and at harvest indicated a tendency to higher blush in sprayed fruits and also a suggestion of diminished size. Starch tests showed considerable rise and fall in the control trees, indicating a slanting of maturity in the original tree population by the earlier dropping of the more mature fruit. Pressure differences between sprayed and unsprayed fruit increased with later harvests. In the latter picks sprayed fruits were more than 2 pounds softer.

Tests on apples withdrawn from 32°F. storage indicated that pressure differences existed throughout storage, converging at the end of storage with the attainment of minimal values. Soluble pectin accumulations corroborated this condition. Respiration measurements and occurrence of physiological disorders revealed no significant differences.

The decline in the concentrations of total titratable acids for the various treatments showed variation in rates and levels. Initial concentrations of acids were successively lower with extended delay of pick. Sprayed lots were lower in acid than their corresponding controls. The rates of consumption in the controls, however, tended to maintain themselves at the same high rate as in the initial pick, whereas the sprayed material declined to 62 per cent by the third pick as compared with its control.

The tendency of successively later picks to produce lower acidity levels is normal, as is also the tendency to produce a compensating slower loss rate in storage. As substantially heavy drop had occurred at the second and third maturities of the controls, the data strongly indicate that comparison is made against controls with a slanted maturity—the early ripening element of the tree population having dropped. This may not explain all the differences between controls and 2,4,5-TP sprayed fruit but should account for a substantial part of the difference.

***2,4,5-Trichlorophenoxypropionic Acid (2,4,5-TP), 2,4,5-Trichlorophenoxyacetic Acid (2,4,5-T) and Maleic Hydrazide (MH)***

Emphasis in the 1952-53 season was on gathering up some of the loose ends from the preceding year's work. One objective was to get a better appreciation of the variation between control trees. Also, it was felt that at least a cursory examination should be made of the application of two other acceptable materials. Ten McIntosh trees were available for these tests, five of which were retained as controls. Of the other five, two were sprayed with 2,4,5-T at 20 p.p.m., one with 2,4,5-TP at 20 p.p.m., one with 2,4,5-TP and MH at 20 and 200 p.p.m. respectively, and the last tree received 200 p.p.m. MH only.

All ten trees were harvested at the regular time and the fruit was stored at 32°F. This was essentially a non-dropping year though two of the control trees did show appreciable drop. The storage investigations showed that all differences which had been reasonably prominent the preceding year were either very small or completely masked by variations in the controls. Among the five controls, however, the rate of acid loss on the basis of tree to tree comparison correlated very well with the proportion of drop. This would further substantiate the theory on the preceding year's work that drop on the reference trees introduces a bias in the acid measurements. The steepness of the line showing diminishing concentration of total titratable acid appeared to be directly proportional to the amount of drop.

In summarizing the results of pre-harvest sprays investigations, it would apear that the substantially different results observed in the keeping behavior of McIntosh apples in certain years are due largely to reference being made to control trees with fruit populations biased by heavy dropping. Further differences may be introduced by using growth regulating materials, but it would seem doubtful that these are of such order as would exceed normal tree variation or be of any practical importance.

The effects of pre-harvest sprays on storage behavior will appear in greater detail elsewhere.

## Maturity Studies

It has been stated that the optimum picking date for McIntosh occurs three days before the respirational climacteric. Various physiological trends had been studied with the idea in mind of forecasting the date of occurrence of the climacteric, but this was without any practical success.

In 1950 a series of picks were made from a tree with a determined date of climacteric. These picks were made while the respirational climacteric was developing and also two days after its occurrence. Examination in storage revealed no essential differences in keeping quality though the post-climacteric pick appeared to have more finish. The total span in picking time was 10 days. It was therefore concluded that harvesting on dates immediately surrounding the climacteric occurrence was sufficiently precise for maximum keeping quality.

Interest was then turned to the incidence of drop. This involved two mutually compromising features: (a) acquiring finish; that is, more size and color, and (b) losing the crop through abscission.

Three years' observations on the cumulative percentage drop from a selected McIntosh tree were plotted against the disappearance of starch for each respective year. Using selected 10-apple samples, the presence or absence of starch was measured by reference to a starch iodine index chart. The exact nature of this index chart (1) is somewhat obscure now, but it appears to be based primarily on maturity rather than on absolute starch content. The index spans the period of starch disappearance and is scaled from one to nine, with the highest number indicating trace or no starch.

In 1950-51, the starch index on the trees rose slowly and uniformly to 6·2 at which point the tree quickly unloaded, indicating homogeneous maturity. Starch indexes on the dropped fruit ranged from 6·5 to 7·5. The following year the tree began to unload 16 days earlier and drop was protracted. The onset of drop occurred at a tree index of 5·8 with the windfalls ranging between 6·8 and 8·0. The starch index rose and fell with time, indicating dissimilarity of tree population. In the third year, tree maturity again tended to more uniformity, with drop onset commencing later. The tree index was 5·1 with the majority of windfalls dropping between 5·5 and 6·9.

It had been hoped that abscission would occur at a precise index and could thereby be predicted. Superficially a spread of 1·1 index points does not appear too precise and is somewhat disappointing. One obvious reason for variation is the various degrees of dissimilarity in maturity in the tree population from year to year. On the other hand, the windfalls vary from year to year in lower to upper index limits. This suggests that there is more to the problem than the relative proportion of the maturity populations on the tree. On the basis of three years' work, however, it would appear that rate of starch loss may be a more significant factor in predicting onset of drop and possibly that after an index of 5·0 has been attained the danger point is at hand.

More recently a quick colorimetric analysis of starch content has been compared with the starch iodine index. Reasonable agreement was noted when the means were calculated on 10-apple or larger samples, but scatter varied to extremes on individual apples. Colorimetric determinations appeared to produce a normal decline relation, almost linear at higher starch concentrations. By interpreting the index in terms of starch determined chemically, the indicated variation of 2·5 on windfalls over the three years of starch index measurements indicates a $\pm 6$ per cent variation of the original total starch content. Using the colorimetric method for determining starch it may be possible to devise a function describing the rapidity of starch disappearance with time, and use the rate of change of the function as a key to the probable onset of drop.

***Reference***

1. Davis, M. B. and D. S. Blair. Cold storage problems with apples. Sci. Agr. 17: 105-114. 1936.

## Freezing Effects on Apple Wood

*M. B. Davis, M. MacArthur and D. Williams*

Beginning in December, 1952, in a series of experiments, 3-year-old twigs of *Malus baccata* var. *Sibirica maxima,* Antonovka, Lobo, McIntosh and *Malus robusta* were subjected to controlled freezing temperatures. The first four varieties were plunged from +28 to −35°F., then brought back through −15 and 0°F. with holds of (a) 14 or (b) 48 hours at each temperature before removal to the greenhouse (60°F.) for recovery. In addition, the same varieties were (c) step-dropped through −15 to −35°F. with temperature rises and holds as in (a). Therefore, the twigs were exposed to (a) 42, (b) 144, and (c) 56 hours at low temperatures (Fig. E-1).

Recovery was greatest in *M. baccata,* indicating its superior hardiness. Exposure for 144 hours caused the most injury, and 56 hours the least. This indicated that the step-drop through −15°F. to the low of −35°F. afforded some protection. Nevertheless, damage was severe in all treatments. All fruit buds and most shoot buds were killed. With 144 hours' exposure a few dormant or accessory buds opened on the 3-year wood only. Many such buds opened on the 2- and 3-year wood after a plunge to −35°F. with 42 hours' total low temperature exposure. On the other hand, not only dormants but a few normal laterals opened on the lower part of the first year and on the second and third year wood after the step-drop through −15°F. to −35°F. with 56 hours' total low temperature exposure.

After eight weeks in the greenhouse, Antonovka and Lobo, exposed to the immediately preceding treatment, developed a very few dormant or accessory buds, but McIntosh was frozen to death. Plunges to −35 without the step-drop through −15°F. killed these three varieties.

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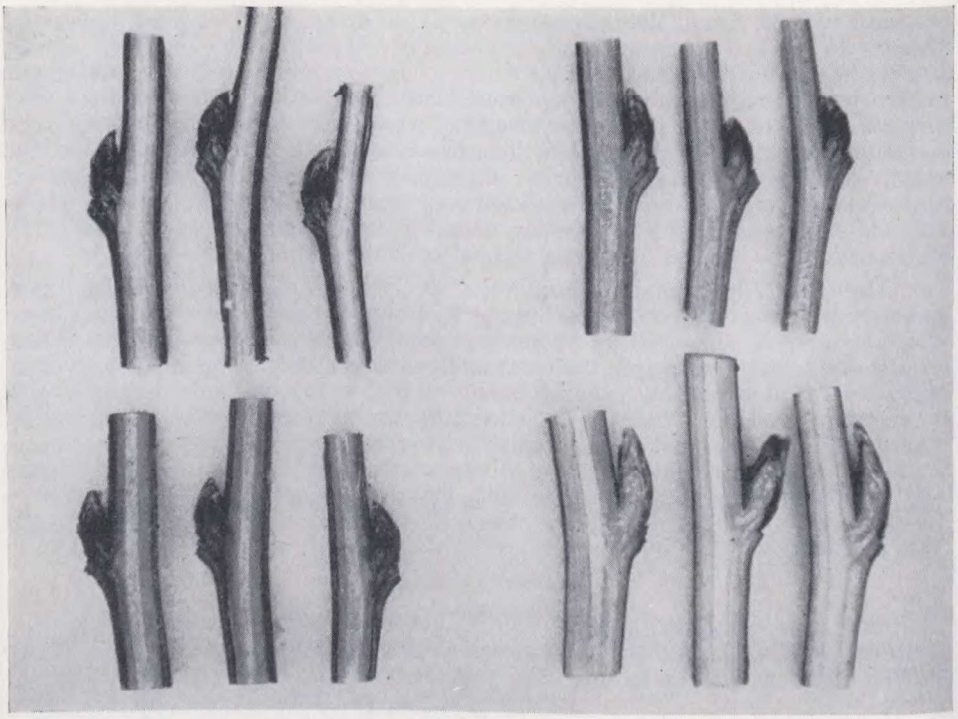

Fig. E-1—Effect of freezing on *M. baccata;* lower right, control; lower left, frozen as (b) in text; upper right, as (c) in text; upper left, as (a) in text.

The terms normal, dormant and accessory as used here require explanation. "Normal" buds are the nodal fruit and shoot buds—laterals, spurs and apicals—formed the preceding growing season. They had been formed by apical meristems. During their formation small cushions of meristematic tissue were isolated. When this previously formed bud was killed, the isolated meristems regained apical dominance and proceeded to develop new buds. "Dormant" buds arose from isolated meristems in the axils of scale leaves on the bud scar flanks. An "accessory" bud arose from a similar meristem below the killed bud, outside the scale leaves but in a foliage leaf axil. Strictly, "adventive" buds on a shoot arise only from regenerated permanent tissue.

Late in December, *M. baccata* was plunged from +30 to −35°F. and samples were withdrawn hourly for 14 hours. The sudden drop to −35°F. killed all buds in all lots and only dormant or accessory buds developed.

Twigs of *M. robusta* exposed to a gradual temperature drop of 4°/hr. through 15 hours to −30°F. and held 1, 4, 8 and 12 hours at −30°F. were practically uninjured. Fruit and shoot buds of the frozen material opened at approximately the same time as the controls. Recovery after longest and shortest holds was similar.

*M. baccata* and *M. robusta* were used January 21 to compare a plunge to −35°F. plus a one-hour hold with the effects of dropping the temperature at 4°/hr. to the same temperature plus holds as in the preceding experiment. The plunge to −35°F. injured *M. robusta* much more severely than *M. baccata.* Only a few dormant buds opened very late on *M. robusta.* In *M. baccata* some shoot and dormant, but no fruit, buds opened. Tip killing occurred and leaf

shape was abnormal. In December all buds formed the previous growing season were killed by this treatment. These differences in reaction indicate that prior outdoor temperatures and depth of dormancy at time of treatment are operable in recovery phenomena. With the gradual drop to the same low, neither variety was damaged externally, but *M. robusta* showed slight increase of internal injury with extended holds. After the slow drop, fruit and shoot buds of both varieties opened. *M. baccata* developed more rapidly than *M. robusta*.

Antonovka, Lobo and McIntosh were subjected on January 30 to the 4°/hr. drop to −35°F. with holds to 12 hours. There was no die-back in any of the varieties. Many of the opened terminal and spur buds were stunted. Few lateral buds opened fully with completely expanded leaves but this was also found in the controls. Internally, leaf and branch traces were damaged (browned) by the 12-hr. hold. McIntosh showed most injury followed by Lobo then Antonovka.

These three varieties and *M. baccata* were, on February 4, subjected to the same gradual drop to −37°F. and held 6, 9 and 12 hours at that temperature. No variety was frozen to death, but development after the 12-hr hold was retarded. Some of the leaves of *M. baccata* were small and narrow; in the remaining varieties many of the leaves were short or had short petioles. Those flowers that did open (all varieties) were normal, but many buds in a cluster and some whole clusters showed initial growth, then stagnation, dying and dropping off. Internally, damage increased with increasing holds. Injury was most severe in McIntosh followed by Lobo, Antonovka and *M. baccata* in that order.

On February 10, the temperature was lowered at the same rate to -40°F. and none of these four varieties was frozen to death, but external and internal injury was greater than when the final low had been −37°F. The longer holds increased the damage. Even with the shortest (6-hr.) hold some flowers of all varieties were injured. Some buds were stunted, became yellow and degenerated. Many opened Antonovka flowers had abnormal—green, shortened and flattened, i.e., diminutive—petals. The filaments of the stamens were so shortened that the anthers appeared to be sessile. The leaves did not expand fully. *M. baccata* was the least severely injured internally. Antonovka followed, but in this experiment Lobo was more damaged than McIntosh. The Lobo tree providing the twigs for this experiment was judged less healthy. Spurs on the Lobo twigs were sparse and very short.

In the final experiment, February 19, the temperature was lowered at 12°/hr. to −40°F. with holds for 6, 9 and 12 hours. Again, no variety was frozen to death. Buds opened, but growth therefrom was stunted. Leaves and flowers showed abnormalities. In all varieties the flower abnormality ranged from green petals to petals with a sharp pointed tip through shortened and flattened petals to those so small as to appear almost lacking. Few leaves grew to full size. Most were small with short petioles, and frequently the number in a cluster was reduced. Occasionally the leaves themselves remained inrolled and closely appressed, adhering to each other by leaf hairs as at emergence, an indication of retarded development. This treatment caused more internal injury than the drop of 4°/hr. to −40°F. Neither cambium nor phloem was killed, but the youngest (outer) xylem and the distal portions of bud, branch and leaf traces showed quite severe injury.

Except in the first experiment all material was removed immediately to a 60°F. greenhouse after the stated hold at the lowest temperature. Thawing was rapid in the sudden change from −35 to + 60°F., for frequently the twigs were pliable before all lots were placed in the water jars. Nevertheless, *M. baccata* and *M. robusta*, thawed rapidly after a slow drop to, and an hour at, −35°F., were injured only slightly or not at all. On the other hand, these two varieties

subjected to a sudden drop from +10 to −35°F., held for an hour and thawed rapidly, were very severely damaged. These experiments differed in rate of freezing only. Thus the greatly increased injury was due to rapid freezing, and the rapid thawing had little deleterious effect. The five varieties used in the experiments in decreasing order of resistance to low temperature were *M. baccata, M. robusta,* Antonovka, Lobo and McIntosh.

These experiments on apple twigs, specifically limited as stated, indicate:

1. Rapid temperature drop is more injurious than ultimate low temperature;
2. The lower the temperature the greater the injury;
3. Extended time at low temperature increases the injury;
4. Rapid drop is more injurious than rapid rise in temperature;
5. Prior temperatures and stage of dormancy affect the injury;
6. The health of the tree affects the resistance to low temperature injury, and
7. Varieties differ in their ability to resist low temperature injury.

## FRUIT AND VEGETABLE PRODUCTS

### Potato Chip Manufacture

*W. D. Powrie*

Many investigators have reported that reducing sugars are responsible for the undesirable dark brown color of potato chips. The reducing sugars can be removed by soaking the sliced potatoes in water.

Potatoes, stored for five months at 38°F., were peeled, sliced at one-sixteenth-inch and dipped in cold or hot water. Dip temperatures and times for desirable chip color were 153 to 163°F. and six to seven minutes.

Finished chips were coated with powdered candy and flash-heated at 1100 to 1300°F. for potato chip confections. The chocolate-coated type was made by dipping unsalted potato chips into bakers' semi-sweet chocolate at 80 to 85°F.

Complete details of processes and keeping quality as determined by this Division may be found in (1, 2).

***References***

1. Townsley, P. M. Eliminate conditioning period in potato chip manufacture. Can. Food Ind. 23(6): 26-29. 1952.
2. Townsley, P. M. and Ethel Dixon. Potato chip confections. Can. Food Ind. 23(7): 21-23. 1952.

### Color Changes in Strawberry Jam

Two months after storage at room temperature, loss of red color in pure strawberry jam is visually apparent. Since consumer preference is for a deep red jam, the color change mechanisms and methods of overcoming this undesirable degradation were investigated.

The investigation (1) showed that the red strawberry pigments, the anthocyanins, are partially destroyed and secondary brown and yellow pigments are formed during jam manufacture and storage. Ascorbic acid and dehydroascorbic acid increase the rate of pigment loss. Although iron and copper do not react directly with strawberry anthocyanins, they indirectly destroy the pigment by accelerating the destruction of ascorbic acid. Strawberry seeds contain components which also increase the rate of color loss.

Perhaps the most important components that degrade the pigment are the precursors of brown pigments such as hydroxymethylfurfural. These components are present in freshly prepared jam, and large amounts are produced when the jam is stored at room temperature.

Since color changes are very rapid above 65°F., the bottled preserves should be brought down to this temperature as quickly as possible after processing. Warehouse temperatures should be maintained at or below 60°F. to prevent color change.

***Reference***

1. Powrie, W. D. and M. B. Davis. Color changes in strawberry jam. Can. Food Ind. 24 (12): 26-27. 1953.

## Freezing

*M. MacArthur and E. Dixon*

*Effects of Holds on Pea and Corn Quality.*—Immediate processing, holds in the pod, and holds after shelling Thomas Laxton peas were compared. Color, flavor and texture deteriorations of held shelled peas were more pronounced than in pod-held peas. Pod holds of eight hours were fair; of 24 hours, poor, and a 24-hour hold of shelled peas rendered them unsuitable for processing. Ascorbic acid losses averaged 23 per cent during blanching, 13·5 per cent with 12 months at 0°F. and 17·3 per cent during final cooking for the table. Corn, cut, blanched, packed and held two hours prior to freezing was equal in quality to no hold. Three- and four-hour holds were lower in value as were husked unblanched lots held 4, 6 and 8 hours. After-harvest holds of 24 and 30 hours caused a marked drop in texture and flavor. Greatest ascorbic acid loss was in the cut, blanched, 4-hour hold.

*Effect of Freezing Method on Beans, Asparagus and Strawberries.*—Stringless green beans frozen unpackaged in an airblast (500 l.f.p.m.) at —20°F. were higher in palatability than similarly prepared lots frozen packaged at 0°F. "static". Ascorbic acid losses were similar; approximately 14 per cent was lost in blanching and 55 per cent of the remainder during one year's storage at 0°F. The two methods of freezing did not affect the palatability of asparagus. Both lots were equal to cooked fresh asparagus. Decreases in value with a year's storage at 0°F. were 16 and 14 per cent respectively of palatability and ascorbic acid content of the freshly frozen product.

Syrup- and sugar-packed strawberries were more flavorful frozen by airblast at —20°F. than frozen "static" at 0°F. Fresh-fruit ascorbic acid content was 60 mg./100 gm. Stored syrup packs had higher palatability and ascorbic acid retention than sugar packs. All samples were still acceptable with one year and with 16 months' storage at 0°F.

*Variety Tests.*—Testing the freezing and canning qualities of fruits and vegetables is an adjunct to breeding and to variety trials. The laboratory has continued conducting these and other applicable tests. Results may be found in the reports of other members of the Division.

# VEGETABLE CROPS

*W. Ferguson, L. H. Lyall and J. J. Jasmin*

*Statistical Analyses, H. B. Cannon*

The high value per acre of vegetable crops and the large acreage involved make the vegetable industry a very important part of Canadian agriculture. This industry embraces the intensive large-scale production of early vegetables in southern parts of Ontario and British Columbia; the numerous market gardens and truck farms including the large, steadily expanding muck soil areas; the production of crops for canning and freezing; vegetable seed growing, and the individual home gardens.

To meet the needs of the vegetable industry several major lines of investigation are carried on in the Horticulture Division. Amongst these are plant breeding, foundation seed production, chemical weed control, methods of culture and various types of trials.

## VEGETABLE BREEDING

Plant breeding for the production of better vegetable varieties is a major part of the vegetable research program. The development of better varieties is interpreted to include resistance to a number of serious plant diseases; increased earliness of maturity to enable crops to mature in short-season districts and extend the cropping season in other districts; better appearance and size for modern marketing; adaptability for canning-crop production; increased yield, quality and flavor, and resistance to drought and wind. Progress in these phases of the work is reported in the following sections.

### Beans

#### *Breeding for Disease Resistance*

Some diseases of beans have reached serious proportions and cause heavy losses in years of widespread infection. These troubles are difficult or impossible to control by conventional means. A project to breed varieties resistant to some of these diseases was started in 1948 in co-operation with the Botany and Plant Pathology Division, Science Service. This includes breeding for resistance to halo blight, common blight, anthracnose and bean mosaic.

*Bacterial Blights.*—This includes halo blight caused by *Pseudomonas phaseolicola* (Burkh.) Dows. and common blight caused by *Xanthomonas phaseoli* (E.F.Sm.) Dows. Field inoculations were made on more than a hundred different varieties including segregating material. No useful degree of resistance to either of these blights was found. The supposedly resistant varieties Fullgreen and Red Mexican were found susceptible to the isolates of halo blight used at Ottawa. The late, indeterminate types like Princezna, Chili Concarne or Hidatsa Red and the *Phaseolus multiflorus* types like Scarlet Runner and Best of All appear to be less susceptible to bacterial blights than the *Phaseolus vulgaris* var. *nanus* or dwarf types.

It has been reported by Strand (3) that resistance to bacterial blights could be found in *Phaseolus mungo* and by Rands and Brotherton (2) that tolerance to blight could be found in some other Phaseolus species.

A small sample of seed of *P. vulgaris* × *P. mungo* from the Tennessee Agricultural Experiment Station was grown for further multiplication and future inoculation to determine its suitability as resistant parent material.

*Anthracnose.*—This disease caused by *Colletotrichum lindemuthianum* (Sacc. & Magn.) Briosi & Cav. is known to exist under different forms or physiological strains. Several bean varieties, Emerson 51, Emerson 847, Cornell 49-242 and Cornell 29-245, proved resistant to most of the single spore isolates grown by the Botany and Plant Pathology Division. Emerson 51 was selected as a parent because of its good horticultural characters. It is a Tendergreen type and was crossed with Topcrop, Contender, Red Mexican, Pacer and Puregold. Three inoculations were made on the progeny of these crosses under controlled greenhouse conditions. The first, using single strains, was made on plants grown from $F_2$ seed; the second, using a mixture of alpha, beta and gamma anthracnose obtained from the Department of Plant Breeding, Cornell University, was made on plants grown from $F_4$ seed. The same mixture was used for the third inoculation on plants grown from $F_5$ seed. The rapid evolution of the segregating populations when placed under artificial inoculation and selection is shown by a comparison of the resistance in the $F_4$ and $F_5$ plants. Eighteen per cent of the $F_4$ plants tested (a total of 5025 plants) were resistant to alpha, beta and gamma anthracnose as compared with 80 per cent for the $F_5$ plants. This rapid trend toward complete resistance seems to indicate good possibilities for new varieties of beans resistant to alpha, beta and gamma strains of anthracnose.

*Virus.*—It is believed that new bean varieties should not be introduced unless resistant to common bean mosaic virus. To this end such resistant varieties as Topcrop, Contender, Puregold and others are used as parent material. In addition, inoculations with common bean mosaic virus are made in the greenhouse to eliminate susceptible plants from the segregating lines.

***Breeding for Earliness, Quality and Mechanical Harvesting***

Several lines have been developed and are under study in comparison with some standard varieties including Round Pod Kidney Wax and Contender. Selections from the following crosses show some promise:

Round Pod Kidney Wax×Bayos
Giant Stringless Green Pod×Sensation Refugee 1066
Round Pod Kidney Wax×Logan
Giant Stringless Green Pod×Idaho Refugee
Round Pod Kidney Wax×Pink
Round Pod Kidney Wax×Refugee

Most of these are in the seventh generation and are sufficiently uniform to be included in the replicated trials for yield and quality in comparison with standard varieties. One cross, Giant Stringless Green Pod×Sensation Refugee 1066, is early maturing; yield is concentrated, and thus the cross may be suitable for mechanical harvesting.

52626—10

The variety New Abundance produces a spike-like inflorescence towards the top of the plant (Fig. F-1). Lamprecht (1) has identified this as due to a recessive gene, *ram*. In 1953 New Abundance was crossed with Contender and Topcrop to incorporate its spike-like inflorescence with the high quality and yielding ability of the latter varieties. The aim here is the development of a variety better suited to mechanical harvesting.

Fig. F-1—New Abundance bean showing the spike-like inflorescence due to the recessive gene *ram*.

***References***

1. Lamprecht, H. Beiträge zur Genetik von *Phaseolus vulgaris*. Über Infloreszenztypen und ihre Vererbung. Hereditas 20:71-93. 1935.
2. Rands, R. D. and W. Brotherton, Jr. Bean varietal tests for disease resistance. J. Agr. Res. 31:101-154. 1925.
3. Strand, A. B. Species crosses in the genus Phaseolus. Proc. Am. Soc. Hort. Sci. 42:569-573. 1943.

## Cabbage

Until recently, cabbage improvement has been limited to making selections from existing varieties. Over a number of years this has resulted in two very promising selections, one of which has been named and introduced as Canadian Acre. The second selection, Ottawa CA-1, has not yet reached the uniformity necessary for introduction to the trade.

*Canadian Acre.*—A very early selection from Golden Acre made in the Horticulture Division some years ago and named in 1950. The strain (Fig. F-2) is now quite distinct from the Golden Acre types grown commercially. It is small-headed, with a low-growing, compact habit. Its earliness, good appearance and exceptional uniformity make it attractive to home and market gardeners.

Fig. F-2—Canadian Acre cabbage showing the exceptional uniformity of maturity and plant type.

*Ottawa CA-1.*—A late selection from the variety Rossebo obtained in 1947 from Jens Roll-Hansen, Norway. The original stock was not uniform. The best of the selections made from it has been given the number Ottawa CA-1. It is a late, firm-headed, short-cored variety which stores well. The plants have a heavy grayish cast and are quite vigorous. It appears to be well adapted across Canada.

***Breeding for Resistance to Clubroot***

This disease, caused by the organism *Plasmodiophora brassicae* Wor., and found on plants of the cabbage family, has reached considerable importance in Ontario and Quebec in recent years.

In co-operation with the Experimental Station at L'Assomption, Que., and the Botany and Plant Pathology Division, Science Service, a breeding project was begun in 1952 to produce resistant varieties suitable for Canadian conditions. Sources of resistance are cabbage-kale hybrids produced at the University of Wisconsin. These are being used in a backcrossing program with Canadian Acre as the recurrent parent. The plants are pollinated in the greenhouse during the winter. The seed is sown and the plants grown for selection in infested soil during the summer.

## Corn

In recent years, the main emphasis in sweet corn breeding has been on the production of improved hybrid varieties. Growers for both market and processing require varieties that mature almost their whole crop at one time. Single-cross hybrids give much better uniformity of maturity and plant and ear type than either double-cross hybrids or open-pollinated varieties. For this reason, single crosses have almost entirely replaced the open-pollinated varieties formerly used for market and processing.

In the Horticulture Division, the breeding program is divided into two main lines:

1. Selection, testing and maintenance of inbred lines.
2. Production, testing and maintenance of single-cross hybrids for home, market or processing.

The principal objectives are to produce definitely high quality hybrids of early and medium maturity for home and market garden use, and somewhat later maturing, high quality hybrids for the processing trade in eastern Ontario.

Some 40 inbred lines are now being maintained as parent material for experimental hybrids. Several of these have been developed from high-quality, open-pollinated varieties or varietal crosses.

Results over several years show that to produce hybrids as early as, or slightly earlier than, Spancross 13.3 and Seneca 60, use of CO-11, CO-13, CO-15, CO-17 and CO-20, the earliest of the Ottawa inbreds, is necessary. Of these, CO-11 (Banting inbred) and CO-17 (Connecticut C.3 selection) are the earliest. CO-13 (Dorinny inbred) is a few days later and carries exceptionally high quality.

To obtain hybrids in the second-early group, three to seven days after Seneca 60, the same inbreds can be combined with the later and larger-eared lines of the CO-100 to CO-149 group, or with the medium early inbreds of the CO-50 to CO-99 group.

The most likely combinations for processing have been those involving CO-100 (Dorick inbred), CO-104 (Connecticut C.13.53 selection), CO-108 (Sungold inbred), CO-150 (Connecticut C.22 selection), and CO-151 (Purdue P.51 selection).

Hybrids which appear particularly promising are:

1. Market or home garden types

   (Standard: Seneca 60; ready in 70 days from sowing.)

   *Ottawa CH-2* (CO-100 × CO-11).—Ready in 73 days, 8 to 12 kernel rows, good quality, productive.

   *Ottawa CH-3* (CO-13 × CO-51).—Ready in 71 days, 8 kernel rows, very high quality, prolific.

*Ottawa CH-6* (CO-108 × CO-20).—Ready in 76 days, 10 to 16 kernel rows, good quality.

*Ottawa CH-8* (CO-17 × CO-13).—Ready in 70 days, 8 to 12 kernel rows, good quality.

Other promising combinations in this group are CO-100 × CO-17, CO-100 × CO-150 and CO-153 × CO-102.

2. Processing types

(Standard: Golden Cross Bantam; ready in 91 days from sowing.)

CO-101 × CO-15.—Ready in 75 days, 10 to 14 kernel rows, large ear, possible early canner.

CO-108 × CO-100.—Ready in 83 days, 12 to 16 kernel rows, large ear, easily harvested.

CO-150 × CO-151.—Ready in 88 days, 10 to 14 kernel rows, good ear type.

Quality is particularly important in sweet corn varieties, and especially in those designed for market or home gardens. High quality—high sugar content and tenderness—is generally lacking in the early and medium hybrids now in general use. Very high quality is one of the outstanding features of the Ottawa hybrids mentioned above.

## Cucumbers

A project was started in 1952 in co-operation with the Botany and Plant Pathology Division, Science Service, for the purpose of breeding an early, high quality cucumber, resistant to cucumber mosaic virus and to bacterial wilt (*Erwinia tracheiphila* (E.F.Sm.) Holland).

### *Breeding for Resistance to Cucumber Mosaic Virus*

Using the variety Shamrock as a source of resistance to mosaic, crosses were made with the variety Delcrow. To determine resistance in the progeny, inoculations were made by rubbing carborundum-dusted cotyledons with a small piece of cheesecloth previously soaked in an aqueous solution containing virus from infected plants. By such abrasion the virus was presumably carried into the epidermis. Results were not always consistent.

A newer technique, termed the "spray gun method" (Fig. F-3), produced infection in all the susceptible control plants tested, as compared with 47 per cent infection with the method described in the preceding paragraph. With the "spray gun method" carborundum dust grit 320 is mixed with a solution of 5 grams of young growing tissue including young leaves from infected plants and macerated in a Waring blendor in 100 millilitres of water. The ground plant tissue is removed by filtration through two thicknesses of cheesecloth leaving only the infected plant juice in solution. To inoculate, this mixture is sprayed at 50 pounds pressure on the cotyledons of the young cucumber plants. Holding the nozzle of the spray gun approximately one inch from the epidermis of the cotyledon, the carborundum particles will penetrate the epidermis and carry the virus into the plant.

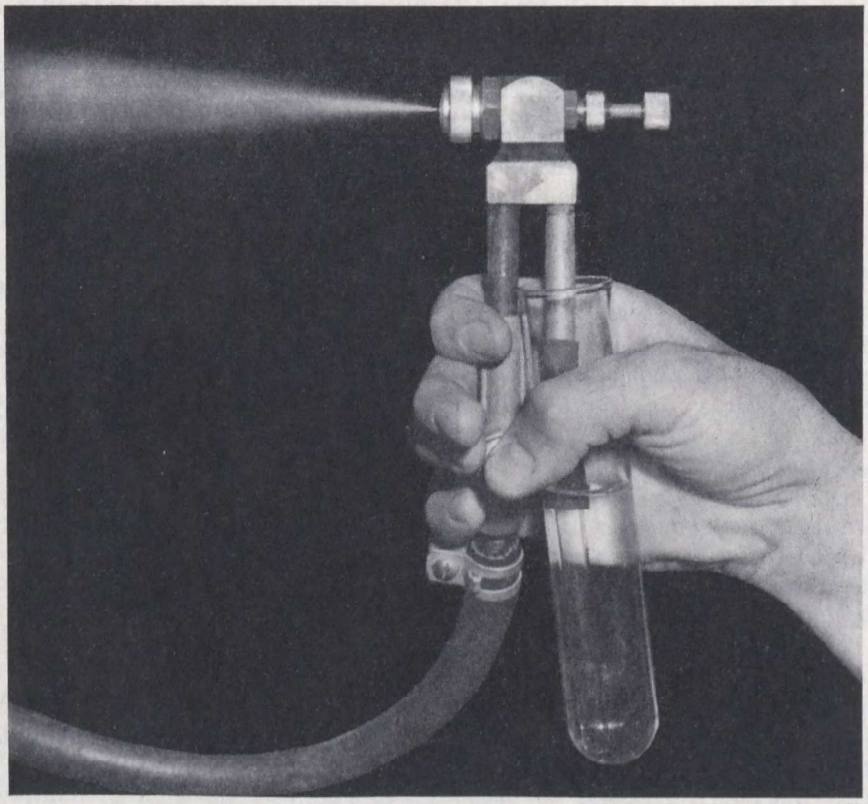

Fig. F-3—Siphon set-up and pneumatic atomizing nozzle used for virus inoculation.

Using the "spray gun method", inoculations were attempted on nine different mosaic-resistant varieties and a susceptible control. The inoculation was prepared from plants which had been inoculated with mosaic virus obtained from the Department of Plant Pathology, University of Wisconsin. The results are shown in Table F-1.

TABLE F-1.—REACTION OF TEN VARIETIES OF CUCUMBERS TO CUCUMBER MOSAIC VIRUS

| Variety | Number of plants under test | Per cent of plants infected |
|---|---|---|
| Marketer (control) | 94 | 100 |
| Ohio MR17 | 74 | 88 |
| Ohio MR25 | 93 | 61 |
| China | 90 | 62 |
| Tokyo Long Green | 74 | 37 |
| Yorkstate | 96 | 27 |
| Hicrop | 98 | 14 |
| Niagara | 60 | 12 |
| Wisconsin SMR 12-9 | 98 | 1 |
| Wisconsin SMR 12-3 | 94 | 0 |

Table F-1 shows that the resistant varieties with the exception of Wisconsin SMR 12-9 and 12-3 showed not only a substantial number of plants infected but also a wide variation between the varieties in percentage of plants infected. The freedom from infection in the Wisconsin varieties SMR 12-9 and 12-3 may indicate a higher degree of homogeneity of resistance or the possibility of more than one strain of mosaic virus.

#### *Breeding for Resistance to Bacterial Wilt*

More than a thousand plants of *Cucumis* spp., including a number of cucumber varieties, were tested under greenhouse conditions for their reaction to bacterial wilt. From this preliminary screening some resistant plant selections were made in each of the following accessions received from the South Carolina Agricultural Experiment Station, Clemson, South Carolina:

| | |
|---|---|
| AODAI ♯1 | P.I. 200816 |
| P.I. 196477 | P.I. 200817 |
| P.I. 197085 | R.W. 255.246-2-4 |

Possibly some of these resistant selections will be of value in breeding for resistant varieties suitable for commerce.

## Eggplant

#### *Inbred Lines and Early Lines*

Few eggplant varieties are well adapted to conditions at Ottawa. Breeding is now directed toward the use of hybrid vigor to improve on present varieties. Inbred lines were developed from the variety Blackie, an origination of this Division introduced in 1930, and also from selections of crosses made between Blackie, New Hampshire and Hetamurasaki.

From the crosses and selections both earliness and good plant type have been obtained in many cases, and some selections have good size of fruit. One selection from Blackie (53-706-1) produced fruits measuring 6·4 inches equatorial and 8·8 inches polar diameter whereas the large-fruited variety Fort Myers Market measured 5·5 by 9·4 inches. This selection is as early as New Hampshire, but, unfortunately, is medium to poor in color. This fault should be easily remedied by the production of $F_1$ hybrids since good fruit color is a dominant character.

#### *Male Sterility*

A male sterile character (Fig. F-4) was found by Jasmin (1) in a population of Blackie eggplant growing in the greenhouse during the winter 1949-50. The type of sterility is functional and is due to a failure of the anthers to dehisce normally. In other words, the pore through which pollen should be released does not form. Otherwise the anthers are normal in all respects.

Microscopic examination of longitudinal and cross sections of the anthers has failed to reveal any abnormalities in the cells of the male sterile anthers. Pollen development is normal; self seed can be produced from these male sterile plants if the pollen is extracted from the anthers and used for hand pollination.

Studies of the $F_1$ populations from male fertile and male sterile parents indicate that this character is recessive and therefore of possible value for the production of commercial $F_1$ seed.

*Production of $F_1$ Hybrids.*—Combining ability tests were started in 1953 to evaluate parental material. In these tests several male sterile lines were crossed with such commercial varieties as Black Beauty, Florida Market, Florida Highbush and Fort Myers Market.

Fig. F-4—Blackie eggplant flowers three days after anthesis. Left, male sterile; right, male fertile.

***Reference***

1. Jasmin, J. J. Male sterility in *Solanum melongena* L: Preliminary report on a functional type of male sterility in eggplants. Proc. Am. Soc. Hort. Sci. 63:443. 1954.

## Onions

***Hybrid Onions and Inbred Lines***

Some numbered selections from earlier crosses are maintained as inbred lines for possible future use in the hybrid breeding program. These include Ottawa ON-1 and Ottawa ON-2 described in the previous Progress Report, 1934-48, and the following:

*Ottawa ON-3* (Ebenezer × White Portugal).—Bulbs white, flat, thin skin, good appearance, good keeper; averaging 2·7 inches equatorial by 1·7 inches polar diameter.

*Ottawa ON-4* (Ebenezer × White Portugal).—Bulbs medium to large, good dark straw color, skin medium thick, good keeper, very good appearance; averaging 2·8 inches equatorial by 2·1 inches polar diameter.

*Ottawa ON-5* (Ebenezer × Yellow Globe Danvers).—Bulbs medium in size, good uniform dark straw color, good keeper; averaging 2·7 inches equatorial by 1·9 inches polar diameter.

In an attempt to transfer the male sterile character as described by Jones (1) into some standard varieties, crosses and backcrosses were made using the male sterile Early Yellow Globe 2129A with pollen of Red Wethersfield, Ottawa ON-1, Ottawa ON-2 and Yellow Globe Danvers 11. This is a time-consuming procedure involving eight backcrosses. Each of these requires two years to complete because of the biennial habit of the onion. Fortunately a male sterile *S ms ms* plant found in Red Wethersfield in 1950 will save the lengthy backcross work with that variety. It is expected that the A and B lines necessary to maintain the male sterile line will be established before long.

In the meantime, a study to evaluate the combining ability of some onion varieties was started. Crosses were made between Senshuki, the Ottawa selections ON-1 to ON-5, Red Wethersfield, Yellow Globe Danvers 11, Sweet Spanish (Riverside), Barcelona, Espanola, Exhibition and Brigham Yellow Globe. This should provide useful information on their value as $F_1$ material.

***Reference***

1. Jones, H. A., and G. N. Davis. Inbreeding and heterosis and their relation to the development of new varieties of onions. U.S.D.A. Tech. Bull. 874. 1944.

## Peas

In the program for the development of improved pea varieties for market and processing, the main objectives are resistance to Ascochyta blight, field resistance to various root rots, concentrated and heavy yields for processing varieties, and high quality.

Of the varieties described in the 1934-48 Progress Report of the Horticulture Division, Alton and Selkirk, the latter formerly known as Laxall, show the most promise. Both are now in the seed trade. Alton is an early, large-seeded, good-quality canning and freezing variety which competes successfully with Thomas Laxton in eastern Ontario. Selkirk has done very well in Western Canada. It is early, moderately dwarf, heavy yielding, and of good quality. It appears to have some drought resistance and its compact plant habit makes it resistant to wind damage.

A third selection which shows promise as a canning variety is Ottawa PE-11, a selection from Onward × Horsford. This is a midseason variety of Perfection type. It is a heavy yielder, with compact plant habit, and moderately concentrated maturity.

***Breeding for Resistance to Ascochyta pisi* Lib.**

This project, originated in the Horticulture Division in 1939, is co-operative with the Botany and Plant Pathology Division, Science Service. Early tests resulted in finding resistance to *A. pisi*, the most resistant pea strain being a selection from V.C. × American Wonder. This strain, now known as Ottawa A-100, remains one of our best sources of resistance. Since 1946 it has been apparent that physiological forms of the fungus are present. Isolation and differentiation of these strains are conducted by the Botany and Plant Pathology Division, Science Service.

In the Horticulture Division, a number of crosses have been made between resistant and susceptible strains of peas. The progenies have been selected under inoculation with *A. pisi*. Eighty-eight fourth to sixth generation selections from these crosses were screened in the field for horticultural characteristics in 1953.

At the same time, a start has been made on a study of the inheritance of resistance to a single form of *A. pisi* using the cross Wilt Resistant Thomas Laxton × A-100. Wilt Resistant Thomas Laxton is susceptible to *A. pisi*. The parents, the $F_1$, and the $F_2$ generations were inoculated with a single form of *A. pisi*. Results are shown in Table F-2.

TABLE F-2.—REACTION OF PARENT VARIETIES AND THE $F_1$ AND $F_2$ PROGENIES OF THE CROSS THOMAS LAXTON W.R. × A-100

| Variety or Cross | Number of plants | | |
|---|---|---|---|
| | Resistant | Susceptible | Total |
| Thomas Laxton, Wilt Resistant | ..... | 45 | 45 |
| A-100 | 48 | ..... | 48 |
| Thomas Laxton, W.R. × A-100 $F_1$ | 46 | ..... | 46 |
| Thomas Laxton, W.R. × A-100 $F_2$ | 349 | 23 | 372 |

This segregation of the $F_2$ generation, in a chi-square test, showed an almost perfect fit to a 15 to 1 ratio of resistant to susceptible plants, which would indicate the possibility of duplicate genetic factors, only one of which is required to give resistance. A further test of the $F_3$ and backcross generations is planned in order to substantiate these preliminary results.

From the results of several years' work, it appears quite possible to introduce acceptable varieties resistant to *Ascochyta pisi*. However, the appearance of new, or at least not previously encountered, forms of the disease complicates the breeding problem.

## Tomato

For many years tomato breeding has formed an important part of the work of the Vegetable Section of the Horticulture Division. As a result of the early breeding work, several early home and market garden varieties were introduced. The best known of these was Abel, named and introduced in 1930. In recent years, however, Abel has been supplanted by new varieties with better plant types, smoother fruit and better yields.

The breeding program at Ottawa may be divided into five sections, comprising:

1. Introduction of male sterility factors into desirable parent lines.
2. Production and testing of $F_1$ hybrids.
3. Breeding improved non-hybrid varieties for home and market use.
4. Breeding improved varieties for processing.
5. Breeding for disease resistance, especially for resistance to *Phytophthora infestans* (Mont.) DBy., the fungus causing late blight of tomatoes.

The major effort at present is on the last three sections, and of these, the late blight project is regarded as particularly important.

### *Induction of Male Sterility*

Any type of male sterility that would eliminate the laborious and costly procedure of hand emasculation of the female parents would be of great assistance in the production of $F_1$ hybrid tomatoes. With this in mind a backcrossing program was begun in 1951 to introduce the positional male sterility

gene (*ps*) into several promising parental tomato varieties. The positional male sterility is due to a condition of adherent corolla and non-dehiscent anthers. However, the pollen when released may be used for selfing. The usefulness of this factor is very limited, for it is often necessary to open the female flowers of *ps* type in order to cross pollinate. The exceptions are flowers with protruding pistils. Plants with this type of male sterility nearly always set a few fruits in the field either as a result of cross-pollination or the escape of a small proportion of self pollen. Because of the weaknesses of the foregoing type of sterility this section of the breeding program has been limited.

A more promising type of sterility, known as "stamenless", and apparently produced by a single recessive gene (*sl*) has been noted by Bishop (1) at the Experimental Station, Kentville, N.S. This latter type is characterized by a lack of stamens under normal conditions although occasionally anthers containing fertile pollen may form and be used to self-pollinate the line.

***Production and Testing of $F_1$ Hybrids***

At present this forms only a small part of the tomato breeding work at Ottawa. To a considerable extent, it depends upon the successful induction of a suitable male sterility factor into the female parents of the hybrids. However, a good many crosses have been made and the $F_1$ generations grown to assess the possible value of the parental lines before attempting to add the sterility factor.

Crosses have been made involving both determinate and indeterminate varieties. Of these $F_1$ hybrids the following appear to be the most promising combinations:

| *Determinate* | *Indeterminate* |
|---|---|
| Meteor × Urbana | Carleton × Churchill |
| Urbana × Ottawa TO-17 | |
| Dixville × Meteor | |
| C855NC4 × Puck | |

In the study of $F_1$ hybrids and in other breeding work the varieties Meteor and Urbana have been very useful parents. Meteor has a small determinate plant, uniform immature fruit color, and is early-ripening. Urbana is semi-determinate, has normal or dark green shoulders, and is a midseason variety. Its most useful characteristics are thick walls and good red flesh color.

***Breeding Non-hybrid Varieties for Home and Market***

Earliness, resistance to fruit cracking and foliage diseases, and high yield are the most important objectives in breeding tomatoes for the Eastern Canadian home or market garden. Whether they should be staking or bush types depends on local demand. Tomatoes with the uniform color gene—lack of dark green shoulders on the immature fruit—are now in considerable demand. Color uniformity and crack resistance appear to have some association. In addition, the uniformly-colored fruits tend to ripen more evenly and the ripe fruits are free of the dark green color and hard yellow shoulders which may be carried over in ripe fruit of the normal type.

The most recent introduction resulting from this section of the tomato breeding is the variety Carleton. Named and introduced in 1952, Carleton is a selection from the cross Abel × Marglobe which was fully described as Ottawa TO-3 in the 1934-48 Progress Report of the Horticulture Division. It is a first early, heavy-yielding, staking variety for the early market and home garden.

Several selections from crosses made in recent years show considerable promise and have been assigned trial numbers.

*Ottawa TO-10.*—A selection from North Dakota 303 × Ventura made in 1940. This is an indeterminate variety which does well on stakes. It is a good cropper, producing smooth fruits with considerable resistance to cracking; primarily a midseason, home garden variety.

*Ottawa TO-21.*—A selection from Ottawa TO-10 × Ottawa TO-4 made in 1948; a determinate plant with heavy foliage and compact habit. The fruit is uniform in color, equatorial diameter 2·6 inches, polar diameter 2·3 inches, smooth, fairly crack resistant; a promising medium early home or market variety. Both parents have been described in the 1934-48 Progress Report of the Horticulture Division.

***Breeding Improved Varieties for Processing***

The Ontario preference in tomatoes for the canning trade is for determinate, vigorous-growing, heavy-yielding varieties with strong stems, fruits held well off the ground, and with fairly heavy leaf cover for sunscald protection. In addition, they should have good red flesh color, smooth fruit, good size and in some cases uniform skin color.

Three new selections from Ottawa crosses approach this type.

*Ottawa TO-17.*—A selection from Bounty × Early Rutgers made in 1941; a vigorous, determinate, heavy-cropping variety. Fruit is uniform in color, meaty, smooth, equatorial diameter 3·0 inches, polar diameter 2·5 inches. Shows promise as a midseason canner.

*Ottawa TO-23.*—A selection from Early Rutgers × North Dakota 38 made in 1941. Vigorous, determinate, with heavy foliage cover giving protection against sunscald. Fruit is uniform in color, smooth, fairly free of cracking, good flesh color; equatorial diameter 2·9 inches, polar diameter 2·4 inches. A good midseason canner.

*Ottawa TO-24.*—A selection from Ottawa TO-10 × Ottawa TO-4 made in 1948. This is a vigorous, determinate, heavy-cropping, midseason variety with heavy foliage and compact habit. Fruit is uniform in color, smooth, firm, fairly resistant to sunscald and cracking, good flesh color; equatorial diameter 2·8 inches, polar diameter 2·5 inches. A promising variety for processing.

***Breeding for Resistance to Late Blight***

Late blight caused by the fungus *Phytophthora infestans* is common to both tomatoes and potatoes. The disease appeared in epidemic proportions in the Ottawa area in 1946, 1950, 1951 and 1952. In general, it appears to have been widespread in Ontario, Quebec and the Maritime Provinces whenever seasonal conditions favored its growth and dissemination. Because of the increasing importance of this disease, a project was begun in 1948 in co-operation with the Botany and Plant Pathology Division, Science Service, for the purpose of breeding or selecting resistant, horticulturally desirable strains of tomatoes.

At Ottawa, a large number of tomato varieties and strains have been artificially inoculated and classified according to their reaction to late blight infection. Out of this have come strains showing two types of resistance. The first, which may be termed moderate susceptibility, was first noted in 1949 in some tomato strains obtained from the Philippine Islands (2). The second type of resistance is much more complete and appears to be due to a hypersensitive reaction on the part of the host plant. This resistance to the "common" strain of late blight has been noted in several lines of the cherry tomato, *Lycopersicum*

*esculentum* var. *cerasiforme*. Not all cherry tomatoes show resistance, but the best of those tested at Ottawa are Geneva T-5, Jamaica Cherry, North Carolina 1951-315-N, New Hampshire 907W and the Mexican cherry tomatoes known as West Virginia 700 and 702.

Both field and greenhouse trials are made in this experiment, but experience has shown that greenhouse inoculations under controlled conditions give a better measure of resistance than field tests. Field trials, even though inoculation is carried out, are dependent on weather conditions, and in the Ottawa area are complicated by the prevalence of other diseases such as Septoria blight, Alternaria blight and anthracnose.

In the greenhouse, the procedure is briefly as follows:

1. Seed is treated with a protective fungicide, then sown in sterilized soil in shallow pots.

2. Ten days after sowing, seedlings are pricked off into 12- by 18-inch flats (50 plants per flat), with at least 100 plants of each strain being tested.

3. Approximately four weeks after sowing, when plants are 4 to 6 inches tall and in the four to six true leaf stage, they are placed in a chamber at 60 to 65°F. and 90 to 100 per cent relative humidity. Here they are inoculated and remain for four to five days before they are rated for disease infection.

The monospore culture inoculum in the swarm spore stage is applied with a large hand sprayer. Initial symptoms usually appear on the second or third day, and the plants are classified on the fifth or sixth day after inoculation.

Each plant is classified 0 to 5 according to the following scale of ratings:

0—Complete freedom from visible symptoms
1—One or two, to a few small necrotic spots
2—Many spots, each separate and small
3—Many spots, each separate and large
4—Severe infection, many spots coalesced
5—Complete killing

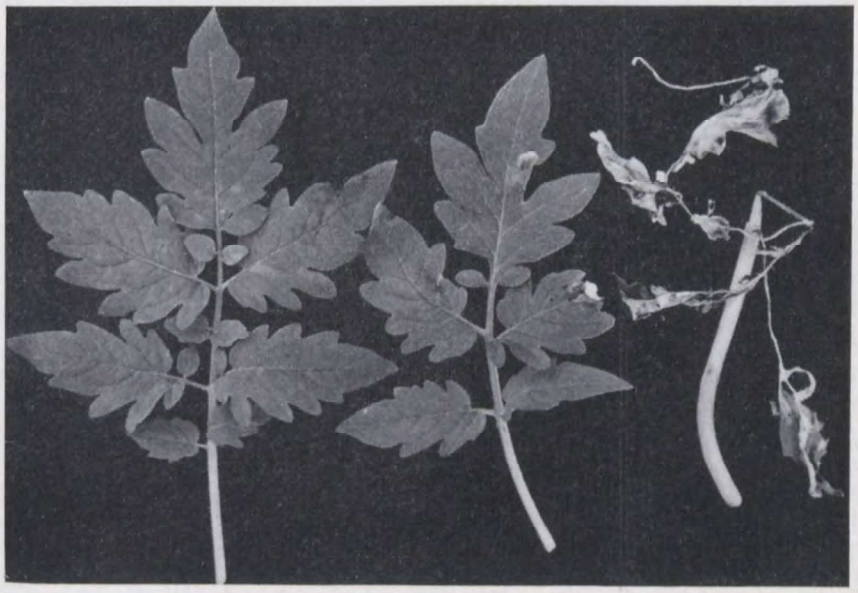

Fig. F-5—Three types of reaction of tomato plants to inoculation with *P. infestans*. Left to right; resistant, intermediate, susceptible.

Under these conditions infection ranges from complete susceptibility in the standard variety Stokesdale to a very high degree of resistance in the most resistant cherry types. Infection appears to be grouped in the three main classes:

Resistant—0 to 2; hypersensitive, pin-point lesion type;

Intermediate—3; necrotic lesions, dendritic type with only slight sporulation;

Susceptible—4 and 5; lesions spreading and sporulating freely.

The intermediate reaction has been regularly noted with Philippine Selections 2, 4, 5, 9 and 11 and U.S.D.A. PI 163426, and is probably due to genes different from those responsible for the resistant reaction. The three types of reaction are illustrated in Fig. F-5.

The reactions of the susceptible variety Stokesdale and of the resistant variety Geneva T-5 to inoculation with the late blight organism are shown in Fig. F-6.

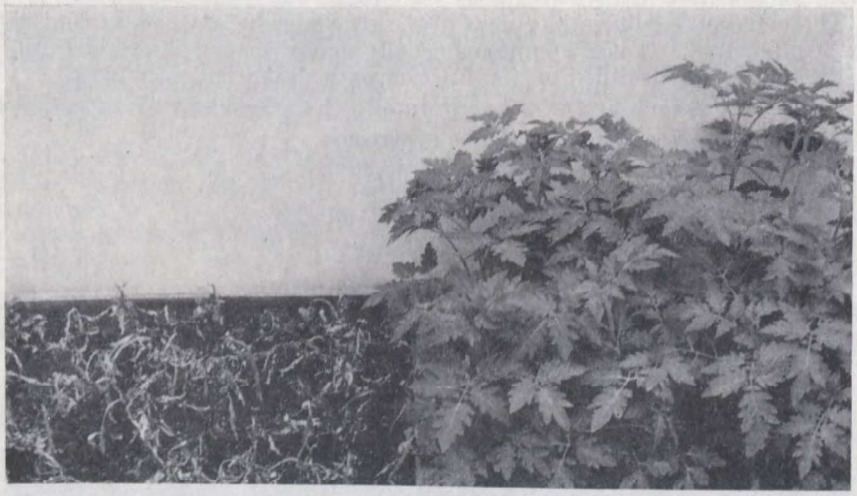

Fig. F-6—Reactions of tomato varieties to inoculation with *P. infestans*. Left, Stokesdale, susceptible; right, Geneva T-5, resistant.

The method of inheritance was studied in 1953, but results to date have been somewhat inconclusive. Inconsistencies in results may have been due to too severe inoculation conditions. An early test of the $F_1$, $F_2$ and first backcross generations of the cross Stokesdale $\times$ Geneva T-5 indicated that resistance was dominant and due to a single gene. In a later test of the same $F_2$ progeny and the progeny of T-5 crossed with a susceptible variety C855.NC4, the single gene theory was not borne out although it was thought that somewhat severe conditions at the time of inoculation may have hindered the full expression of the hypersensitive reaction characteristics.

The results of the latter are shown in Table F-3.

TABLE F-3.—REACTION OF PARENT VARIETIES AND THE $F_1$, $F_2$ AND THE FIRST BACKCROSS PROGENIES OF CROSSES BETWEEN RESISTANT AND SUSCEPTIBLE VARIETIES TO A SINGLE STRAIN OF *P. INFESTANS*

| Record Number | Variety, selection or cross | Total number of plants | Per cent resistant (0 to 2) | Per cent susceptible (3 to 5) |
|---|---|---|---|---|
| TB. 54-27 | Stokesdale[1] | 100 | ..... | 100 |
| TB. 54-28 | C855.NC4 | 100 | ..... | 100 |
| TB. 54-29 | Geneva T-5 | 100 | 96 | 4 |
| TB. 54-30 | C855.NC4 × T-5 $F_1$ | 50 | 100 | ..... |
| TB. 54-31 | C855.NC4 × T-5 $F_2$ | 500 | 19 | 81 |
| TB. 54-32 | (C855.NC4 × T-5 $F_1$) × C855.NC4 $F_1$ | 50 | 20 | 82 |
| TB. 54-37 | Stokesdale × T-5 $F_2$ | 400 | 64 | 36 |

[1]Susceptible control.

The intermediate reaction shown by the Philippine and certain other selections has been transmitted in some crosses but not in others, as shown in Table F-4. It would seem to indicate that this reaction is due to more than one gene, and that the "susceptible" parent may supply an additive effect. In previous work (2) the variety Tuckqueen has proved more susceptible than Dansk Export, Champion Original, or Philippine 5. This may account for the high percentage of susceptible plants in the cross Tuckqueen × Champion Original. The crosses between several lines of Philippine 5 and Geneva T-5 show two distinct reactions, resistant and intermediate, with a few susceptible plants. Turrialba Mixed and Small Fruited Mixed show the variability which may be encountered in mixed seed lots unselected for their reaction to late blight.

TABLE F-4.—REACTIONS OF TEN TOMATO VARIETIES AND SEGREGATING PROGENIES TO INOCULATION WITH A SINGLE STRAIN OF *P. INFESTANS*[1]

| Record No. | Variety or cross | Number of plants in indicated reaction classes | | | | | | Per cent | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | Resist. (0 to 2) | Susc. (3 to 5) |
| TB. 53-46[2] | Stokesdale | — | — | — | — | 89 | 11 | ..... | 100 |
| TB. 53-47[3] | Geneva T-5 | 7 | 92 | 1 | — | — | — | 100 | ..... |
| TB. 53-48 | Turrialba Mixed | — | — | — | 28 | 67 | 5 | ..... | 100 |
| TB. 53-49 | Small Fruited Mixed | 2 | 1 | 3 | 16 | 75 | 3 | 6 | 94 |
| TB. 53-50 | Dansk Export × Phil. 5 $F_2$ | 1 | — | — | 17 | 82 | — | 1 | 99 |
| TB. 53-51 | Dansk Export × Champion Original $F_2$ | — | — | — | 46 | 54 | — | ..... | 100 |
| TB. 53-52 | Tuckqueen × Champion Original $F_2$ | — | — | — | — | 100 | — | ..... | 100 |
| TB. 53-53 | Phil. 5A1 × Geneva T-5 $F_2$ | — | 63 | 1 | 34 | 2 | — | 64 | 36 |
| TB. 53-54 | Phil. 5A2 × Geneva T-5 $F_2$ | — | 45 | 17 | 36 | 2 | — | 62 | 38 |
| TB. 53-55 | Phil. 5B1 × Geneva T-5 $F_2$ | — | 41 | 24 | 34 | 1 | — | 65 | 35 |

[1]Each test based on 100 plants.
[2]Susceptible control variety.
[3]Resistant control variety.

In the Botany and Plant Pathology Division, Science Service, Ottawa, a study is being made of disease isolates from many sources using a differential host series of both tomato and potato varieties. Within the limits of this host range, the majority of isolates have been placed in the "common" race which has been given the arbitrary designation Race 1. This race has been used as the source of inoculum in the experiments reported here. Two other races have been found and assigned the numbers 2 and 3. No resistance to Race 2 has

yet been found, although such selections as Geneva T-5 and N.H. 907W show a tolerant reaction to it. Race 3 is less virulent, giving a susceptible reaction on Stokesdale and resistant reactions on Geneva T-5, and on Philippine 4 which gives only an intermediate reaction to Race 1.

The effect of age of the host plant on its reaction to *P. infestans* was studied in 1952. The following varieties were inoculated with the common strain of late blight:

| | |
|---|---|
| Geneva T-5 | resistant |
| Philippine 2 | intermediate |
| Philippine 11 | intermediate |
| Stokesdale | susceptible |

Seeds of each variety were sown at 10-day intervals to provide plants 60, 50, 40, 30, 20 and 10 days old on the date of inoculations. The 60-day-old plants had the flowers fully open on their first truss, while the 10-day-old plants were still at the cotyledon stage.

In each of the four varieties there was a high percentage of "escapes" in the 10-day-old group. These small seedlings were unable in most cases to retain sufficient inoculum and moisture to produce good infection. There appeared to be a slight tendency towards less infection in the 50- and 60-day-old plants, but this may have been the result of difficulty in rating such large plants on the same scale as the small plants in the first true leaf stage. It was not evident, however, that susceptibility increased with age. None of these plants was in any way senescent. With senescence, increased infection is expected, since it has been observed in the past that senescent foliage, even of resistant plants, allows the development of the pathogen.

The results summarized in this report indicate that a satisfactory degree of resistance to the common strain of *P. infestans* may be bred into commercial varieties of tomatoes.

***References***

1. Bishop, C. J. A stamenless male sterile tomato. Am. J. Bot. 41:540-541. 1954.
2. Ferguson, W., L. H. Lyall and H. N. Racicot. Tomato breeding for resistance to *Phytophthora infestans* (Mont.) DBy. I. Methods of inoculation and preliminary results. Sci. Agr. 32:57-66. 1952.

## Chemical Weed Control

Work on chemical weed control in vegetable crops has been expanded since publication of the preceding Progress Report. Investigations for weed control in vegetable canning crops have also been carried out at the Horticulture Substation, Smithfield, Ont. A discussion of some of the results obtained with various chemicals is presented here.

### *Calcium Cyanamide*

As the result of a preliminary test in 1948 in which granular calcium cyanamide showed evidence of weed control in canning peas, a further investigation was carried out the following year as a co-operative experiment at the Horticulture Substation, Smithfield, Ont., and the Experimental Stations at L'Assomption, Que., and Kentville, N.S.

Cyanamide was applied just before emergence at 60 pounds and 200 pounds per acre on randomized plots each 7 by 32 feet. The peas were drill-seeded with rows 7 inches apart. Treatments were replicated six times except at

L'Assomption where three replications were used. Weed counts were taken at six random locations in each plot two weeks after crop emergence. In addition, the yields of shelled peas were recorded at harvest to determine the effect of the treatments on crop production. A summary of these results is shown in Table F-5.

TABLE F-5.—EFFECT OF CALCIUM CYANAMIDE ON WEED COUNTS AND WEIGHT OF SHELLED PEAS AT THREE STATIONS

| Cyanamide | Smithfield | | L'Assomption | | Kentville | |
|---|---|---|---|---|---|---|
| | Weed counts per 36 sq. ft. | Shelled peas lb./ac. | Weed counts per 36 sq. ft. | Shelled peas lb./ac. | Weed counts per 36 sq. ft. | Shelled peas lb./ac. |
| Control | 1,404 | 1,600 | 654 | 3,645 | 2,208 | 2,620 |
| 60 lb./ac | 438 | 1,814 | 612 | 3,880 | 1,336 | 2,620 |
| 200 lb./ac | 72 | 1,827 | 552 | 2,550 | 512 | 3,000 |

At Smithfield and Kentville the number of weeds in the treated plots was markedly reduced, especially where cyanamide was applied at the heavier rate. At Smithfield, where the predominant weeds were lamb's quarters, weed control remained reasonably good in the treated plots throughout the season. In the treated plots at Kentville weed control did not remain effective through the season and the treatments were not considered sufficiently satisfactory. Neither treatment gave satisfactory weed control at L'Assomption, nor was there evidence of any beneficial effect on yield. At Smithfield and Kentville, it appeared that increased yields might be associated with use of cyanamide.

Further studies were carried on at Smithfield in 1950 using the same size of plot, but with five rates of application of granular calcium cyanamide. The treatments were replicated six times using a latin square design. Fertilizer, 0-12-6, was applied as in the preceding year at 300 pounds per acre before seeding. The control plots received nitrogen at the same rate as the lowest cyanamide application. The cyanamide treatments were applied six days after seeding and weed counts taken a month later. The yields of shelled peas at harvest are shown in Table F-6.

TABLE F-6.—EFFECT OF CALCIUM CYANAMIDE ON WEED COUNTS AND WEIGHT OF SHELLED PEAS AT SMITHFIELD, ONTARIO, 1950 AND 1951

| Cyanamide | 1950 | | | 1951 | | |
|---|---|---|---|---|---|---|
| | Weed counts per 36 sq. ft. | Shelled peas lb./ac. | Texture meter reading | Weed counts per 36 sq ft. | Shelled peas lb./ac. | Texture meter reading |
| Control | 232 | 3,223 | 103 | 1,114 | 2,475 | 105 |
| 60 lb./ac | 110 | 3,151 | 98 | 768 | 2,125 | 108 |
| 120 lb./ac | 140 | 3,674 | 99 | 648 | 2,435 | 105 |
| 200 lb./ac | 74 | 2,865 | 98 | 526 | 2,260 | 108 |
| 400 lb./ac | 60 | 2,892 | 101 | 254 | 2,050 | 105 |
| 600 lb./ac | 32 | 2,372 | 99 | 230 | 2,380 | 109 |

Table F-6 shows that weeds were not a problem in the plots in 1950 and that the treatments were of doubtful value in producing large yields. A repetition of the experiment in 1951 showed marked reduction of weeds following application. However, yields were depressed in most cases.

Following application, cyanamide requires moisture for most effective weed control and is toxic for only a short period. If conditions remain dry, weeds are little affected. Similarly, weeds developing a few days after treatment are unaffected unless crowded out by crop growth which may have flourished as a result of the weed-killing and crop fertilizer properties of the cyanamide. Under the conditions of these experiments, the cyanamide treatments were largely associated with yields similar to or lower than the control.

It is concluded that effective weed control for the season and increased yields in canning peas are uncertain where granular calcium cyanamide is used as a pre-emergence herbicide.

However, granular calcium cyanamide is a useful herbicide and a source of nitrogen for asparagus. Recommendations are that it be applied at the rate of 400 pounds per acre just before, or early in the cutting season. Weeds will germinate and grow later in the cutting season. These can usually be eliminated by an application of calcium cyanamide dust at 75 to 100 pounds per acre following the last cutting.

***3-Para Chlorophenyl-1,-Dimethyl Urea***

This herbicide is more commonly referred to as CMU, Karmex W or Telvar. Experimental work in 1951 indicated that CMU might be an effective pre-emergence herbicide for a number of vegetable crops. Beans, beets, cabbage, carrot, corn, cucumber, lettuce, onion, peas and spinach were sown in sandy loam soil, and CMU was sprayed on the plots in varying concentrations from 0.25 to 10.0 pounds per acre. A period of good weather followed with little rain until the plants were well up. Weed control was excellent even at the lowest concentration. Beans showed little or no injury up to 4 pounds per acre. Corn and peas revealed no damage at 0.5 pounds per acre while the beets, carrots and spinach showed fairly good growth. The larger-seeded sorts appeared to be more resistant to CMU.

In 1952 a more complete and intensive investigation on beans resulted in severe damage to the plants in most treatments. Immediately after sowing Contender and Round Pod Kidney Wax beans in clay loam, CMU was applied as a spray at rates of 1, 2, 3 and 4 pounds in 35 gallons of water per acre. This was followed by several very heavy rains within a few days. As the young plants emerged and developed their first true leaves, they quickly showed symptoms of CMU injury and died. This resulted in a kill of almost 100 per cent in the 2-, 3-, and 4-pound treatments. Treatment at one pound per acre appeared to be the critical rate with injury or killing occurring in some plots and not in others. Weeds were almost completely eliminated where CMU was applied, even where the beans were not injured.

CMU has a very low solubility in water. It is assumed that the heavy rains following treatment dissolved much of the chemical and increased its availability to the plants. The surface runoff from the heavier treatments caused extensive killing of beans and weeds in adjacent plots which in some cases were control plots or one-pound-per-acre plots.

Results from a subsequent experiment where heavy rains did not follow treatment confirm the above interpretation. A rate of 0.75 pound per acre caused no injury to the beans. One pound caused negligible injury to a few seedlings. Two pounds caused more injury but almost all the plants recovered. Severe damage and killing followed the 3- and 4-pound applications.

In 1952 CMU at 0.5, 1.0, 1.5 and 2.0 pounds per acre was applied immediately after sowing canning peas. Weed counts did not vary significantly except in comparison with the control plots. The treatments were not accom-

panied by any marked increase in yield. Jasmin and Ferguson (7) found that CMU injury to the pea plants was much more severe and extensive on light sandy soil than on heavier soil with a higher organic content. The 2-pound-per-acre application caused much less damage on the heavier soil.

Beets, carrots, lettuce and spinach were sown in 1952 to observe the residual effects of the 1951 applications. No attempt was made to control weeds. Where 5 or more pounds per acre had been applied, CMU injury was observed as late as July 31 on all vegetables except carrots. No injury was observed where lower applications had been made, indicating little or no residual injurious effect. The residual weedicide effect is well illustrated in Table F-7.

TABLE F-7.—WEIGHT OF WEEDS JULY 31, 1952, FROM PLOTS TREATED WITH CMU THE PREVIOUS YEAR

| Treatment, 1951 | Pounds of weeds per plot[1], 1952 |
|---|---|
| Control, no weeding | 102·5 |
| CMU, 10 pounds per acre | 67·0 |
| CMU, 6 pounds per acre | 65·8 |

[1]Plot=200 square feet.

These experiments and those of other workers indicate that the action of CMU as a pre-emergence weed killer in most vegetable crops is not predictable and may be greatly influenced by rain. Nevertheless, CMU is useful as a weed killer in asparagus and is recommended for that crop. It should be applied just before the cutting season starts at the rate of one to two pounds per acre depending on the type of soil. The lower rate should be used on light, sandy soils.

***Herbicidal Oil***

The oil most commonly used as a weed killer in vegetable crops is Stoddard solvent, the dry cleaning fluid. Numerous workers have reported on the use of this material on carrot, parsnip, parsley and dill. It is a selective herbicidal oil causing these crops little or no injury. It will kill or severely damage the foliage of most weeds.

Stoddard solvent has an aromatic content in the neighborhood of 15 per cent. It seemed possible that a variation in the aromatic content might affect the herbicidal properties of this material. In 1950, Stoddard solvent containing 6, 13, 18 and 21 per cent aromatics by weight was sprayed on plots of carrots. In a similar experiment the following year, the aromatic contents were 7·5, 15·5, 19 and 21·5 per cent by weight. Rate of application was 60 gallons per acre. Each treatment was replicated four times in the first experiment and five times in the second.

Excellent weed control with no apparent injury to the crop plants was obtained in each case. The weed growth where present was far less than in the control plots regardless of whether or not the control plots had been cultivated. In addition, the yields of carrots were much higher from the treated than from the control plots. It was concluded from this work that variation of the aromatic content, within the limits of the concentrations used in these experiments, makes no appreciable difference in weed control or carrot yields.

This selective herbicidal oil is recommended for use on carrot, parsnip, parsley and dill applied as a spray at 60 to 80 gallons per acre. If the spraying is confined to the rows, 30 to 40 gallons are sufficient, and any weed growth between the rows can be kept in check by cultivation.

A non-selective herbicidal oil with a high aromatic content (about 50 per cent by weight) is also obtainable. This was not found satisfactory for general use since it kills by contact. Thus, a time lapse of one or two weeks is necessary between land preparation and seeding to allow weeds to appear and be destroyed. In most cases, such delay in seeding is out of the question. Nevertheless, this non-selective contact herbicide is useful for spot treatment and where avoidance of dilutions or spray mixtures is desirable.

***Disodium 3, 6-endoxohexahydrophthalate***

This herbicide is more commonly known as Endothal 3003 and appears to be a useful herbicide for sugar beets. In experiments during 1953 it showed some value as an effective agent for controlling weeds in table beets, a crop which previously had not shown much immunity to the effects of most herbicides.

The most satisfactory treatment was a pre-emergence spray applied within two or three days after sowing at the rate of 6 pounds of active ingredient in 45 gallons of water per acre. This treatment not only caused no injury to the beets but also, in comparison with the control, caused a reduction of more than two-thirds the number of weeds as based on plot examination more than five weeks after treatment. The predominant weeds were lamb's quarters, red-root pigweed, purslane, oak-leaf goosefoot and barnyard grass. Where Endothal was used, these were reduced to a few lamb's quarters and red-root pigweed.

Other pre-emergence treatments applied at the same time were sodium trichloroacetate or sodium TCA; 3-para-chlorophenyl-1, 1-dimethyl urea or CMU; isopropyl N3-chlorophenylcarbamate or Chloro IPC; 3-phenyl-1, 1-dimethyl urea or URAB. None was so effective in weed control as Endothal, and two were definitely detrimental to the crop.

A post-emergence application of Endothal at the rate of 4 pounds of active ingredient per acre one month after sowing did little or no damage to the beet plants but weed control was not nearly so satisfactory as with the pre-emergence treatment.

***Alkanolamine Salts of Dinitro-ortho-secondary Butylphenol***

This is one of the dinitro herbicides developed for pre-emergence treatments. It is also commonly known as Premerge. It was found harmful and therefore not satisfactory for use on such small-seeded crops as carrot, beet, onion, spinach, radish, lettuce and parsnip. For peas and beans it is quite satisfactory. Treatments applied after sowing and before crop emergence caused little or no injury to those two crops and effectively controlled such weeds as lamb's quarters, red-root pigweed, oak-leaf goosefoot and purslane. Pre-emergence applications of 4 to 8 pounds in 45 gallons of water per acre have been found satisfactory for peas and beans. Severe injury may occur to the crop if sprayed when the seedlings have emerged.

***Ammonium Dinitro-secondary Butylphenate***

This compound is also a dinitro herbicide but is selective, especially on peas. A spray application of one pound in 40 gallons of water per acre when the peas were 4 to 6 inches high gave good control of broad-leaved weeds.

Young, actively growing weeds are most susceptible. Peas escape injury because their leaves permit the spray to run off. Any slight injury due to droplets in the axils of the leaves soon disappears. Grasses showed little or no damage in the experiments.

***N, 1-naphthyl Phthalamic Acid***

This material commonly known as Alanap-1 is well adapted to weed control in some of the cucurbits. In preliminary experiments in 1952, an application at the rate of either 8 or 10 pounds in 50 gallons of water per acre gave excellent weed control with no damage to cucumber plants. Good practical weed control was obtained with a rate of 5 pounds per acre, and a less satisfactory control with 2 pounds per acre. These treatments were applied one day after sowing the seed. The fruit from treated plants showed no abnormalities, and yields were much higher than from untreated control plots.

The following year, in a further experiment, Alanap-1 was used on citron, cucumber, melon, pumpkin and squash. Pre-emergence applications were made two days after sowing at rates of 2, 4, 6 and 8 pounds in 45 gallons of water per acre.

Ten weeks after planting there was fair weed control at the 6- and 8-pound rates. Such weeds as were present (red-root pigweed and lamb's quarters) could have been hoed out easily when small. Thus, these treatments were classed as giving practical weed control. The 2- and 4-pound rates did not show much improvement over the control plots. These had a large vigorous weed population with red-root pigweed and lamb's quarters predominating.

In other plots, Alanap-1 was applied at rates of 4 and 8 pounds per acre after the plants had emerged. Weeds were kept under control by hand cultivation for four weeks after planting, at which time the plots were treated. Although one plot in the 4-pound treatment showed marked reduction in weed size but not in number, the duplicate plot showed no effect on the weeds over most of the area. Similarly, one 8-pound treatment plot showed a marked reduction in the number and size of the weeds, but the duplicate showed no such effect. These treatments were classed as generally not satisfactory. With 6- and 8-pound treatments, squash showed less plant growth, and fruit development was considerably delayed. Apparently, Alanap-1 may be harmful to squash if applied after plant emergence.

Two years' results with Alanap-1 indicate variation in effect from year to year. Other pre-emergence herbicides showed similar variations. These variations may be due to differences in organic content of the soils or climatic conditions at or following application.

***Other Chemicals***

*MCP* (2-methyl-4-chlorophenoxyacetic acid).—Spray applications of the sodium salt on growing pea plants at rates of 2.5 and 7.5 ounces per acre reduced the weed population to half that of the control plots. The treatment distorted the pea vines somewhat but this gradually disappeared. Similar results were obtained with a 2 per cent sodium salt dust applied at 100 and 200 pounds per acre.

*Crag Herbicide 1* (sodium 2, 4-dichlorophenoxyethyl sulphate).—This substance is not active on plant foliage, but in contact with the soil it kills or stunts weed seedlings as they emerge. In one experiment it gave effective weed control for as long as six weeks in corn and peas. This herbicide is also well adapted to weed control in strawberries and is recommended accordingly.

*Sesin* (2, 4-dichlorophenoxyethyl benzoate).—Another growth-regulator type of herbicide. It was used in tomatoes immediately following the last cultivation on July 20, 1953. Although relatively few weeds developed in the control plots during the rest of the season, the treated plots contained fewer weeds at the end of the season. At the rate used, 4 pounds of active ingredient in 160 gallons of water per acre, the plants developed some leaf roll which persisted for the rest of the season. Possibly, very dry conditions following application kept damage to a minimum. Neither yield nor fruit quality was affected adversely.

*MH-30* (maleic hydrazide).—Applications of post emergence spray did not kill the weeds in beets, peas and corn. Weeds were dwarfed or further growth was prevented. Growth of the crop plants was also inhibited.

*Aero sodium cyanamid* (monosodium cyanamide).—Good results were obtained when applied as a post emergence treatment of peas and onions at the rate of 15 to 20 pounds in 45 gallons of water per acre. These treatments reduced the weed population to less than one-third that of the control.

*Chloro IPC* (isopropyl N 3-chlorophenyl carbamate).—This chemical reduced the grass population markedly when applied as a pre-emergence herbicide for beets and spinach. It was applied at one pound in 45 gallons of water per acre following planting, when conditions were favorable for quick germination. Beets showed a slight dwarfing effect. Broad-leaved weeds were not effectively controlled at this rate.

*Sodium TCA* (sodium trichloracetate).—Grasses in beets and spinach were effectively controlled by a crop pre-emergence treatment of 10 pounds of sodium TCA per acre. Application was made under the same conditions as Chloro IPC. Neither beets nor spinach was damaged.

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## Effect of Maleic Hydrazide on Vegetable Storage

Leopold and Klein (1), Wittwer (2) and others report that maleic hydrazide is an auxin-antagonist with the ability to reduce the metabolism of plants. Experiments at the Horticulture Division were started in 1951 with the liquid amine of maleic hydrazide (MH-30) on onions, and later, with the sodium salt of maleic hydrazide (MH-40) on onions, spinach and asparagus.

### *Onions*

A definite and consistent reduction in the number of sprouted bulbs resulted from the maleic hydrazide treatment as shown in Table F-8.

TABLE F-8.—PERCENTAGE OF ONION BULBS SPROUTED, ROTTED AND MARKETABLE AFTER SEVEN MONTHS' STORAGE AT 45°F.

| Variety | Number of bulbs | Treatment | Sprouts | Rot | Marketable |
|---|---|---|---|---|---|
| | | | % | % | % |
| Ottawa ON-2 | 100 | MH-30[1] | 2 | 18 | 80 |
| | 100 | Control | 18 | 2 | 80 |
| Yellow Globe Danvers No. 11 | 40 | MH-30 | 0 | 45 | 55 |
| | 40 | Control | 25 | 0 | 75 |
| Early Yellow Globe | 50 | MH-30 | 0 | 74 | 26 |
| | 50 | Control | 36 | 14 | 50 |

[1]All MH-30 treatments at 2,500 p.p.m.

Less sprouting occurred when maleic hydrazide was used but, on the other hand, rots increased so that at the end of storage the number of marketable bulbs was either decreased or showed no advantage over the non-treated lot. However, in another experiment with Yellow Globe Danvers No. 11 and Sweet Spanish (Riverside) onions, approximately 80 per cent of the former, a good storing variety, and only 2 to 3 per cent of the latter, a poor storing variety, were marketable after seven months' storage. About two-thirds of the loss in Yellow Globe Danvers No. 11 was due to sprouting, the remaining one-third to rot. Losses in Sweet Spanish (Riverside) were about equally divided between sprouting and rot. In these two varieties spraying about two weeks before the plants started to mature resulted in less sprouting than spraying just as they were beginning to mature.

### *Spinach*

The effect of maleic hydrazide on the storage life of harvested spinach was investigated. Spinach plots were sprayed at varying times before harvest, and stored at 32°F. Rate of application had some influence but time of application was the critical factor. Keeping quality was improved appreciably when the spinach was sprayed with MH-40 at a concentration of 7,500 p.p.m. eight days before harvest. However, maleic hydrazide is a growth inhibitor, and although the early-sprayed plots stored better, yield was lower. Unfortunately, later spraying did not prolong the storage life of spinach.

### *Asparagus*

Attempts were made to evaluate the action of maleic hydrazide as a growth inhibitor on the elongation of spears and the formation of fiber in asparagus when treated after harvest.

Treatment in order was as follows:

Spears were treated individually for 8 hours at different concentrations of maleic hydrazide, placed in water for 16 hours, left to dry at ordinary room temperature for 24 hours, and cooked for evaluation of fiber content (Table F-9). This was evaluated by the spoon-squash technique wherein the soft asparagus tip was removed by pressure with the back of a spoon, and the remaining fibrous portion was measured.

TABLE F-9.—EFFECT OF MALEIC HYDRAZIDE ON GROWTH AND FIBER DEVELOPMENT IN ASPARAGUS SPEARS AFTER HARVEST

| Treatment | Average length of spears | | Fibrous part of spears | |
|---|---|---|---|---|
| | At harvest | After 8 hrs. | Av. length | As per cent of total length |
| | in. | in. | in. | |
| Control | 6·0 | 6·48 | 4·15 | 64 |
| MH, 2,500 p.p.m. | 6·0 | 6·23 | 3·66 | 59 |
| MH, 5,000 p.p.m. | 6·0 | 6·09 | 3·34 | 55 |
| MH, 10,000 p.p.m. | 6·0 | 6·04 | 3·01 | 50 |
| L.S.D. (P=·05) | ..... | 0·12 | 0·72 | |

Variation in the concentration of maleic hydrazide affected elongation. Elongation was greatest in the control, and with increase in maleic hydrazide concentration, growth decreased significantly. The control had significantly more fiber than the two highest concentrations of maleic hydrazide. There was no significant difference in fiber between the several concentrations of maleic hydrazide nor between the control and the lowest concentration.

***References***

1. Leopold, A. C. and W. H. Klein. Maleic hydrazide as an anti-auxin in plants. Science 114:9. 1951.

2. Wittwer, S. H. Michigan State College, Mich., U.S.A. Personal correspondence. 1951.

## Irrigation

An irrigation experiment started in 1951 at Ottawa in co-operation with the Field Husbandry Division was designed as a four-year rotation with grain one year, grass two years and vegetables one year in that order and with three replications.

In the vegetable part of the rotation, cabbage, sweet corn, potatoes and tomatoes are each grown in plots 15 by 40 feet with five rows in each plot three feet apart. Each plot is divided lengthwise to permit two fertilizer rates, 500 pounds and 1,000 pounds per acre of 5-10-13 fertilizer. Yields are recorded from one row in each fertilizer treatment. The center and the two outside rows in each plot are used as guard rows. Plants within the row are spaced as follows: cabbage, Copenhagen Market, 1½ feet; corn, Golden Cross Bantam, hills 3 feet apart with 3 plants per hill; potatoes, Sebago, 1 foot; tomatoes, Carleton (not staked) 5 feet.

Yields obtained from the three replications in 1953 are shown in Table F-10. Since no irrigation was supplied in 1951 and 1952 the yields show no differences attributable to irrigation and are omitted here. Between June 25

and September 10, 1953, the plots were irrigated seven times with 1 inch of water at each application. During the same period 6·38 inches of rainfall were recorded. The cabbage plots were harvested after five irrigations, and the first two pickings of tomatoes were made after six irrigations.

TABLE F-10.—MARKETABLE YIELDS OF CABBAGE, CORN, POTATOES AND TOMATOES IN 1953 FROM IRRIGATED AND NON-IRRIGATED FERTILIZED PLOTS

| Crop | Fertilizer at 500 lb./ac. | | Fertilizer at 1,000 lb./ac. | | Total | |
|---|---|---|---|---|---|---|
| | Irrigated | Non-irrigated | Irrigated | Non-irrigated | Irrigated | Non-irrigated |
| CABBAGE— | | | | | | |
| Total number of heads | 78 | 77 | 77 | 77 | 155 | 154 |
| Total weight of heads, lb. | 279·1 | 219·4 | 322·5 | 255·9 | 601·6 | 475·3 |
| Mean weight per head, lb. | 3·6 | 2·8 | 4·2 | 3·3 | 3·9 | 3·1 |
| CORN[1]— | | | | | | |
| Total number of hills | 26 | 26 | 26 | 26 | 52 | 52 |
| Total number of ears | 120 | 104 | 114 | 93 | 234 | 197 |
| Total weight of ears, lb. | 72·0 | 56·9 | 69·3 | 51·3 | 141·3 | 108·2 |
| Mean yield per hill, lb. | 2·8 | 2·2 | 2·7 | 2·0 | 2·7 | 2·1 |
| POTATOES— | | | | | | |
| Total number of plants | 111 | 114 | 111 | 114 | 222 | 228 |
| Total weight of tubers, lb. | 209·7 | 147·8 | 210·7 | 156·0 | 420·4 | 303·8 |
| Mean yield per plant, lb. | 1·9 | 1·3 | 1·9 | 1·4 | 1·9 | 1·3 |
| TOMATOES— | | | | | | |
| Total number of plants | 23 | 23 | 24 | 24 | 47 | 47 |
| Total number of fruit | 632 | 722 | 602 | 782 | 1,234 | 1,504 |
| Total weight of fruit, lb. | 147·7 | 145·4 | 151·7 | 173·3 | 299·4 | 318·7 |
| Mean yield per plant, lb. | 6·4 | 6·3 | 6·3 | 7·2 | 6·4 | 6·8 |
| Mean weight per fruit, lb. | 0·23 | 0·20 | 0·25 | 0·22 | 0·24 | 0·21 |

[1]Results based on two replicates; wildlife damage made third replicate valueless.

NOTE.—Other factors affecting yield did not permit statistical analysis.

Irrigation was accompanied by increased yields for cabbage, sweet corn and potatoes. The heavier fertilizer treatment increased the yield of cabbage but in sweet corn and potatoes this was not evident. Although irrigation was not accompanied by an increase in yield of tomatoes there was an increase in the average size of fruit. There is also some indication that fertilizer increased the yield in the non-irrigated but not the irrigated plots of tomatoes.

## Seed Production and Verification Trials

Seed production and verification trials are related in that all seed stocks grown for foundation status are subjected to verification in field trials.

### *Seed Production*

Seed stocks for foundation status are produced in limited quantity at this Division and at other Experimental Stations and Provincial institutions. All the seed, except a few varieties, is handled through the Horticulture Division, and sold to seed producers for the production of registered and certified seed.

Careful selection has improved many of the stocks and maintained them in a high degree of purity. Moreover, a pedigree of each seed lot is maintained so that it can be traced back to its origin or source. The stocks produced ensure the Canadian seed grower of a supply of pedigree seed adapted to

Canadian conditions. As a rule, this seed is produced at Experimental Stations in districts where those varieties are commonly grown and this helps avoid unsuitable regional influence on selection.

Foundation seed is produced from varieties or strains originated by the various Stations and from other varieties and strains originated elsewhere but required by popular demand for vegetable growing in Canada. All the varieties grown are not listed in this report. A total of 238 are assigned to the various institutions. Of these 164 are carried by the Dominion Experimental Stations and 74 by Provincial institutions. Foundation seed production is conducted in close co-operation with the Canadian Seed Growers' Association.

In addition, a substantial quantity of seed is produced in connection with material developed under the plant breeding program. Much of the seed of these originations is used for testing in co-operative and in commercial trials to determine their adaptability, merit and value as new varieties suitable for introduction under name.

During the period covered by this report the following quantities of seed have been produced:

| | | | |
|---|---|---|---|
| Bean | 574 lb. | Onion | 40 lb. |
| Beet | 62 lb. | Parsnip | 32 lb. |
| Cabbage | 11 lb. | Pea | 5,591 lb. |
| Carrot | 143 lb. | Radish | 51 lb. |
| Citron | 8 lb. | Soybean | 1,874 lb. |
| Sweet Corn | 1,582 lb. | Spinach | 151 lb. |
| Cucumber | 16 lb. | Squash | 20 lb. |
| Eggplant | 1 lb. | Swiss Chard | 21 lb. |
| Leek | 13 lb. | Tomato | 258 lb. |
| Lettuce | 10 lb. | Turnip | 4 lb. |
| | Total ..... | 10,462 lb. | |

***Verification Trials***

All seed stocks for foundation status require a certificate of health from plant pathologists based on plant examination in the field and on laboratory analysis for seed-borne diseases. They are then subjected to a rigid test in the verification trials for purity and trueness to type. Verification trials are conducted in this Division and at various Dominion and Provincial Stations across Canada. This arrangement avoids the possibility of loss or harmful effect of climatic conditions at any one locality. It also provides information on the behavior or performance of each seed stock under a range of growing conditions. When a stock has successfully met these conditions, it is granted a foundation certificate by the Canadian Seed Growers' Association and can be sold for the production of registered seed.

## Vegetable Varieties Showing Promise in Merit Trials

Merit trials, organized in this Division, are designed to test new varieties or strains and obtain information on their merit or value in comparison with the best varieties commonly grown. The information is of interest to growers, seedsmen, horticultural research workers and others. It is made available annually as a report from this Division. The seed is obtained from experimental institutions and seed companies.

These are co-operative trials. In addition to the trials in this Division, these varieties are also grown by the following co-operators at the institutions mentioned:

G. C. Warren, Dominion Experimental Station, Charlottetown, P.E.I.
J. O. Vandal, Faculté des Sciences, Université Laval, Quebec, Que.
H. R. Murray, Department of Horticulture, Macdonald College,Que.
I. D. W. Smith, Provincial Horticultural Experiment Station, Vineland, Ont.
H. R. Hikida, Department of Plant Science, University of Manitoba, Winnipeg, Man.
R. J. Hilton, Department of Plant Science, University of Alberta, Edmonton, Alta.
L. G. Denby, Dominion Experimental Station, Summerland, B. C.
J. B. Teir, Department of Horticulture, University of British Columbia, Vancouver, B.C.

The merits of a variety are based on such features as earliness, yield, appearance, flavor, color, quality, and resistance to disease or insects. Other important points include regional adaptability and whether the variety is suited for processing and for market or home garden.

During the past five years, 1945 samples comprising 286 varieties have been grown and tested. Some considered to have considerable merit are discussed here.

***Beans***

*Topcrop.*—This variety was developed in the United States Department of Agriculture from Full Measure × U.S. No. 5 and was formerly identified as Fulcrop. It has shown merit over several years across Canada. The plants are 15 to 17 inches tall, strong, and immune to mosaic. The pods are medium green, attractive, 5 to 6 inches long, round, stringless and free of fiber. It is a good yielding variety and received high rating for earliness, quality, appearance and concentration of maturity which makes it valuable for canning and freezing.

*Contender.*—Originated in the United States Department of Agriculture, this variety traces back through a number of crosses involving Commodore, Streamliner and U. S. No. 5 Refugee. Contender has been highly rated in the tests across Canada for several years and may be considered slightly superior to Topcrop. The plants vary in height according to season and locality. They were 14 inches under dry conditions at Morden, and 22 inches at Ottawa. Contender is an early green-podded variety, round, stringless, high in quality and yield. The pods are long and may vary from one-half to one and one-half inches longer than Topcrop.

***Broccoli***

*Waltham 29.*—An origination of the Massachusetts Agricultural Experiment Station, Amherst, Mass., U.S.A., and developed for autumn production. The uniformity and firm, compact, dark green main curds or heads were well liked, particularly at Ottawa, Vineland and Vancouver.

***Cabbage***

*Bonanza.*—Developed by the Ferry-Morse Seed Company, Detroit, Mich., U. S. A., as a midseason variety. It compared favorably with Glory of Enkhuizen and was highly regarded at Macdonald College, Vineland, Morden, Winnipeg, Summerland and Vancouver. It has a comparatively small core and a hard, firm head which resists splitting.

*Canadian Acre.*—Developed in the Horticulture Division, Ottawa, this is an early selection from Golden Acre. It was remarkable for its earliness, small size, neat appearance and outstanding uniformity of size and maturity at Winnipeg, Morden, Vineland, Ottawa and Macdonald College. It should be of value as a small, early type for market and home garden.

*Ottawa CA-1.*—This numbered selection is not yet ready for introduction as a named variety. It was developed in the Horticulture Division by selection from the Norwegian variety Rossebo. It has proved outstanding for several years as a late variety for autumn production. It has wide adaptability and was prized for its fairly short stem, good quality, firm ball-shaped heads and very short core. Looseness of some wrapper leaves is a minor fault requiring further selection.

*Viking Small Early.*—A selection made by Stokes Seeds Limited, St. Catharines, Ont. This is early and produces larger plants than Canadian Acre. It lacks the uniformity of Canadian Acre in that this selection varies in head shape, size and maturity. It should be of value for early market and home use.

*Wisconsin Golden Acre.*—An origination from the University of Wisconsin, Madison, Wis., U. S. A., a small-headed strain resistant to yellows. It showed up well at Charlottetown and Ottawa for its uniformity, appearance, firmness and earliness. However, the heads split soon after reaching maturity.

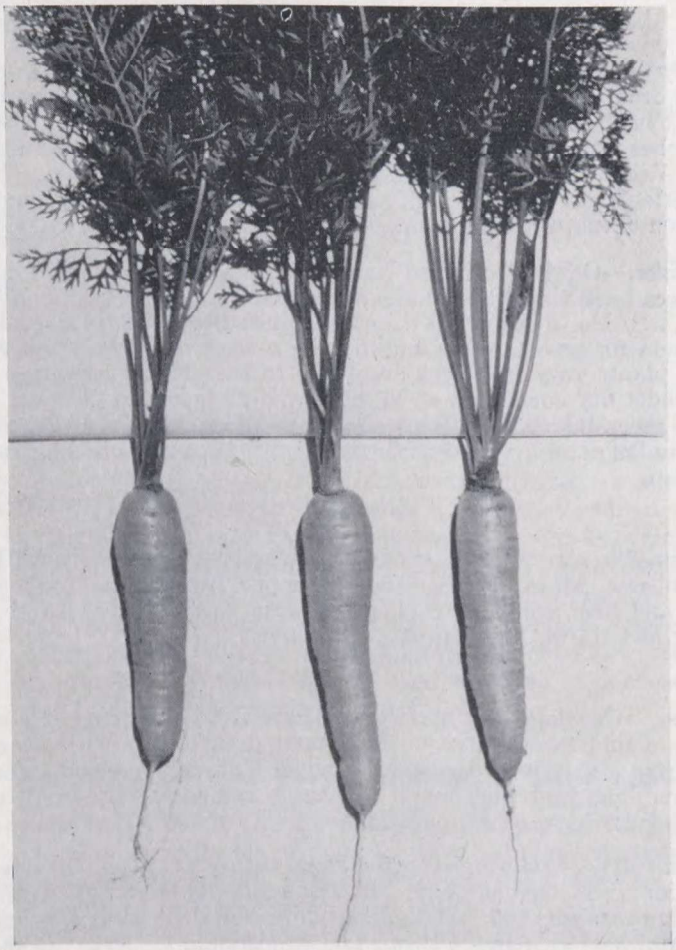

Fig. F-7—Typical roots of Nancy carrot at the bunching stage.

***Carrot***

*Gold Spike.*—An origination of the Ferry-Morse Seed Company, Detroit, Mich., U. S. A., Gold Spike was tested in 1953 and was preferred at Quebec, Ottawa, Vineland, Winnipeg, Edmonton and Vancouver. Roots are long and slender with a fine crown, good color and quality. It seems well adapted to muck soils.

*Imperida.*—A short-top, bunching carrot, originated at the University of Idaho Experimental Station, Parma, Idaho, U. S. A. It is similar to a good strain of Imperator and performed well at Vineland, Morden, Winnipeg, Summerland and Vancouver. Long tapering roots, good surface and flesh color, small core and small tops are favorable features. The necks appear weak and are subject to breakage at storage stage.

*Nancy.*—This origination of Associated Seed Growers Inc., New Haven, Conn., U. S. A., is intermediate between Nantes and Chantenay. It showed merit at Ottawa, Macdonald College, Morden, Edmonton and Vancouver. It is of medium length with sloping sides and a blunt tip (Fig. F-7). The color is good and the core medium to small. The appearance is pleasing although the shape is somewhat variable.

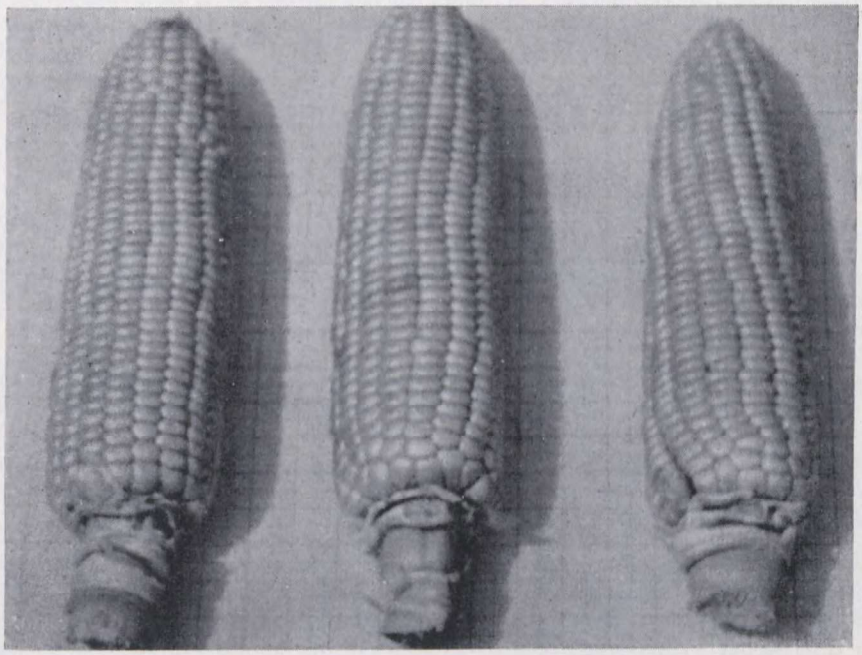

Fig. F-8—Typical ears of Seneca Arrow sweet corn.

***Cauliflower***

*Dania.*—This variety was developed by L. Daehnfeldt Limited, Odense, Denmark. In the 1952 trials it showed exceptional earliness and was the first variety to reach maturity. The heads were medium in size; the leaves were short and did not cover the curd.

*Improved Holland Erfurt.*—This selection was produced by Ohlsens Enke Seed Company, Copenhagen, Denmark, and was grown in comparison with Dania. Although slightly later, maturity was better concentrated and the longer leaves gave better head cover.

***Corn***

*Gold Rush.*—Originated by Corneli Seed Company, St. Louis, Mo., U. S. A., this variety performed well at several Stations. It is early or second early with ears averaging 8 inches in length with 10 to 16 rows of yellow kernels. It is a good general purpose variety for home garden, market and processing in some localities.

*Seneca Arrow.*—One in a series developed by Robson Seed Farms, Hall, N.Y., U.S.A. It is too late for short-season localities, but as a midseason variety it performed well at other localities. Plants are tall with few tillers and ears well up on the stalk. It is a good yielder of ears about 7½ inches long with 10 to 16 rows of yellow kernels (Fig. F-8) and is best suited for home or market production.

***Cucumber***

*Marketer.*—Although not a new variety, Marketer is mentioned here because it was superior in tests with the newer hybrids, Sensation Hybrid and Hybrid C. Marketer was superior in color, shape, appearance and yield. Earliness is important in cucumbers and this variety was as early as or earlier than the others. Marketer was originated by Associated Seed Growers Inc., New Haven, Conn., U.S.A.

***Lettuce***

*Great Lakes 659.*—A selection made by the Dessert Seed Co., El Centro, Cal., U.S.A., this was highly regarded at Charlottetown, Ottawa, Morden, Edmonton and Summerland. It is an early, sure-heading variety with firm heads of crisp texture and good flavor. It has large wrapper leaves with thick ribs, and appears to be more resistant to tip-burn than most varieties.

*Penn Lake.*—A selection from the cross Great Lakes × Imperial 847 made at Pennsylvania State College Agricultural Experiment Station, U.S.A.. This is a variety which shows regional adaptation. At Ottawa, Vineland and Charlottetown, it is subject to tip-burn and soft-rot. It has performed very well at Winnipeg, Summerland and Vancouver, but is considered inferior to Premier Great Lakes at Macdonald College and Edmonton.

*Premier Great Lakes.*—This is a selection out of the Great Lakes variety made at Pennsylvania State College Agricultural Experiment Station, U.S.A., and is also known as Early Great Lakes. It has shown wide adaptation, and in the 1949 Merit Trials was regarded as superior to Penn Lake and Great Lakes at Ottawa, Vineland, Macdonald College, Edmonton, Morden and Charlottetown.

*Salad Bowl.*—An origination of the United States Department of Agriculture, this leaf lettuce variety shows a wide adaptation. It has a distinctive, compact, rounded growth habit, giving it a very attractive appearance. It appears to be a useful variety for the home and market garden, and possibly for greenhouse forcing.

***Muskmelon***

*Minnesota Midget.*—Developed at the University of Minnesota Agricultural Experiment Station, St. Paul, Minn., U.S.A., this early maturing variety yields a large number of small, attractive melons about 4 inches in diameter. They are finely netted, have salmon-colored flesh, fine texture and sweet flavor. The season is one week to ten days later than Farnorth, the small-fruited, very early variety developed at the Dominion Experimental Station, Indian Head, Sask. It has done well at Ottawa, Vineland and Summerland, but has not been so well suited as Farnorth to conditions at Winnipeg, Vancouver and Macdonald College.

***Onion***

*Autumn Spice.*—This hybrid variety obtained from F. H. Woodruff and Sons Inc., Milford, Conn., U.S.A., has done well under a wide range of conditions at Charlottetown, Ottawa, Vineland, Winnipeg, Morden, Edmonton and Vancouver. It is a midseason variety, earlier than Autumn Star and a few days later than Yellow Globe Danvers No. 11. The bulbs are of the Yellow Globe type, not large but very uniform and attractive in appearance. They matured well at most Stations and stood up well in storage.

*Autumn Star.*—Another hybrid from the same source as Autumn Spice. It has not shown such wide adaptation, being slightly later than Autumn Spice and not maturing so well in some localities.

***Peas***

*Ottawa PE-11.*—Originated at the Horticulture Division, Central Experimental Farm, Ottawa, this is a selection from the cross Onward×Horsford. Although still under number, this variety has been highly rated at Charlottetown, Macdonald College, Ottawa, Vineland, Morden and Edmonton. It produces a vigorous but compact plant of Perfection type and season. Peas are light green but of good quality for canning. It is a very heavy yielder and in Ontario it appears to have some resistance to root rot.

*Perfected Freezer.*—A selection from Rogers Bros. Seed Co., Idaho Falls, Idaho, U.S.A., this variety did well at Ottawa, Vineland, Morden, Edmonton, Summerland and Vancouver. It is ready for processing at the same time as Perfection; the plant is sturdy, medium height, with pods borne well off the ground; yield is heavy and the dark green peas are firm and medium in size. The variety is resistant to Fusarium wilt and appears well adapted for freezing.

*Tiny Tim.*—Developed by the Dominion Experimental Station, Morden, Man., this variety is a very dwarf type which may have value as a novelty for the home garden. It has a sturdy vine about 12 inches high, with 2½-inch pods, each containing about seven seeds. It matures very early; is between Alaska and Thomas Laxton in season. It is designed mainly for prairie conditions where its dwarf habit is an advantage against strong winds.

*Topper.*—Developed by F. H. Woodruff and Sons Inc., Milford, Conn., U.S.A., Topper showed merit at Ottawa, Vineland, Morden, Macdonald College and Vancouver. Its chief merits are moderately concentrated maturity, medium to heavy yield, vigorous but fairly compact habit, medium to large straight pods borne well off the ground, and well-filled with large, dark green peas of good quality. It is resistant to Fusarium wilt, and should be useful for market and home garden.

***Pepper***

*Vinedale.*—Originated at the Horticultural Experiment Station, Vineland, Ont., this new variety has shown merit at Charlottetown, Quebec, Ottawa, Vineland, Morden, Winnipeg and Summerland. It is generally regarded as a productive, early, good quality, sweet red pepper for home or fresh market, and has already supplanted Harris' Earliest for this purpose.

***Radish***

*Cherry Belle.*—An origination of A. R. Zwaan and Co., The Hague, Netherlands, now widely distributed and very well liked across Canada. It has a short top with globe- to olive-shaped roots and a characteristic bright scarlet surface color; flavor is generally mild and texture crisp. It has the ability to retain this crispness for a longer period than the standard varieties of the same Scarlet Globe type.

*Comet.*—The stock of this variety maintained by the Horticulture Division, Central Experimental Farm, Ottawa, was highly regarded at Charlottetown, Macdonald College, Ottawa, Vineland, Morden and Vancouver. It is a good bunching variety with a medium top. Roots are bright red, globe- to olive-shaped; very uniform for shape and color.

***Spinach***

*America.*—A comparatively recent introduction from N. V. Sluis & Groot, Enkhuizen, Netherlands. It is a very slow-bolting variety producing plants about 7 inches tall with a spread of approximately 9 inches. Foliage is dark green, heavily savoyed, and of good quality. Because of its slow-bolting habit it is favorably regarded at Macdonald College, Ottawa, Vineland, Morden, Winnipeg and Edmonton.

***Tomato***

*Carleton.*—An origination of the Horticulture Division, Central Experimental Farm, Ottawa, this variety is a selection from the cross Abel×Marglobe, and was fully described under the number Ottawa TO-3 in the Progress Report 1934-48 (pp. 72 and 83). It is an indeterminate staking variety which has done well at Charlottetown, Macdonald College, Ottawa, Vineland, Morden, Winnipeg and Vancouver. It is a first early staker with fruits 2.5 to 3 inches in equatorial diameter under most conditions. It is suitable for the home garden or for the first early market, the fruits being well suited to the cardboard tube or package method of marketing.

*Early Lethbridge.*—An origination of the Dominion Experimental Station, Lethbridge, Alta., this variety was formerly known as L-3700-3. It is in the same season as Early Chatham, and is also determinate in habit. The plant is larger, gives more cover, and the fruit is better colored and slightly larger than Early Chatham. This variety is especially adapted to the vegetable growing areas of southern Alberta, but also has a place in other short season regions of Canada.

*Meteor.*—A non-hybrid variety developed by the Dominion Experimental Station, Morden, Man., this variety is slightly earlier than Monarch, but under most conditions does not produce quite so heavily. It has done well at Charlottetown, Ottawa, Morden, Winnipeg, Edmonton and Summerland. It is of determinate habit, with smooth fruit usually slightly smaller than Monarch. Meteor is only slightly later than Early Chatham, but produces larger and better quality fruit. It is a promising determinate type for the home garden or early market.

*Monarch.*—Developed at the Dominion Experimental Station, Morden, Man., this is an $F_1$ hybrid between selected lines of Early Chatham and Bounty. It is a determinate plant type which produces a good early and total yield of well-colored red fruit about 2.5 to 3.0 inches in equatorial diameter. Its ability to produce a well-concentrated early yield of good market type fruits has made it well liked at Ottawa, Charlottetown, Winnipeg, Morden, Summerland and Vancouver. It is more vigorous and larger fruited than Early Chatham. Also, it is earlier with smoother, better quality fruit than Bounty.

***Watermelon***

*New Hampshire Midget.*—Developed at the University of New Hampshire Agricultural Experiment Station, Durham, N.H., U.S.A., this is a small melon for the home garden. It is an oval type about 6 to 8 inches long, with a very thin rind and is easily cracked. Flesh is red, sweet, but not so crisp as many of the older watermelon varieties. It has a place as an early melon for short season districts where the larger-fruited varieties cannot be ripened.

***References***


1. Ferguson, W., L. H. Lyall and J. J. Jasmin. Can. Dept. Agr., Div. of Hort. Prog. Rept. 1934-48, pp. 77-84. 1950.
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## Variety Trials and Recommendations

In addition to the Verification Trials and Merit Trials, other trials are carried on involving relatively large numbers of varieties. These provide a measure of evaluating introductions in comparison with older standard varieties. The variety trials also serve as standards of comparison for evaluation of selections produced under the breeding program.

From these trials it is possible to prepare a list of varieties which can be recommended for the Ottawa region. The varieties recommended are:

| | |
|---|---|
| Asparagus | Mary Washington, Paradise. |
| Bean | *Bush type*<br>Green podded — Contender, Tenderlong, Tendergreen Improved, Topcrop.<br>Yellow podded—Kinghorn Special Wax, Pacer, Round Pod Kidney Wax.<br>*Pole type*<br>Green podded—Blue Lake No. 65, Decatur, Green Pod, Kentucky Wonder. |
| Beet | Crosby's Egyptian, Detroit Dark Red. |
| Broccoli | De Cicco, Waltham 29. |
| Cabbage | *Early*: Canadian Acre, Golden Acre, Viking.<br>*Midseason*: Bonanza, Copenhagen Market, Glory of Enkhuizen, Jersey Wakefield.<br>*Late or winter*: Chieftain (Savoy), Danish Ballhead (or Hollander), Penn State Ballhead.<br>*Red for pickling*: Red Acre or Red Rock.<br>*Chinese*: Michihli. |

| | |
|---|---|
| Carrot | Amsterdam, Chantenay, Gold Spike, Imperator, Imperida, Nantes. |
| Cauliflower | Dania, Erfurt, Snowball. |
| Celery | *Green*: Summer Pascal, Utah. |
| | *Golden*: Cornell 19, Golden Plume. |
| Citron | Green Seeded, Red Seeded. |
| Corn | *Home garden* |
| | Early—Dorinny, Pickanniny, Seneca 60. |
| | Midseason—Golden Bantam, Seneca Arrow. |
| | Late—Golden Cross Bantam. |
| | *Market garden* |
| | Early—Seneca 60, Spancross. |
| | Midseason—Gold Rush, North Star, Seneca Arrow. |
| | Late—Golden Cross Bantam, Seneca Chief. |
| Cucumber | *Slicing*: Burpee Hybrid, Delcrow, Marketer, Straight Eight. |
| | *Pickling*: Mincu, National or Snow Pickling. |
| Eggplant | Black Beauty, New Hampshire. |
| Leek | Giant Carentan. |
| Lettuce | *Leaf type*: Black Seeded Simpson, Grand Rapids, Greenhart, Salad Bowl. |
| | *Crisp head*: Great Lakes 659, Imperial 456, Imperial 847, Premier Great Lakes. |
| | *Butter head*: Big Boston. |
| Muskmelon | *Early*: Farnorth, Golden Champlain, Honey Gold, Minnesota Midget. |
| | *Maincrop*: Bender's Surprise, Delicious 51, Harper Hybrid. |
| Onion | Autumn Spice, Early Yellow Globe, Ebenezer, Red Wethersfield, Yellow Globe Danvers No. 11. |
| | *For transplanting*: Sweet Spanish, Yellow Globe Danvers No. 44. |
| | *For pickling*: Silverskin or White Portugal. |
| Parsley | Moss Curled. |
| Parsnip | Guernsey or Hollow Crown. |
| Pea | *Early*: Alton, Arctic Sweet, Thomas Laxton, Wisconsin Early Sweet. |
| | *Midseason*: Laxton Progress, Little Marvel, Topper. |
| | *Late*: Director, Onward, Perfected Freezer, Prince of Wales, Stratagem. |
| Pepper | *Hot*: Hamilton Market, Hungarian Yellow Wax. |
| | *Sweet*: Vinedale, Pennwonder. |
| Pumpkin | Connecticut Field, Sugar. |
| Radish | Cherry Belle, Comet, French Breakfast. |
| Rhubarb | Canada Red, Early Sunrise, Macdonald, Ruby, Valentine. |
| Spinach | America, Bloomsdale, King of Denmark. |
| Squash | Buttercup, Butternut, Golden Hubbard, Green Hubbard, Kitchenette, Table Queen (Des Moines or Acorn). |
| Swish Chard | Lucullus. |
| Tomato | *Bush type*: Meteor, Monarch (hybrid). |
| | *Staking*: Carleton, Quebec 5, Valnorth. |
| Turnip | *Summer*: Purple Top Milan, White Top Milan. |
| | *Swede or Rutabaga*: Acadia, Laurentian. |
| Vegetable Marrow | Long White Bush, Long White Trailing. |
| Watermelon | Early Canada, New Hampshire Midget, Sweet Sensation. |

Yield is a very important feature in the choice of a variety and, to a large extent, determines the value of the crop to the grower and canner.

Table F-11 compares the 1953 yields of some of the newer varieties of snap beans with others at Ottawa. Each variety was replicated four times in single 30-foot rows, with six pickings over an 18-day period.

TABLE F-11.—YIELDS OF EIGHT VARIETIES OF SNAP BEANS

| Variety | Pounds per acre |
|---|---|
| Contender | 14,800 |
| Topcrop | 12,600 |
| Tenderlong | 10,000 |
| Rival | 9,800 |
| Wade | 8,600 |
| Unrivalled Wax | 8,000 |
| Improved Commodore | 7,600 |
| Round Pod Kidney Wax | 5,400 |
| L.S.D. (P=·01) | 1,800 |

Although the yields in Table F-11 represent results for one year only they show the importance of variety in relation to yield.

An interesting comparison was made in 1952 and 1953 between indeterminate and determinate tomato varieties. The indeterminate or staking varieties were staked and spaced two feet apart in rows three feet apart. In 1952 the plants were trained to single stems and in 1953 to two stems. The unstaked determinate or bush varieties were spaced three feet apart in rows four feet apart in a randomized block design with six replications each containing twelve plants of each variety. Table F-12 shows the best yielding varieties for these two years.

TABLE F-12.—EARLY AND TOTAL YIELDS IN TONS PER ACRE OF MARKETABLE RIPE TOMATOES AT OTTAWA IN 1952 AND 1953

| Varieties | 1952 | | 1953 | |
|---|---|---|---|---|
| | Early yield | Season yield | Early yield | Season yield |
| STAKED— | | | | |
| Carleton | 5·1 | 35·3 | 4·4 | 17·9 |
| First of All | 4·8 | 34·4 | 1·4 | 12·2 |
| Early Scarlet | ..... | ..... | 2·5 | 19·0 |
| L.S.D. (P=·05) | 0·7 | ..... | 1·1 | ..... |
| BUSH— | | | | |
| Early Chatham | 3·8 | 24·6 | 2·7 | 15·7 |
| Bounty | 2·3 | 28·2 | ..... | ..... |
| Meteor | 3·3 | 24·2 | 2·2 | 17·2 |
| Monarch | 3·3 | 31·4 | 0·6 | 21·2 |
| Mustang | 3·3 | 31·0 | ..... | ..... |
| L.S.D. (P=·05) | 0·5 | ..... | 0·6 | ..... |

The early yields cover the first three weeks of harvest. The last pick in 1952 was made on September 25 when the staked varieties were still healthy. The bush varieties succumbed to late blight on September 10 and no fruit was picked after that date. In 1953 picking ended on September 14. Sprays were applied both years for late blight control.

Carleton was an excellent producer of early fruit and gave a good crop throughout the season. Early Chatham, the highest early-yielding bush variety but considerably behind Carleton, is not considered a very desirable variety at Ottawa.

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## Co-operation with Other Institutions

The Vegetable Section of the Horticulture Division has two main fields of co-operation distinct from the co-operation of personnel or laboratories on specific projects. The type of co-operation differs depending on whether the participants are Provincial institutions or Dominion Experimental Branch Farms and Stations. The two types of co-operation are explained and summaries of certain results are presented.

### *Provincial Institutions*

Since 1947, the Horticulture Division has maintained a horticultural research officer at each of the following Provincial institutions:

Horticultural Experiment Station, Vineland, Ontario.

University of Manitoba, Winnipeg, Manitoba.

University of British Columbia, Vancouver, B.C.

The primary responsibilities are the production of foundation vegetable seed, conducting verification trials on foundation seed stocks, and participating in the merit trial program of this Division.

In the five years 1949-1953, through careful selection, 20 seed stocks of various varieties were produced at the Experimental Station, Vineland; 5 at the University of Manitoba and 14 at the University of British Columbia. These were granted foundation status.

The merit trials are organized in the Horticulture Division. Seed of new varieties is sent to a number of institutions to test for adaptability and value. The Experiment Station, Vineland, tested 253; University of Manitoba, 224, and University of British Columbia, 231. The results obtained are included as part of the section on merit trials in this Progress Report.

At the Horticultural Experiment Station, Vineland, Ontario, I. D. W. Smith is engaged with O. J. Robb of that Station in a co-operative breeding project with greenhouse cucumbers for resistance to *Erysiphe cichoracearum* DC. which causes powdery mildew.

At the University of Manitoba, Winnipeg, Manitoba, H. R. Hikida has reported, in 1949 and since, rather extensive damage to tomato plants caused by 2, 4-D drift from grain fields. Selection work has resulted in a Purple Head selection of cauliflower or heading broccoli. It is superior to the parent variety in size, shape and appearance but unfortunately is several weeks later in maturity.

At the University of British Columbia, Vancouver, British Columbia, J. B. Teir made a study of the varietal characteristics of eight varieties of leeks. Classification was difficult because of similarities between and differences within varieties. Varieties compared were: American Flag, Musselburgh, Giant Carentan, Liege Dark Green, Prizetaker, Elephant, The Lyon, and Blue Leaf. Of these, Giant Carentan was the only one with completely parallel-sided stalks. All others were bulbed to some degree. The amount of bulbing and shape of the bulb were not sufficiently distinct to permit definite classification. In color of foliage, American Flag was light green; Musselburgh was slightly darker; Giant Carentan, Liege Dark Green, Prizetaker and Elephant were medium dark green;

The Lyon was dark green, and Blue Leaf was dark blue-green. Neither size of stalk nor leaves showed sufficient differences to permit distinction between varieties.

In a planting-date experiment with four onion varieties, J. B. Teir found that all four produced larger bulbs from seed sown in the field than when sown early under glass and transplanted to the field. The comparisons in Table F-13 make this distinction quite clear. The experiment was of a preliminary nature with 30-foot-row plots. Results are based on 50 average bulbs per plot.

TABLE F-13.—BULB SIZE IN FIELD-GROWN AND TRANSPLANTED ONIONS

| Variety | Date sown | Date transplanted | Average bulb size | | Doubles in usable size | Bullnecks in usable size | Wt. 50 mature bulbs |
|---|---|---|---|---|---|---|---|
| | | | P[1] | E[2] | | | |
| | | | in. | in. | % | % | lb. |
| Australian Brown | April 27 | ..... | 1·78 | 2·23 | 13 | 9 | 9·73 |
| | May 5 | ..... | 1·76 | 2·10 | 18 | 29 | 9·70 |
| | March 15 | May 19 | 1·70 | 2·01 | 35 | 18 | 7·50 |
| Yellow Globe Danvers | April 27 | ..... | 2·31 | 2·77 | 5 | 16 | 18·38 |
| | May 5 | ..... | 2·07 | 2·54 | 14 | 2 | 13·13 |
| | March 15 | May 19 | 1·84 | 2·29 | 15 | 12 | 10·31 |
| Red Wethersfield | April 27 | ..... | 1·58 | 2·3 | 6 | 12 | 8·75 |
| | May 5 | ..... | 1·47 | 2·3 | 13 | 23 | 8·75 |
| | March 15 | May 19 | 1·38 | 2·1 | 9 | 22 | 6·25 |
| White Portugal | April 27 | ..... | 1·72 | 2·60 | 22 | 15 | 11·56 |
| | May 5 | ..... | 1·58 | 2·21 | 15 | 26 | 11·00 |
| | March 15 | May 19 | 1·56 | 2·21 | 18 | 39 | 8·59 |

[1]Polar diameter. [2] Equatorial diameter.

J. B. Teir assisted in the preparation of "Vegetable varieties—description and uses". B. C. Dept. Agr. Hort. Circ. 77. 1953.

Publications on co-operative work include the following:

1. Smith, I. D. W. Dominion-Provincial vegetable projects. Hort. Exp. Sta., Ont. Dept. Agr. Rept. for 1949 and 1950, pp. 57-59.

2. Smith, I. D. W. Dominion-Provincial vegetable projects. Hort. Exp. Sta. Ont. Dept. Agr. Rept. for 1951 and 1952, pp. 46-47.

3. Smith, I. D. W. Cabbage, cauliflower, broccoli and brussels sprouts. Ont. Dept. Agr. Circ. 117. March, 1952.

4. Smith, I. D. W. Peppers and egg-plants. Ont. Dept. Agr. Circ. 196. June, 1954.

***Branch Stations***

More than 30 Experimental Farms and Stations in the Experimental Farms Service across Canada conduct horticultural work. One major contribution to co-operative assistance was the organization and co-ordination of a large part of the vegetable work at the Stations in two large regions of the country.

In 1951 a conference was held with the Horticulture research officers of nine Stations in Manitoba, Saskatchewan and Alberta. In 1953 a similar conference was held with the officers of four Stations in New Brunswick, Prince Edward Island and Newfoundland.

Differences in plot size and plant spacing were common between the Stations. It was agreed that observation plots would consist of rows 30 feet long and the spacing of plants within the row would be as follows:

**Stations in Prairie Provinces**

| | |
|---|---|
| 1 inch | —beets (bunching), carrot and radish; |
| 2 inches | —beets (storage), garlic, leek, onion (sown) and peas; |
| 3 inches | —beans and parsnip; |
| 4 inches | —kohl rabi, onion (transplanted) and summer turnip; |
| 6 inches | —celery and rutabaga (Swede turnip); |
| 12 inches | —chard, Chinese cabbage, citron, corn, cucumber, lettuce, muskmelon, spinach and watermelon; |
| 18 inches | —broccoli, Brussels sprouts, cabbage, cauliflower, eggplant and pepper; |
| 2½ feet | —asparagus; |
| 3 feet | —pumpkin, squash, tomato and vegetable marrow; |
| 5 feet | —rhubarb. |

**Stations in Maritime Provinces**

| | |
|---|---|
| 1 inch | —beets (bunching), carrot and radish; |
| 2 inches | —beets (storage), garlic, leek, onion (seed and sets) and peas; |
| 3 inches | —beans and parsnip; |
| 4 inches | —kohl rabi, onion (transplants) and summer turnip; |
| 6 inches | —celery, chard, Chinese cabbage, lettuce (leaf), rutabaga (Swede turnip) and spinach; |
| 8 inches | —corn; |
| 12 inches | —cucumber (pickling); |
| 15 inches | —lettuce (head); |
| 18 inches | —asparagus, broccoli, Brussels sprouts, cabbage, cauliflower, eggplant and pepper; |
| 2 feet | —citron, cucumber (slicing), muskmelon, tomatoes (staked); |
| 2½ feet | —rhubarb; |
| 3 feet | —pumpkin, squash, tomatoes (unstaked) and vegetable marrow. |

At the Maritime Stations staked tomatoes are in rows three feet apart and unstaked tomatoes in rows five feet apart. With these exceptions row width varies between the Stations according to moisture conditions and cultural practices.

With replicated yield plots a uniform spacing distance was set up for beans, corn, pickling cucumbers, peas and tomatoes. The number of varieties, design and number of replications may vary according to the purpose of each experiment and other factors.

For uniformity and co-ordination between Stations, standard procedures were set up. Briefly, these state: location of guard rows; limitation to four or fewer years for variety observation and five or fewer years for replicated field experiments (perennial plants excepted); measurements in inches and tenths; weights in pounds and tenths; yields to include only marketable produce. A complete and uniform record system was also set up.

Some co-operative breeding projects were set up and are now under way. For example, the Prairie co-operative tomato breeding project for earlier varieties suitable for the Prairie Provinces has progressed appreciably.

A co-operative pea variety experiment has been under way for two years at eight Experimental Stations in the Prairie Provinces. The variety Selkirk, an origination of this Division, was earlier than Lincoln at every Station and produced the heaviest yield of shelled peas in the totals for all Stations. It is expected that Selkirk will at least prove a complementary variety to Lincoln, the most popular variety on the Prairies at present. Four other varieties are grown in this experiment; Little Marvel, Thomas Laxton, Director and Ottawa PE-1, the last two being originations of this Division.

## Investigations on Plot Size—Vegetables

*H. F. Beingessner and H. B. Cannon*

In experimental procedure it is desirable to know the variations present, their cause or source, and some measure of their magnitude. Variation is measured by such standard designs or plans as the random block, latin square, factorial arrangements and incomplete blocks. But the basic unit is the plot that lies within the design. Plot size and replication tend to control soil heterogeneity. Therefore so that a design may efficiently consider soil variations, the size of plot should be at an optimum for a specific set of conditions. Since the design is only as efficient as its structural components, the optimum plot size is vitally important in research. Unfortunately, very little information is available on plot size for horticultural investigations. Some progress is being made, however, through the medium of uniformity trials.

In 1951 two uniformity trials were conducted at the Horticulture Division. One trial consisted of a block of Carleton tomatoes divided into fifty-seven rows each containing seven plots of four plants, a total of 399 plots. Tomato spacing was four feet apart both within and between the rows. The second trial was a block of Giant Stringless Green Pod beans, divided into twenty rows of thirteen 10-foot plots. Total individual plot yields were tabulated.

Unfortunately for the purpose of these trials the plot yields in either block were not variable, indicating that the soil was rather uniform throughout. Therefore, in the analyses, emphasis was placed on the uniformity of replication rather than on soil heterogeneity. The coefficient of variation, calculated from the analysis of variance on each size of plot, was used to compare the relative efficiency of the various plot sizes. In the tomato trials, five "variety" on "treatment" plots were assumed in each block while in the bean trial a three "variety" block was used. Tables F-14 and F-15 give the coefficients of variation for the tomato and bean trials.

TABLE F-14.—COEFFICIENTS OF VARIATION FOR PLOT SIZES IN THE TOMATO TRIAL

| Plot width in rows | Length of plot in numbers of plants | | | | | | |
|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 20 | 24 | 28 |
| 1 | 11·3 | 9·2 | 7·3 | 7·3 | 6·8 | 6·0 | 5·5 |
| 2 | 8·5 | 7·2 | 5·9 | 6·2 | 5·6 | 5·5 | 5·4 |
| 3 | 6·2 | 7·1 | 7·5 | 7·7 | 6·9 | 6·6 | 6·0 |

TABLE F-15.—COEFFICIENTS OF VARIATION FOR PLOT SIZES IN THE BEAN TRIAL

| Plot width in rows | Length of plot in feet | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 |
| 1 | 12·1 | 8·3 | 7·5 | 5·7 | 4·9 | 5·3 | 4·8 | 4·6 | 4·5 | 4·5 | 4·5 | 4·7 | 4·8 |
| 2 | 4·3 | 5·3 | 5·2 | 3·8 | 3·2 | 3·3 | 3·1 | 3·4 | 3·5 | 3·5 | 3·7 | 4·0 | 4·0 |
| 3 | 9·4 | 9·4 | 8·0 | 6·8 | 6·6 | 6·1 | 5·7 | 6·0 | 5·3 | 5·3 | 5·3 | 5·5 | 4·8 |

In Table F-14 variation decreased as the plots lengthened. No advantage appears in the use of multiple-row plots. The 12-plant single-row plot was the optimum size for the conditions at the Horticulture Division for Carleton tomatoes.

In Table F-15 a similar decrease in variation was observed as the plots were lengthened, but in this instance the extreme uniformity between plots makes statistical interpretation difficult. The single-row 30-foot plot gave a coefficient of variation of 7.5 per cent as compared to 9.4 per cent for a three-row 10-foot plot. A two-row 30-foot plot gave almost the same coefficient of variation as the single-row 60-foot plot. There is an indication that on uniform soils it may be possible to increase the width of plots.

## POTATO INVESTIGATIONS

*N. M. Parks*

### National Potato Seedling and Variety Tests

Since 1948, approximately 25,000 seedlings and over 100 named varieties have been included in the National Potato Seedling and Variety Tests, a co-operative project between Experimental Farms and Science Services of the Canada Department of Agriculture, Provincial Institutions, Agricultural Colleges, certain Universities and growers. Thirty-five stations undertake the major part of the tests, but many varieties and seedlings are also tested on Illustration Stations and growers' farms.

A very large number of the seedlings and most of the named varieties tested or under test were originated in the potato breeding program of the Dominion Experimental Station, Fredericton, N.B., but some came from plant breeders in England and Scotland. In addition, twenty-five varieties were submitted for evaluation by private plant breeders in Canada, a procedure necessary when licensing for sale under the Canada Seeds Act is contemplated.

The potential of any seedling or variety is readily assessed in the widespread testing locations provided by the plan. Suitability of the new material for commercial purposes depends in part on the reactions of growers and consumers in different areas.

Thus far eight varieties have been recommended and licensed. These are as follows:

*Canso* and *Keswick*.—Originated at Fredericton, N.B.; resistant to certain strains of late blight.

*Kennebec*.—U.S.D.A. origination; resistant to certain strains of late blight.

*McIntyre*.—Origin unknown; blue-skinned; grown mostly in coastal areas of the Maritime Provinces and known there from early times.

*Manota*.—Re-selected by the University of Manitoba from a seedling originated in North Dakota. Earlier maturity and freedom from hollow heart.

*Ontario*.—U.S.D.A. origination; scab resistant.

*Pontiac*.—U.S.D.A. origination; red-skinned; high yielding.

*Teton*.—U.S.D.A. origination; has certain resistance to bacterial ring rot.

## Multiplying and Distributing Canso and Keswick Potato Varieties

A major project under the supervision of the Potato Section of the Horticulture Division during 1950-51 was the multiplication and distribution of seed of the late-blight-resistant potato varieties, Canso and Keswick.

Seed was multiplied under contract between this Division and three growers in each province, Prince Edward Island and New Brunswick, two each in Nova Scotia, Quebec, Ontario and British Columbia and one in Manitoba. The quantity they produced in 1950 was approximately 6600 bushels of Canso and 3200 bushels of Keswick.

Among the more than eight thousand requests for seed, those applications from growers of certified seed potatoes were given first consideration so that the quantity would be multipled mainly as seed in 1951. The remaining surplus was made available to purchasers of ten or more bushels, with the request that plantings be entered for certification where possible. The seed produced under contract was distributed to 725 growers throughout Canada.

## Potato Marketing Project

The Montreal, Ottawa and Toronto markets were surveyed in 1951-52 to determine the grade and culinary quality of potatoes at consumer level. From the results the committee in charge recommended that a fact finding study should be undertaken to determine:

1. Whether consumers are conscious of quality of potatoes;
2. The feasibility of grading and marketing potatoes commercially on a culinary basis and packaging them in uniform sizes;
3. Cost of grading and packaging;
4. Premiums that consumers would pay for such potatoes, and
5. Data on consumer acceptance of the packaged product.

A co-operative project was therefore organized between Agricultural Engineering, Horticulture and Marketing Service, Canada Department of Agriculture on the one hand, and Dufferin Potato Growers' Co-operative, Shelburne, and Dominion Stores, Toronto, on the other.

Commercial equipment for grading potatoes on a dry-matter basis by specific gravity consisting of a brusher, brine tank, washer and drier was set up. A sizer was included in the line. Since dry-matter content is a criterion of quality, potatoes graded by specific gravity are considered quality graded. Such quality-graded and sized potatoes were packed in distinctive 10-pound paper packages and marketed through six Dominion Stores' Toronto markets. Each store that handled the experimental potatoes is located in an area varying in consumer purchasing level.

An analysis of 1952-53 sales and data on the returned questionnaires included in each package indicated the following:

1. Consumers will pay a substantial premium for clean, uniformly-sized, attractively packaged potatoes.
2. No clear-cut conclusion could be drawn from the data on the dry-matter content as a criterion of consumer preference. Consumer preference appears to depend entirely upon individual evaluation.

3. The data from one year's operation was inadequate to determine fully the added cost of the commercial grading. The project was therefore continued through the 1953-54 marketing season, but the data have not yet been fully analysed.

## Potato Packaging

To obtain information on washed, packaged potatoes, a present consumer demand, the Horticulture Division investigated commercial problems of water volume, water absorption and the need for drying, at the Dufferin Potato Growers' Co-operative warehouse, Shelburne, Ont. Results were as follows:

1. The average run of potatoes, first brushed then washed, requires approximately 24 gal./bu. at tap pressure.
2. Katahdin potatoes, withdrawn from storage at 40°F. and 70 per cent relative humidity, remaining in the washer three minutes and with free moisture removed by running over felt rollers, increased in weight an average of 3 oz./bu. (18·75 lb. or approximately 2 gal./100 bu.). Adhering moisture varies considerably with variety and percentage relative humidity of storage.
3. For immediate packaging in consumer packages after washing, heat drying is essential.

## Methods of Detecting Hollow Heart in Potatoes

Hollow heart, a serious problem in the 1952 crop, is usually associated with, or brought about by, too rapid or irregular plant growth. The condition is common in certain large-tubered, fast-growing varieties during wet seasons or when grown in fertile soils. However, tuber size is not a definite indication because small tubers may also be affected. There is no reliable external symptom.

Studies were initiated to develop a commercial-scale detection method. The only methods found to have commercial possibilities were brine flotation and fluoroscopic inspection. With brine flotation practically all hollow-hearted tubers can be eliminated. However, to eliminate the final percentage, adjustment of the brine solution to the specific gravity of practically every remaining potato is necessary. Nevertheless, by using a high brine concentration the amount of hollow heart in runs of potatoes separated by brine flotation can be held within the grade tolerance.

Visual inspection of tubers by X ray proved one hundred per cent efficient. The obstacle to using the X-ray method lies in the detrimental effects of the rays on the operator, necessitating costly protective equipment.

## Blackening of Potatoes

The Horticulture Division and the Chemistry Division, Science Service, are jointly studying certain phases of the potato blackening problem.

Blackening of potatoes exists in several forms. In the past, one of the common forms was only rarely observed in the raw tuber, but showed up when the potato was cooked. This type and the experiments thereon are discussed by H. Hill and H. B. Heeney in the Nutrition and Soil Management Section of this Progress Report. Recently, consumers have also been complaining about a different type. Here, the "black spots" are beneath the periderm; can usually be seen as faint smudges through the skin of the raw potato, and are quite definite as gray to black areas in the peeled potato. They, too, are dark to black when cooked.

In earlier studies at the Horticulture Division, large numbers of tubers from many sources were examined. The examinations indicated that such quite localized "black spots" were associated with bruising and could be compared with a peculiar type of apple bruising, erroneously called "apple scald" by the trade.

These early conclusions on the cause of "black spots" have been fairly well substantiated by recent results when large numbers of potatoes were examined both visually and microscopically. Commercially grown potatoes, mechanically harvested and handled, had seven times as many black spots as the same varieties grown on experimental areas, hand harvested and handled; and in the laboratory, mechanically induced bruising gives the same type of blackening.

It is believed that when the living potato tissue is bruised, cell walls may be broken and the cell constituents infiltrate into the intercellular spaces causing the production of volatiles through natural fermentation processes; hence, the discoloration of the surrounding tissue. The cell wall need not necessarily be broken, but the bruising pressure may damage the delicate internal living membrane lying close to the wall. Death of the protoplasm results. This is readily seen by microscopic examination. Some cells are broken, others may be whole but dead with the protoplasmic contents coagulated and more or less embedding, to forming a thin layer around, the starch grains. Moreover, these "black spots" have numerous enlarged air or gas spaces apparently caused by wall distortion or breakdown so that a very thin layer appears white and spongy in contrast to the darkened mass of the whole lesion or to undamaged nearby tissue. Further, the degree of bruising or size and number of black spots is closely associated with the tuber maturity at harvest, with methods of harvesting and handling, and with potato temperature at any handling from harvest to storage removal.

## Potato Tuber Models

Great confusion has existed on proper tuber type of specific potato varieties. The result is variability in type at exhibits.

The tuber type of a potato variety is selected and determined by the plant breeder or the one who originates or selects the variety. Once the type is decided upon and selected and the variety developed, this type will remain the same so long as the variety is grown under similar environmental and climatic conditions and is propagated asexually by tuber cuttings. Even though the tuber shape may change somewhat with differences in environment such as soil type, fertilization and climate, the shape will revert to the original when grown again under conditions similar to the initial. If reversion to the original type does not then occur either of two things has happened; (1) the potato has become infected with a virus such as spindle tuber, which distorts the shape, or (2) a mutation has occurred.

The plant breeder's description is official and cannot be altered in any way until a different type, the result of mutation within the variety, has been re-selected.

Specimen tubers as described by the plant breeders who originated them have been selected by the Horticulture Division, and modeled by W. A. Bronnum, under commission by the Plant Protection and Promotion Branch, Department of Agriculture, N.B. These models enable selection for trueness to type.

## Co-operative Potato Projects in Ontario

Co-operative potato investigations have been carried on in Ontario between this Division and the Field Husbandry Department, O.A.C., Guelph, Ont., over a period of 18 years. Since 1948 the following studies have been conducted:

(1) Potato seedling and varietal evaluations;

(2) Nutritional investigations, including
  (a) Analyses of commercial fertilizers,
  (b) Ratios of N, P, K, Ca and Mn, and
  (c) Sources of N, P, and K;
(3) Fertilizer placement;
(4) Rotations;
(5) Dates of planting;
(6) Scab control;
(7) Chemicals for weed control;
(8) Plant defoliators;
(9) Regional seedling and varietal trials, and
(10) Quality determinations.

Results of the foregoing studies have been published in Annual Progress Reports.

## Ontario Potato Scab Research Project

Common scab of potatoes is a very troublesome problem to potato growers in Ontario. As a result of representations made by growers to the Ontario Minister of Agriculture for assistance in finding a control, a co-operative project between this Division and the Department of Field Husbandry, O.A.C., Guelph, was initiated in 1948. The aforementioned groups were made responsible for obtaining and testing seedlings and varieties for resistance to common scab.

Since the inception of the project in 1940, 8514 unselected and 167 selected scab-resistant seedlings, originating in the potato breeding program at Fredericton, N.B., have been evaluated for resistance to common scab. In addition, a large number of scab-resistant seedlings and named varieties obtained from plant breeders in the United States and other countries have been tested.

Table F-16 shows the percentage and type of scab on certain scab-resistant seedlings and varieties at various locations in Ontario. Both percentage and type vary with the location.

TABLE F-16.—AVERAGE PERCENTAGE AND TYPE OF SCAB INFECTION ON THIRTEEN SEEDLINGS AND FOUR POTATO VARIETIES FOR TWO YEARS AT FOUR ONTARIO LOCATIONS

NOTE.—Seedlings and three varieties selected for scab resistance. Katahdin, non-resistant.

| Variety | Location 1 | | Location 2 | | Location 3 | | Location 4 | |
|---|---|---|---|---|---|---|---|---|
| | Average per cent of scab | Type* | Average per cent of scab | Type | Average per cent of scab | Type | Average per cent of scab | Type |
| F1407-66 | 63·75 | 2, 3 | 9·00 | 1, 2 | 1·15 | 2, 3 | 1·00 | 1 |
| F1413-133 | 19·65 | 1, 2 | 0·88 | 1 | 2·62 | 1, 2 | 2·36 | 1, 2 |
| F1413-223 | 0·53 | 1 | 1·51 | 1 | 0·32 | 1, 2 | 0·59 | 1 |
| F1514-32 | 1·15 | 1 | 0·30 | 1 | 0·65 | 1 | 0·20 | 1 |
| F1524-53 | 4·43 | 1 | 2·52 | 1 | 0·42 | 2 | 1·05 | 1 |
| F1602-1 | 2·65 | 1, 2 | 1·43 | 1 | 1·30 | 1 | 0·50 | 1 |
| F1615-21 | 6·55 | 1, 2 | 0·43 | 1 | 0·46 | 2, 3 | 1·05 | 1 |
| F1705-62 | 8·32 | 1, 2 | 0·83 | 1 | 0·80 | 1, 2 | 1·77 | 1 |
| F1707-37 | 3·80 | 1 | 0·59 | 1 | 0·89 | 1, 2 | 1·07 | 1 |
| F1711-9 | 7·14 | 1, 2 | 0·52 | 1 | 0·62 | 1, 2 | 6·42 | 1 |
| F1712-151 | 5·20 | 1, 2 | 3·25 | 1 | 0·66 | 2, 3 | 1·46 | 1, 2, 3 |
| F1713-9 | 1·74 | 1 | 0·62 | 1 | 0·85 | 1, 2 | 1·18 | 1, 2 |
| F1738-84 | 8·97 | 1, 2 | 1·68 | 1 | 1·25 | 1, 2 | 8·09 | 1 |
| Menominee | 2·69 | 1 | 1·52 | 1, 2 | 0·87 | 1, 2 | 4·66 | 1 |
| Ontario | 1·22 | 1 | 0·93 | 1 | 0·86 | 1, 2, 3 | 0·83 | 1 |
| Seneca | 1·95 | 1 | 1·01 | 1 | 0·43 | 1, 2 | 0·69 | 1 |
| Katahdin | 29·48 | 1, 2, 3 | 3·22 | 1, 2 | 2·97 | 2, 3 | 1·40 | 1 |

*Type designations: 1, a slight netting or scurf scab; 2, intermediate to deep lesions; 3, severe, deep lesions.

From the data in Table F-16 it is evident that certain seedlings and varieties possess considerable resistance to one or more of the physiological races of the common scab organism, *Streptomyces scabies*. However, the commercial value of a potato depends not alone on its scab resistance but also on such attributes as suitable maturity, shape of tuber, yield and culinary quality. Although the variety Ontario is grown in commercial quantity, the evaluated seedlings and varieties listed as showing sufficient scab resistance are lacking mainly in one or more desirable commercial qualities.

## DOMINION HORTICULTURAL SUBSTATION, SMITHFIELD, ONTARIO

### Apple Breeding

*D. S. Blair and L. P. S. Spangelo*

In this project, all crosses have been made in the Horticulture Division, Ottawa. Approximately ten thousand seedlings have been planted at Smithfield for fruit evaluation. Progeny data are recorded to obtain information on the ability of parents to transmit desirable tree and fruit characteristics.

From 1949 to 1953 inclusive, 923 seedlings fruited. The varieties Cortland, Cox Orange, Crimson Beauty, Delicious, Hume, Jonathan, Lawfam, Linda, Lobo, McIntosh, Melba, Milton and Sandow are involved in the parentages. A number of seedlings have been selected and are being propagated for further testing as commercial varieties. Their introduction numbers, parentage and brief descriptions follow.

*T-391* (Cox Orange × McIntosh).—Apples are of commercial size, well colored, very good quality; attractive and with a highly aromatic flavor resembling that of Cox Orange. It is harvested at the same time as McIntosh and should be marketed out of storage at 32°F. by December 15. The tree comes into bearing at an early age.

*T-392* (Sandow × Delicious).—An attractive late maturing seedling of good quality. It has the same season as Sandow and might prove superior to Sandow in tree characters.

*T-393* (McIntosh × Sandow).—An apple of commercial size, good quality and appearance. It keeps as long as McIntosh and will be superior to McIntosh if it proves productive.

*T-394* (Linda × Lawfam).—A very attractive apple of commercial size and good quality. It keeps longer than McIntosh at 32°F.

*T-395* (McIntosh × Sandow).—Apples are of good appearance and quality. Selected as a seedling that might prove a better keeper than Sandow.

*T-396* (Delicious × Sandow).—This is a promising seedling because of its appearance and good keeping quality. It has fairly good eating quality.

*T-397* (Delicious × Linda).—Good size and appearance; a late keeper of low acidity and good quality.

*T-398* (Delicious × Linda).—Apples are of good size, uniform shape and good appearance, and keep as long as Delicious.

*T-399* (McIntosh × Linda).—A very attractive apple of good size and fairly good quality. Keeps about as long as McIntosh and is being evaluated in comparison with that variety.

*T-3910* (McIntosh × Linda).—An attractive apple resembling McIntosh in flavor. It does not keep any longer than McIntosh at 32°F., and will prove valuable only if it is superior to McIntosh in production.

*T-3911* (Delicious × McIntosh).—An apple of good size, fairly attractive with above medium quality. It is of Delicious season.

*T-3912* (Delicious × Sandow).—Good size, appearance, and fairly good quality; keeps longer than McIntosh.

*T-3913* (McIntosh × Sandow).—A medium quality, very attractive apple that keeps longer than McIntosh.

*T-3914* (Delicious × Linda).—An attractive apple that lacks a bit in size. It is rather acid in flavor but is of medium quality and keeps longer than McIntosh.

*T-3915* (Delicious × Linda).—A very attractive apple of conic shape, low in acidity but fairly good quality. It does not keep longer than McIntosh.

*T-401* (Linda × Lawfam).—This selection has good size, appearance, fairly good quality, and keeps longer than McIntosh.

*T-411* (Sandow × McIntosh).—An apple of good size and fairly good appearance which will keep longer than McIntosh.

*T-412* (Sandow × McIntosh).—An apple of moderate acidity and which lacks somewhat in quality. It is fairly attractive, and will keep longer than McIntosh.

*T-413* (Sandow × Cortland).—A large apple, attractive, but lacking somewhat in quality and inferior to Sandow in this respect. It keeps longer than McIntosh and will be of some value if it proves more productive than Sandow.

*T-414* (Linda × Elmer).—An apple of good appearance, low acidity and fairly good quality. It does not keep much longer than McIntosh and needs to be more fully evaluated in comparison with that variety.

Cortland, McIntosh and Sandow progeny data have supported the findings at Ottawa that these three varieties are very promising parents. The Sandow × Cortland and Sandow × McIntosh progenies have been very uniform in fruit color, shape, eating quality and storage behavior. The rather sprightly flavored Linda has combined well with the low acidity variety Delicious.

Although tree hardiness data are recorded, the selected seedlings have not yet been fully evaluated for this character. It is expected, however, that seedlings of Delicious and Linda parentage will be satisfactory only for those areas where the climate is less severe than at Ottawa.

## Fruit Variety Trials

### *Apples*

All promising Ottawa selections have been planted, and many that mature early have shown considerable promise for the area. These are all being evaluated in comparison with Crimson Beauty and Melba. Of those tested, O-271, O-272, O-274, O-275, O-276, O-277, O-279, O-292, O-293, O-296, O-341, and O-342 ripen earlier than Melba and, in general, are superior to Crimson Beauty in eating quality. All of these seedlings with the exception of O-292 (Melba × Astrachan), O-293 and O-296 (both Melba × Yellow Transparent)

are of Melba-Crimson Beauty parentage. It is apparent that O-342 is the best of the early ripening selections, followed closely by O-277, and O-341 is fully equal to Crimson Beauty in early maturity.

The early ripening varieties Close, Red Crimson Beauty, Stark Earliest and the selection U.S.D.A. 49 have some promise. Probably Red Crimson Beauty is the most promising. The yellow-fruited Lodi follows the foregoing group in maturity and is recommended in preference to Yellow Transparent. The various red sports of Melba are superior to Melba.

Among the fall selections, O-244 (McIntosh × Duchess) and the red sport of Atlas have proved the most promising. However, O-244 should be carefully thinned because of overproduction. The T-391 (Cox Orange × McIntosh) seedling is a promising high quality, early winter apple. It will keep in first class condition at 32°F. until early December.

Four varieties, Bancroft, Lawfam, Sandow and Toshkee, originated at Ottawa have shown enough promise to be recommended for limited commercial planting. (See following section on consumer acceptance by marketing trials.)

Lawfam is uniformly good in size and appearance and as judged by marketing tests has been readily accepted by the consumers.

The Toshkee tree is semi-dwarf; bears an annual crop of good-sized, highly colored fruits, and is acceptable in quality as judged by marketing tests.

Sandow is a very high quality winter variety. Although it resembles Northern Spy in eating quality, the fruits are more attractive; the trees come into bearing at an earlier age and seem to be more productive than Northern Spy.

Bancroft is a precocious, late winter, annual bearing variety. It is inferior to Sandow in eating quality, yet it has enough quality to be readily accepted by the consuming public.

Spartan (McIntosh × Yellow Newtown), originated by the Summerland Experimental Station, has excellent color and very good quality, but has lacked good commercial size. It keeps in excellent condition at 32°F. until early January.

Cortland has proved very satisfactory and although it probably would have to be marketed in competition with McIntosh, it is recommended for commercial planting. It comes into bearing early and the fruits are excellent for dessert purposes and processing.

Melrose appears promising as a good quality, highly colored winter apple, but this conclusion is based on the few apples produced thus far.

*Consumer Acceptance by Marketing Trials.*—Since 1951 consumer acceptance of varieties introduced by the Horticulture Division, Central Experimental Farm, Ottawa, has been determined by marketing trials. In these trials the method was the inclusion of a card in the marketing container. This card gave the origin of the variety and requested return of the card after indicating an opinion of the usefulness of the variety. A summary of the survey is given in Table G-1.

TABLE G-1.—RESULTS OF APPLE MARKETING TRIALS

| Variety | Number cards returned | Number of consumers who liked the variety | | |
|---|---|---|---|---|
| | | Generally | For eating | For cooking |
| Bancroft | 90 | 86 | ..... | ..... |
| Sandow | 88 | 85 | ..... | ..... |
| Lawfam | 85 | ..... | 76 | 53 |
| Toshkee | 19 | ..... | 13 | 12 |

When Bancroft and Sandow were marketed the questionnaires indicated only general desirability. It was felt that this information was not sufficient. Later marketing trials requested desirability based on eating and cooking quality. Although the foregoing data are limited, they indicate that all varieties in the test are of value from a consumer point of view. The limited trials have proved that consumer acceptance can be fairly well determined by this method and plans have been made for more extensive trials.

***Strawberries***

A rather extensive collection of June and everbearing varieties has been tested.

Data have shown that Premier is still the most promising commercial variety. Tennessee Beauty and Sparkle should be thoroughly tested by commercial growers. Both varieties have had very good appearance; Sparkle is highly productive, and both seem firm enough for commercial use. Temple, although promising, is probably more adaptable to home gardens than commercial plantings because it tends to be dark in color and somewhat soft in texture. The production and berry firmness of Tennessee Shipper attracted considerable attention. Empire, Eden, Erie and Essex, all originated by the New York State Agricultural Experiment Station, have good size and color but lack too much in firmness. Empire was the most promising of the four.

The everbearing varieties Red Rich and Streamliner have been superior to the standard variety Gem. Superfection has resembled Gem very closely. The only improvement over Gem is in the greater plant vigor.

## Apple Rootstock Trials

*D. S. Blair, H. F. Beingessner and H. B. Cannon*

Apple rootstock investigations have been carried on at Smithfield since 1948. Rootstock effect upon the size and the yielding ability of McIntosh and Kinkead Red Spy trees in early life is shown in Table G-2.

TABLE G-2.—AVERAGE SIZE AND CUMULATIVE YIELD OF McINTOSH AND KINKEAD RED SPY TREES AT SIX YEARS OF AGE

| Rootstock | Number of trees | Spread | Average yield |
|---|---|---|---|
| | | ft. | lb./tree |
| McINTOSH ON— | | | |
| Antonovka seedlings | 16 | 9·3 | 8·1 |
| *M. robusta* No. 5 | 16 | 9·0 | 5·1 |
| EM I | 16 | 8·1 | 12·6 |
| EM II | 16 | 8·3 | 16·5 |
| EM VII | 16 | 7·7 | 14·9 |
| EM XII | 16 | 9·3 | 0·6 |
| KINKEAD RED SPY ON— | | | |
| Antonovka seedlings | 16 | 5·6 | ..... |
| *M. robusta* No. 5 | 16 | 4·8 | ..... |
| EM I | 16 | 4·7 | ..... |
| EM II | 16 | 4·7 | ..... |
| EM VII | 16 | 4·5 | ..... |
| EM XII | 16 | 4·9 | ..... |

Table G-2 shows that at six years of age McIntosh trees on EM XII and on Antonovka seedling rootstocks have the greatest spread while those on EM VII have the least spread. The McIntosh trees on EM I and II rootstocks are intermediate in spread. The trees on *M. robusta* No. 5 have a spread almost equal to that of the trees on EM XII and on Antonovka seedling rootstocks.

Because of the upright habit of the Kinkead Red Spy variety, and since the trees have not as yet come into bearing, only minor differences in spread are apparent. The Kinkead Red Spy trees on Antonovka are the largest while those on EM VII are the smallest as indicated by tree spread. The trees on the other rootstocks are similar in size but are only slightly larger than those on EM VII.

Some tendency towards early bearing is exhibited by McIntosh trees on EM I, II and VII, and to a lesser extent on Antonovka and *M. robusta* No. 5. The McIntosh trees on EM XII are somewhat later in coming into bearing. Whether these differences are of commercial importance will largely depend upon their future performance.

At six years of age, regardless of rootstock, no fruit has been produced on the Kinkead Red Spy trees.

## Crop Rotation Studies with Vegetable Canning Crops

*H. Hill and H. B. Heeney*

Vegetable canning crops provide a major portion of the cash income of many farms in the Ontario counties of Northumberland, Durham and Prince Edward. In Northumberland, canning crops are grown on light-textured soils such as Percy fine sandy loam, Bondhead loam, and Brighton sandy loam, while in Durham the somewhat deeper, heavier-textured Newcastle loam is more common. Clay loams are predominant in Prince Edward, but such soils are frequently shallow, and precipitation is deficient and poorly distributed during the growing season. With the occurrence of relatively high temperature during the cultivation period, organic matter decomposes rapidly and its maintenance is difficult.

While the average farmer in this area does keep a small number of livestock, the amount of manure produced is insufficient to maintain soil organic matter and soil fertility with land under continuous cultivation. The grower consequently is faced with the problem of adopting crop rotations which allow the highest cash income from vegetable canning crops and yet maintain soil fertility with the restricted amount of manure that is available. Present soil management practices are based on general rather than specific knowledge and on local economy. In many areas soil fertility has declined and soil has eroded. With this in mind a group of plots with different rotations of canning peas, tomatoes and corn was established in 1946 at the Smithfield Substation on Percy fine sandy loam with the purpose of investigating changes in soil constituents and crop yields over an extended period. The study has been in progress for seven years and although an adequate assessment of the different rotations cannot yet be made certain trends are apparent.

Changes that have occurred in certain soil constituents during the initial seven-year period in different rotations with canning peas, tomatoes and corn are reported.

In a two-year rotation of peas and tomatoes or peas and corn, where in addition to commercial fertilizer, twelve tons of manure were applied every second year and two green manure crops were grown after harvesting the peas, an increase occurred in soil organic matter, exchangeable potassium and easily acid soluble plus adsorbed phosphorus. Results from another rotation where the corn stover was returned to the soil indicate this practice to be helpful in maintaining soil organic matter. The highest yields of corn, peas and tomatoes occurred where manure was used, and the highest average yields were obtained in two-year rotations with uninterrupted production of canning crops.

In rotations in which red clover was seeded in the peas and corn, the pea or corn yield was materially reduced, and it has been decided to accept this finding and to discontinue these rotations. A practice used by other workers, and which should do much to help in organic matter maintenance, is planting Italian fall rye with tomatoes and corn at the last cultivation. Italian fall rye gives an additional green manure crop after the tomato or corn crops and in short rotations might do much in maintaining or improving soil fertility. These practices are now being included in certain revised rotations.

Soil test values, as well as the calculated additions and removals of phosphorus and potassium, suggest that larger amounts of phosphorus and smaller amounts of potassium were used than were necessary for the particular area.

The details of these studies may be found in "The Effect of Various Canning Crop Rotations on Certain Soil Constituents over a Five-Year Period" by H. Hill, R. F. Bishop and H. B. Cannon. Can. J. Agri. Sci. 33:210-215. 1953.

### Studies on Soil Management of Pickling Cucumbers

The production of pickling cucumbers in the area serviced by the Horticulture Substation, Smithfield, is relatively new and general information on soil management is urgent. In other areas warm soils, well supplied with organic matter and retentive of moisture, are needed for this crop. Where irrigation is not practiced or possible, mulching has given good results. In the Smithfield area the soils are generally light and not too well supplied with organic matter. Precipitation during the growing period is unevenly distributed, and unless special management practices are followed soil moisture may constitute a grave limiting factor for high production.

Three methods of management were compared on an area that had received a broadcast application of 5-10-13 at 800 pounds per acre and manure at 20 tons per acre. The three treatments applied to the area were:

(1) Control—no further treatment;

(2) Manure in furrow—well-rotted manure to a depth of 2 inches at the bottom of the plant furrow and covered with soil before planting, and

(3) Straw mulch—a 3-inch layer of straw applied when the plants were established.

The results of the trials over a three-year period indicated that either manure in the furrow or a straw mulch resulted in a significantly higher yield and more valuable crop than the control treatment. The yield on the plot receiving manure in the furrow was consistently higher than that on the mulched plot but the difference was not significant. The mean yields and dollar values were as given in Table G-3.

TABLE G-3.—YIELD AND VALUE OF PICKLING CUCUMBERS UNDER DIFFERENT SYSTEMS OF MANAGEMENT

| Treatment | Yield | Value |
|---|---|---|
| | t./ac. | $/ac. |
| Control | 14·8 | 806 |
| Manure in furrow | 18·5 | 973 |
| Straw mulch | 18·0 | 939 |

With either straw mulch or manure in the furrow the available soil moisture did not drop below 50 per cent throughout the growing period, while on the control plot the available moisture was below this critical level from mid-July until

mid-August. Soil temperature records indicated, however, that the benefit of better moisture relationships in the mulched plot was partially counteracted by the 3 to 5°F. lower soil temperature 6 inches under the mulch. It is possible that this lower temperature is responsible for the lower yields in the straw mulched plot relative to the plot receiving manure in the plant furrow.

## Cold Storage

*W. R. Phillips*

The storage unit at Smithfield, five storage chambers and space for grading and ripening, was first used for the 1950 harvest. The unit utilizes various types of insulation as corkboard, fiber-board and fiber glass for a long-term test. Casual observations on room operation indicate that all are satisfactory. Condensate has been noted on the storage wall surface of the most exposed part of the building. This is not necessarily an indication of low insulating value. More exhaustive examinations will be made on dampness and other forms of deterioration.

All storage rooms are cooled with floor mounted blower coil units with electric defrost elements. The fan-motors are multiple speed. The type of unit installed not only provides uniform temperature distribution throughout the storage room but can also deliver high air velocities for initial cooling and slower air movements for holding.

The short water supply necessitated the use of an air-cooled condenser and air-cooled compressor units. This has had high demonstration value to many storage units lacking an adequate water supply.

During the first year's operation, a demonstration experiment using McIntosh apples was conducted. Three maturities of McIntosh apples grown in the same orchard were stored in one room at 32°F. Duplicates were stored in a local commercial warehouse having a good apple storage record.

Members of the taste panel, local residents connected with apple production and marketing, could not distinguish between samples removed from storage January 21. On March 3, however, samples stored at the Substation storage rated 53 per cent in quality compared with 45 per cent in the commercial plant. Samples stored at the Substation also suffered less from storage disorders as follows:

| *Storage* | *% Core Flush* | *% Breakdown* |
|---|---|---|
| Commercial | 89.0 | 26.0 |
| Substation | 55.0 | 6.0 |

In the light of subsequent studies in handling and temperature control, these data indicate that storage temperatures were higher and the fruit was handled more roughly in the commercial storage.

Relationship between maturity and quality was interesting. Apples harvested early rated 51 per cent; at the peak, 59 per cent, and at the end of the season, 53 per cent, thus stressing importance of harvesting at the correct stage for high storage quality.

The following three years were devoted to Spy storage. Cooling rates were established and efficiency of operation of the storage unit measured. The largest room holding slightly over 1,000 bushels was used for this purpose.

### *Precooling*

Six hundred bushels in orchard boxes were loaded at one time to create a reasonably heavy refrigeration load. Thermocouples were placed in the centers of apples located in five different positions throughout the whole load. Four of

the leads were located in the center of the box, and one was located in an exposed apple. Thus in all except one instance the points selected were those most likely to be slow in cooling.

The initial apple temperature was near 65°F. The fastest cooling rate in the room was at the end farthest removed from the blower coil and the slowest was, as expected, at the center of the stack. The time required to reduce the temperature from 65 to 40°F. in relation to room location was as follows:

| | |
|---|---|
| Farthest from blower coil | 30 hours |
| Near blower coil | 69 hours |
| Center of the stack | 87 hours |
| Exposed apples on top (various parts of room) | 6 hours |

The six-hour cooling rate represents a very small proportion of the apples and, therefore, holds no particular significance. What is striking, however, is the comparatively long time required to reduce the temperature at the point slowest to cool—87 hours at the center of the stack.

Contributing factors in the slow cooling rate may be:

(1) Too close stacking;

(2) Not sufficient clearance at ceiling, and

(3) Icing-up of cooling coils because of high evaporation rate from apples.

The following year, these conditions were corrected by increasing the space from 3½ to 5½ inches between every second tier of boxes (this space, of course, ran parallel to air flow both years). A space equal to the depth of one box was left between top of the stack and ceiling. The special feature, however, was operating the cooling coils at temperatures above freezing to avoid heavy frost accumulation during the precooling stage.

In previous studies of cooling rates, the rate of apple cooling increased markedly as the ambient temperature was decreased. However, after the ambient temperature had reached a point 10 degrees lower than the apples, only a relatively small increase in cooling rate was obtained for a corresponding decrease in temperature. Therefore, the room temperature was adjusted downwards as the fruit cooled, so that a 10-degree differential could be maintained between the storage room air and the mean fruit temperature throughout the cooling period. As a result, the rate of cooling (65 to 40°F.) was reduced from 87 to 24 hours by using the higher ambient temperature. It is assumed that the increased cooling rate was effected mostly through decreased condensation on the cooling coils resulting in more effective heat transfer.

***Condensate Reductions***

A suction pressure regulator was used to control cooling surface temperatures in tests to observe moisture condensation ratio. The cycle was a two-week period, running alternately at approximately 5 degrees and 15 degrees below room temperature.

The results were as expected. The low temperature differential (5 degrees below room temperature) resulted in a proportionally longer running time. The important feature was that, in spite of this, the total condensate was reduced. Thus, operating at the higher evaporation temperature should conserve moisture loss from the fruit.

## Vegetable Trials and Experiments

*W. Ferguson, L. H. Lyall and J. J. Jasmin*

Research in vegetable crops at the Smithfield Substation is largely devoted to canning crops which constitute a major industry in eastern Ontario. The staff of the Vegetable Section of the Horticulture Division carry on this work at Smithfield.

In the considerable plant breeding for the development of better canning varieties the early or ground work for each new variety is done at Ottawa, but the selection from the various and numerous lots of breeding material is done at Smithfield.

A good deal of the other work with vegetables is handled in similar fashion. For more complete information reference should be made to the Vegetable Crops section of the 1949-53 Report.

### *Corn*

Sweet corn trials are conducted at Smithfield in order to assess at least a few of the many hybrid varieties now in the seed trade on their possible value to growers for processing in eastern Ontario. Observation trials are first conducted and the better varieties are selected for inclusion in the advanced trials. Results have been unreliable in three of the five years covered by this report. Poor soil conditions in 1950 and damage by wildlife in 1952 and 1953 prevented accurate recording of data and for these reasons the results given in Table G-4 are for 1949 and 1951 only.

TABLE G-4.—YIELD IN TONS PER ACRE OF UNHUSKED EARS OF NINE VARIETIES OF SWEET CORN

| Variety | 1949 | | 1951 | |
|---|---|---|---|---|
| | Harvest date | Yield | Harvest date | Yield |
| Golden Cross Bantam | Aug. 20 | 4·38 | Sept. 6 | 6·88 |
| Golden Bounty | Aug. 20 | 3·90 | ..... | ..... |
| Early Tendermost | Aug. 20 | 3·80 | ..... | ..... |
| Ottawa CH-1 | Aug. 12 | 3·64 | ..... | ..... |
| Sugar Prince | Aug. 15 | 2·88 | ..... | ..... |
| Seneca Arrow | ..... | ..... | Aug. 31 | 8·94 |
| Golden Hybrid 2439 | ..... | ..... | Sept. 14 | 8·30 |
| Golden Crown | ..... | ..... | Sept. 6 | 8·20 |
| Iochief | ..... | ..... | Sept. 14 | 8·06 |
| L.S.D. (P=·05) | ..... | ·59 | ..... | ·64 |

Golden Cross Bantam and Golden Hybrid 2439 are standard canning varieties in the Smithfield area, and on the basis of the two years' trial no changes can be recommended. Seneca Arrow is a productive variety with good quality but lacks the kernel depth of the two standard hybrids.

### *Cucumber*

*Variety Trial.*—With the establishment of a cucumber pickling factory in the Smithfield area in 1951 it was considered advisable to undertake variety testing and cultural experiments with this crop.

An observation trial of 18 varieties, the majority of which were pickling types, was carried on in 1951. One 50-foot row of each variety was planted with rows 5 feet apart and 18 inches between plants in the row. The cucumbers were

harvested at three-day intervals throughout the season and separated into pickling grades. Table G-5 shows the yields obtained and the comparative cash values. Since this was simply a preliminary trial with no replications, no attempt has been made to convert the data to an acreage basis.

TABLE G-5.—YIELD AND APPROXIMATE VALUE OF PICKLING GRADE CUCUMBERS, SMITHFIELD, 1951

| Variety | Yield in pounds per plant according to fruit diameter | | | | | Approximate value in cents per plant |
|---|---|---|---|---|---|---|
| | 1⅛-in. | 1⅜-in. | 1½-in. | Large | Total | |
| Sensation Hybrid[1] | 1·22 | 1·85 | 2·70 | 2·19 | 7·96 | 25·56 |
| Hybrid 5A[1] | 0·89 | 1·16 | 1·93 | 2·48 | 6·46 | 18·66 |
| Burpee Hybrid[1] | 0·78 | 1·18 | 2·10 | 2·03 | 6·08 | 17·99 |
| Double Yield | 0·84 | 1·35 | 1·70 | 1·81 | 5·70 | 17·77 |
| Delcrow[1] | 1·16 | 1·01 | 1·13 | 1·05 | 4·35 | 16·32 |
| Mincu | 0·68 | 1·21 | 1·91 | 1·36 | 5·15 | 16·23 |
| Boston Pickling | 0·81 | 1·04 | 1·66 | 1·70 | 5·20 | 16·10 |
| Surecrop Hybrid[1] | 0·69 | 1·09 | 1·69 | 2·16 | 5·63 | 16·00 |
| Chicago Pickling | 0·81 | 1·17 | 1·36 | 1·50 | 4·84 | 15·59 |
| National Pickling | 0·70 | 0·98 | 1·76 | 1·88 | 5·31 | 15·54 |
| Pickler | 0·62 | 0·99 | 1·64 | 2·03 | 5·28 | 14·84 |
| Quick Grow | 0·59 | 1·03 | 1·63 | 2·06 | 5·31 | 14·79 |
| Ohio MR17 | 0·56 | 1·10 | 1·68 | 1·70 | 5·03 | 14·64 |
| York State | 0·56 | 0·92 | 1·59 | 2·45 | 5·52 | 14·42 |
| Producer | 0·59 | 0·92 | 1·79 | 1·41 | 4·70 | 14·14 |
| Model | 0·46 | 0·84 | 1·71 | 1·90 | 4·91 | 13·18 |
| Snow Pickling | 0·62 | 0·82 | 1·28 | 1·68 | 4·40 | 12·82 |
| Shamrock[1] | 0·42 | 0·75 | 1·36 | 1·40 | 3·94 | 11·15 |

[1]Standard slicing varieties grown for comparison with the picklers.

The most noteworthy point in this trial was the performance of the hybrid slicing varieties, especially Sensation Hybrid, which produced a very heavy yield of pickling grade cucumbers. These are longer than fruits of pickling varieties of the same thickness and may not necessarily have the other characteristics required of a good pickling variety.

*Spacing Trial.*—In addition to the variety observation trial in 1951, a trial was conducted to determine the optimum number of plants per hill. Plots were 5 by 20 feet with hills 18 inches apart in the row; six replications. The results shown in Table G-6 indicated that for the conditions of this experiment three plants per hill gave the heaviest yields of all grades of pickling cucumbers.

TABLE G-6.—COMPARISON OF YIELDS PRODUCED BY VARYING NUMBERS OF PLANTS PER HILL

| Number of plants per hill | Total yields of cucumbers in pounds for 6 rows according to fruit diam. | | | | | Approximate value in dollars |
|---|---|---|---|---|---|---|
| | 1⅛-in. | 1⅜-in. | 1½-in. | Large | Total | |
| 1 | 61·1 | 78·8 | 109·1 | 159·8 | 408·8 | 12·02 |
| 2 | 61·7 | 98·0 | 139·1 | 190·0 | 488·8 | 13·96 |
| 3 | 70·1 | 105·0 | 156·3 | 234·7 | 566·1 | 15·75 |
| 4 | 56·9 | 91·8 | 152·6 | 197·0 | 498·2 | 13·81 |

***Peas***

*Variety Trials.*—These trials at the Smithfield Substation are designed to give comparative tests of pea varieties when grown as canning crops in the area. In observation trials at Ottawa and Smithfield new introductions are

collected and compared with standard varieties. From these trials the more promising varieties are selected for the advanced trials at Smithfield. Each variety plot consists of approximately one one-hundredth of an acre, and is replicated five times. The peas are sown as for a canning crop and are harvested at the optimum time for canning (as indicated by texture-meter readings).

The advanced trials have been conducted at Smithfield since 1947, and the results shown in Table G-7 include the figures from that date.

Among the early maturing types Alton, a variety originated by this Division, has, in five years of yield testing, consistently outyielded Thomas Laxton, a standard variety of similar type. Both are high quality, medium-large seeded varieties different in type from Alaska and Wisconsin Early Sweet. Loyalty, although tested for only one year, appears very promising. It is a heavy yielder, only two or three days later than Alton and is of good quality for canning. Wasatch is early and heavy yielding but is pale in color and lacks sweetness.

TABLE G-7.—YIELD IN POUNDS PER ACRE OF TWELVE VARIETIES OF SHELLED GREEN CANNING PEAS, SMITHFIELD, 1947-53

| Variety | Number of years tested | Average for years tested | 1953 |
|---|---|---|---|
| Loyalty | 1 | 5,964 | 5,964 |
| New Era | 2 | 5,106 | 5,599 |
| Pride | 3 | 5,032 | 5,775 |
| Wasatch | 3 | 4,884 | 4,565 |
| Ottawa PE-11 | 3 | 4,424 | 5,369 |
| Alaska | 1 | 4,160 | ..... |
| Perfection, Wilt Resistant | 1 | 4,112 | ..... |
| Early Sweet No. 103 | 1 | 4,095 | ..... |
| Alton | 5 | 3,704 | ..... |
| Thomas Laxton | 3 | 3,676 | ..... |
| Prince of Wales | 2 | 2,948 | ..... |
| Wisconsin Early Sweet | 3 | 2,686 | ..... |
| L.S.D. (P=·05) | ..... | ..... | 1,487 |

New Era, a new variety from the University of Wisconsin, Madison, Wis., U.S.A., is a heavy yielding variety of the Early Perfection type. Although resistant to Fusarium wilt and near-wilt, this lacks color and flavor. Pride is a standard variety maturing about the same time as Loyalty and equal in quality. Ottawa PE-11 is heavy yielding and shows considerable resistance to root rots. It resembles Perfection but is generally a heavier yielder under Smithfield conditions.

*Spacing Experiments.*—Peas grown for commercial canning are usually sown with a grain drill in rows 7 to 8 inches apart with the seeds approximately 2 inches apart in the row. Since many of the varieties now grown for processing have a vigorous branching habit, the canning companies have been doubtful whether the standard spacing should be recommended for widely different varieties grown in different parts of the country.

With the objective of determining the optimum planting distances for some of the standard canning varieties used in eastern Ontario, a pea spacing experiment was conducted at the Smithfield Substation in 1952 and 1953 on three standard canning varieties:

Wisconsin Early Sweet—early, small vine.
Pride—midseason, vigorous, bushy vine.
Alderman—late, medium height, heavy foliage.

These were all sown at several different spacings in plots 12 by 12 feet with four replications of each spacing treatment.

*Variable spacing between and within rows.*—The differences between the three spacing treatments in 1952 were not large (Table G-8), but all three varieties showed the same trend towards lower production of shelled peas at the wider spacings. In 1953 a fourth treatment (2 by 16 inches) was added, and this (Table G-8) produced further evidence of the lowered yields resulting from wide planting. The general trend was similar to that shown in 1952, except that the 2- by 8-inch spacing gave slightly heavier yields than the 4- by 4-inch spacing. In both seasons soil compaction and drought injury was greater with the wider spacings than with the closer plantings where the plants themselves shaded the ground and prevented excessive drying of the surface soil.

TABLE G-8.—PEA SPACING EXPERIMENT. I—VARIABLE SPACING BETWEEN AND WITHIN ROWS—YIELDS OF SHELLED GREEN PEAS

| Variety and spacing (inches) | Pounds of shelled peas per acre | |
|---|---|---|
| | 1952 | 1953 |
| WISCONSIN EARLY SWEET— | | |
| 4 by 4 | 4,161 | 2,783 |
| 2 by 8 | 3,383 | 3,025 |
| 1 by 16 | 3,072 | 2,118 |
| 2 by 16 | ..... | 1,815 |
| L.S.D. (P=·05) | Differences not significant | 787 |
| PRIDE— | | |
| 4 by 4 | 6,184 | 4,235 |
| 2 by 8 | 5,250 | 4,265 |
| 1 by 16 | 4,628 | 3,816 |
| 2 by 16 | ..... | 3,025 |
| L.S.D. (P=·05) | 1,182 | 484 |
| ALDERMAN— | | |
| 4 by 4 | 3,539 | 3,055 |
| 2 by 8 | 3,111 | 3,146 |
| 1 by 16 | 2,412 | 2,844 |
| 2 by 16 | ..... | 2,118 |
| L.S.D. (P=·05) | 470 | 605 |

*Variable spacing between rows.*—Plants were all 2 inches apart in the row; basic spacing between rows, 7 inches; but in this section of the experiment the following spacings were used:

1. All rows 7 inches apart.
2. All rows 14 inches apart.
3. Two rows at 7 inches, then 1 row omitted (14-inch space).
4. Two rows at 7 inches, then 2 rows omitted (21-inch space).
5. Three rows at 7 inches, then 2 rows omitted (21-inch space).

This spacing trial was conducted in 1952 only, and the results (Table G-9) are on Wisconsin Early Sweet and Pride. Both varieties gave significantly greater yields of shelled green peas from the 7-inch or "normal" row spacing than from all other treatments. The next best spacing was that in treatment 3 where two rows were planted 7 inches apart and the next omitted. Wider spacing gave considerably lower yields, probably due to both the smaller plant population and to the fact that with wide spacings between rows pod-loaded

plants tended to lie on the ground. As in the preceding spacing trial there was again evidence of more rapid drying out of the surface soil in the plots with widely spaced rows.

TABLE G-9.—PEA SPACING EXPERIMENT. II—VARIABLE SPACING BETWEEN ROWS; PLANTS ALL TWO INCHES APART IN THE ROW; SEVEN-INCH BASIC SPACING BETWEEN ROWS—YIELDS OF SHELLED GREEN PEAS, 1952

| Spacing treatment | *Pounds of shelled green peas per acre* | |
|---|---|---|
| | Wisconsin Early Sweet | Pride |
| 1. 7 inches between rows | 4,158 | 4,477 |
| 2. 14 inches between rows | 3,206 | 3,328 |
| 3. 2 at 7 inches, 1 omitted | 3,570 | 4,235 |
| 4. 2 at 7 inches, 2 omitted | 3,025 | 3,509 |
| 5. 3 at 7 inches, 2 omitted | 3,146 | 3,328 |
| L.S.D. (P=·05) | 666 | 920 |

On the basis of these results under the conditions encountered at the Smithfield Substation, there is no evidence that any changes from the normal planting distance for processing peas should be recommended to the growers in eastern Ontario.

***Tomato***

*Variety Trials.*—In the tomato variety trials at Smithfield new varieties are grown first in observation trials, from which the most promising are selected and tested in the advanced trial. This is a replicated trial grown under conditions similar to those found in the Smithfield area. Yields are recorded with the marketable fruits classified as Canada Grades 1 and 2. Each variety plot consists of 20 plants and is replicated six times; rows are six feet apart and plants three feet apart in the row. This trial was not conducted in 1953 but the results from 1948-52 are summarized in Table G-10.

TABLE G-10.—YIELD IN TONS PER ACRE OF CANADA GRADES 1 AND 2 TOMATOES, SMITHFIELD, 1948-52

| Variety | Number of years tested | First two weeks | | Season | |
|---|---|---|---|---|---|
| | | Average for years tested | 1952 | Average for years tested | 1952 |
| Ottawa TO-9 | 1 | 2·71 | ..... | 26·7 | ..... |
| Jefferson | 1 | 0·61 | ..... | 23·5 | ..... |
| Geneva No. 7 | 3 | 1·25 | 0·75 | 22·3 | 18·5 |
| Fortune | 1 | 0·71 | ..... | 22·6 | ..... |
| Ottawa TO-17 | 3 | 1·03 | 0·12 | 22·1 | 21·9 |
| Ontario | 2 | 0·81 | ..... | 20·4 | ..... |
| Ottawa TO-14 | 1 | 0·62 | 0·62 | 19·3 | 19·3 |
| Red Jacket | 3 | 1·42 | ..... | 18·4 | ..... |
| Geneva John Baer | 5 | 1·12 | 0·62 | 18·3 | 23·1 |
| Rutgers × Pritchard $F_2$ | 1 | 0·06 | 0·06 | 17·2 | 17·2 |
| Ottawa TO-4 | 5 | 1·09 | 0·39 | 16·7 | 16·6 |
| Early Geneva No. 6 | 1 | 0·70 | ..... | 16·4 | ..... |
| Gem | 3 | 1·30 | ..... | 16·4 | ..... |
| Early Garden State | 1 | 0·10 | 0·10 | 15·7 | 15·7 |
| Early Jersey | 1 | 1·81 | ..... | 15·1 | ..... |
| Longred | 3 | 0·68 | 0·06 | 14·9 | 17·8 |
| Scarlet Dawn | 2 | 0·99 | 0·38 | 14·6 | 17·8 |
| Early Rutgers | 1 | 0·05 | ..... | 14·3 | ..... |
| Wisconsin 55 | 2 | 1·25 | ..... | 13·8 | ..... |
| Keystone 40-46 | 1 | 0·35 | ..... | 13·2 | ..... |
| Clark's Early | 1 | 0·47 | ..... | 11·8 | ..... |
| Bonny Best | 1 | 0·32 | ..... | 11·1 | ..... |
| L.S.D. (P=·05) | ..... | ..... | 0·21 | ..... | 3·72 |

Although earliness is not the main consideration in selecting varieties for canning in eastern Ontario, it is of considerable importance. To be of value a variety should mature in about the same season as Geneva John Baer, the standard variety in the area. Several varieties listed in Table G-10, although giving a heavy seasonal yield in one or two years of testing, are not consistently early enough for the Smithfield area. Early Garden State, Early Rutgers, Fortune, Jefferson, Keystone 40-46, Longred, Ontario, Rutgers × Pritchard $F_2$ and Wisconsin 55 are in this category. Several other varieties, although early enough, have faults such as small fruit size, cracking, rough fruit, yellow ends, and poor flesh color. Because of one or more of these faults Bonny Best, Clark's Early, Early Geneva No. 6, Gem, Geneva No. 7, Ottawa TO-4, Ottawa TO-9, Ottawa TO-14 and Scarlet Dawn cannot be regarded as good canning varieties. The widely used Geneva John Baer has good fruit size and good red flesh color, but the plant is rather sprawling, and the fruits crack badly in some seasons. Red Jacket is productive but has rather pale flesh color and is subject to various defoliating diseases. Ottawa TO-17 is very promising because of its heavy yield, smooth, large fruits, and good foliage cover. In flesh color, however, it is not so good as Geneva John Baer.

*Comparison of Plants Started by Different Methods.*—In 1949 a preliminary study was made on the influence of different methods of starting tomato plants on the yield of marketable fruit. The five treatments used were:

1. Seed sown April 5 in soil in the greenhouse; plants grown in soil in greenhouse flats, moved to hotbeds on May 1 and set out in the field on May 31.
2. Handled as in treatment 1, except that the plants were grown in vermiculite instead of soil, and fed with a solution of 8-24-8 fertilizer.
3. Seed sown in soil in a hotbed on April 5 in rows 4 inches apart, and thinned on April 23 to 2 inches between plants in the row; set out in the field on May 31.
4. Seed sown in soil in a cold frame on April 23 in rows 4 inches apart, and thinned on May 9 to 2 inches between plants in the row; set out in the field on May 31.
5. Seed sown directly in the field on May 17 and covered with "hotcaps" (waxed paper protectors). Four or five seeds were sown at each "hill" and the plants were later thinned to one per hill. Final spacing of plants was 4 by 4 feet.

The influence of these treatments is demonstrated in Table G-11.

TABLE G-11.—MARKETABLE YIELD OF TOMATOES IN TONS PER ACRE FROM FIVE METHODS OF STARTING PLANTS, SMITHFIELD, 1949

| Methods | First two weeks | Season |
|---|---|---|
| 1. Grown in flats (soil) | 1·9 | 14·8 |
| 2. Grown in flats (vermiculite) | 1·3 | 12·7 |
| 3. Sown in hotbed | 2·4 | 15·6 |
| 4. Sown in coldframe | 1·4 | 12·5 |
| 5. Sown in field (hotcaps) | ..... | 7·1 |

Although based on only one year's results it was apparent that the best plants and the heaviest marketable yields were obtained from the plants grown by treatment 3, the method most commonly employed by Ontario growers. These plants were healthier, with better root growth, and generally in better condition for transplanting to the field than were those from the other treatments.

*Use of Hormones to Induce Fruit-setting.*—The use of various growth promoting substances to induce fruit-setting in tomatoes has become fairly widespread. Results have been quite variable depending mainly on tomato plant location and temperature conditions at the time of application. At Smithfield in 1949 in an observation trial the variety Geneva John Baer was divided into four plots of 25 plants each. The four treatments consisted of A-900 at 20 p.p.m. and 60 p.p.m.; Sure Set at 30 p.p.m. and an untreated control. A-900 was sprayed on the entire plant; Sure Set was sprayed on the flower clusters only. Sprays were applied on July 6 and 15. The yields in pounds per plot were as follows:

| | Plot 1<br>A-900<br>20 p.p.m. | Plot 2<br>A-900<br>60 p.p.m. | Plot 3<br>Sure Set<br>30 p.p.m. | Plot 4<br><br>Control |
|---|---|---|---|---|
| Marketable yield to Aug. 15 | 38.9 | 38.2 | 33.1 | 25.2 |
| Marketable yield for season | 283.8 | 154.3 | 239.0 | 318.2 |

The increases in early yield, particularly in plots 1 and 2, were quite marked. In commercial production this would be an important consideration and the increased crop value might be sufficient to compensate for a possible reduction in total yield. This would be especially true of tomatoes grown for the fresh market, although not of likely value in production for canning.

***Chemical Weed Control***

Research in recent years has led to one of the most spectacular advances in modern agriculture, the chemical control of numerous weeds in a wide range of crops. Horticultural crops have been no exception. In fact, the high acre value and frequent high production costs make horticulture a major field of investigation for weed control.

Extensive weed control experiments are carried on in the Horticulture Division at Ottawa. Some of the investigations are also conducted at the Smithfield Substation. Since the work at both places is closely integrated the results are published in one article in the Vegetable Crops section of the 1949-53 Report.

# DOMINION EXPERIMENTAL SUBSTATION FOR MUCKLANDS, STE. CLOTHILDE, QUE.

*F. S. Browne*

The Substation was established in 1936 for the purpose of conducting research and experimental work on organic soils. It comprises 80 acres situated in an area of 17,000 acres of high grade organic soil and within 30 miles of other areas with a total of 34,000 acres of the same soil type. All the 51,000 acres are within 50 miles of Montreal and a number of smaller cities and large towns.

Most of the surface soil on these areas to a depth of 8 inches to 2 feet originated from grass and sedge, now in an advanced stage of decomposition. Underlying this is a deposit of forest debris only slightly decomposed, loose and open in structure, and usually about 2 feet in depth. Below the forest debris is a jelly layer composed of aquatic muck formed from both salt and fresh water flora. The jelly layer overlies marl.

The surface layer is usually mildly acid and well-suited to the growing of practically all vegetables. The forest debris layer where it originated from hardwood such as maple and elm is neutral to mildly alkaline in reaction. Where the original cover was spruce, balsam or pine, the pH value is often 4·5 or lower. The aquatic or jelly layer is highly alkaline largely because it contains great quantities of shells from various species of Crustacea and Mollusca. Almost the entire acreage of organic soil in the region borders streams. These streams have now been deepened and drainage of areas for cultivation can be easily effected.

## Potato Variety Trials

Although large crops of high quality potatoes can be grown consistently on the organic soils of southwestern Quebec, none of the generally grown commercial varieties are so well suited to the particular conditions of this area as to conditions prevalent on mineral soils. A crop grown on organic soil with its high nitrogen content together with ample moisture tends to lack maturity and contains a high percentage of rough potatoes. Also, with the very heavy top growth normally produced on this soil type, control of late blight is often extremely difficult.

With the introduction of the blight-resistant varieties late blight ceased to be a factor for a few years. Most of this group of varieties produced potatoes of high quality with other desirable characters. However, after a few years new strains of blight developed to which the hitherto blight-resistant varieties have no resistance. As a result it is now as difficult to control late blight in so-called blight-resistant varieties as it is in other varieties.

Of over 500 varieties and seedlings grown at Ste. Clothilde in the last five years none are now immune to late blight and only a very few have slight resistance. However, among this lot a few have otherwise desirable characters that in part meet the requirements for organic soils in the region. Keswick, the most promising variety, is inclined to produce rather large rough potatoes, but the quality is high, the yield good, and it is sufficiently early to mature satisfactorily in the average season. Kennebec, a variety originated in the United States, is very productive, and yields potatoes of good quality that are relatively smooth, but inclined to be large. However, it matures late and

only with very early planting or favorable seasons will the tubers reach a desirable maturity. Fairly satisfactory crops have also been obtained with Netted Gem. This too is a late variety, but the russet-skinned tubers are excellent in quality. Netted Gem requires an even, continuous supply of moisture and relatively high soil fertility.

A few of the numbered seedlings not yet commercially available are quite promising and may prove superior to the varieties now grown on organic soils.

***Effect of Vine Killing***

The practice of killing potato vines to hasten maturity before the tops die normally or are killed by frost is now quite general. On the organic soils of southwestern Quebec where potato tops grow very large, vine killing has the additional desirable feature of helping to get rid of the tops which can be a great nuisance when digging the crop. Also, if material with fungicidal value such as copper sulphate or the dinitro herbicides are used, the vine-killing application will control late blight that might otherwise infect the tubers.

In opposition to these definite advantages premature killing of potato vines will normally reduce crop yield. To obtain definite information on this subject an experiment was conducted in 1952-53 with Green Mountain. Vines were killed on three different dates and a fourth area was left until vines were killed by frost. The experiment was conducted in quadruplicate with results as shown in Table H-1.

TABLE H-1.—EFFECT OF VINE KILLING ON YIELD OF GREEN MOUNTAIN POTATOES, AVERAGE RESULTS, 1952 AND 1953

| Date treated | Date dug | Yield in bushels per acre | | | | |
|---|---|---|---|---|---|---|
| | | Small | No. 2 | No. 1 | Large | Total |
| Aug. 11 | Aug. 28 | 47·2 | 57·6 | 98·3 | 0·0 | 203·1 |
| Aug. 21 | Sept. 6 | 26·0 | 103·2 | 149·7 | 9·8 | 288·7 |
| Sept. 2 | Sept. 12 | 27·2 | 106·0 | 208·5 | 36·1 | 351·5 |
| Control | Sept. 22 | 8·7 | 103·1 | 311·6 | 48·7 | 472·1 |
| L.S.D. (P = ·05) | | | | | | 43·9 |

Table H-1 shows that under the conditions of this experiment killing potato vines before the crop reached nearly normal maturity resulted in a loss of both marketable and total yield. This decrease was related directly to time of vine killing prior to maturity. Although the total yield of small and No. 2 potatoes increased with delayed vine killing until potatoes reached maturity, the yield of No. 1 grade rose consistently as the date of the vine killing was delayed. Oversized or large potatoes also increased with maturity but large potatoes in the control plots were only 13 per cent of the total crop. Therefore, premature killing of potato vines may substantially reduce yields and monetary returns. However, vines of late varieties grown on organic soil seldom mature before frost occurs, and vine killing is usually necessary to hasten maturity and prevent the spread of late blight. Vine killing late in the season will not affect the yield seriously.

In 1953 dry-matter content of potatoes vine-killed August 11 was 17.2 per cent. Dry-matter content increased with each succeeding vine killing. The control, wherein the vines were killed by frost on September 24, had a dry-matter content of 22.6 per cent, the highest. Since cooking quality increases with dry-matter content, it is obvious that with late varieties early killing of potato vines will prevent the development of high quality in potato tubers.

## Hydro Cooling

*W. R. Phillips, F. S. Browne and P. A. Poapst*

***Celery***

Although this crop can be grown to perfection in many parts of Canada, Canadian celery is largely replaced on our markets by imported material soon after the end of the growing season. The reason is that the crop is difficult to store, and, with the storage facilities available in Canada, the storage life is short. As a result, much of the crop is rushed onto the market and sold at low prices, or, if held too long, breaks down in storage and so is wasted. One of the reasons for this early breakdown is the very slow cooling of celery when placed in ordinary cold storage. Also, since celery wilts and so becomes unmarketable as a result of a very small moisture loss, ordinary precooling methods which remove moisture are not satisfactory.

In previous studies of storage behavior of celery, conducted at the Horticulture Division, it was observed that wetting the celery before storage did not impair the keeping quality. With this fact established experiments were conducted on cooling in refrigerated water before storage to extend the storage life.

For this purpose a mechanically refrigerated precooler was built. The precooler consists of two insulated metal-lined tanks. The smaller tank (5 ft. by 2 ft. by 29 inches deep) has approximately 25 cubic feet capacity, holding about 125 gallons of water.

The water in this tank is cooled by refrigeration coils. The original design consisted of 24 lengths of ½-inch pipe carrying fins 3 by 3 inches, with ½-inch spacing, each length being 53 inches long.

Refrigeration of the pipes is effected by a 5 h.p. Freon condensing unit. Since this unit provides refrigeration for the storage room as well as the unit, it is well over capacity for the precooler alone. If the precooler is run independently, a 3 h.p. unit would be adequate for a tank of this size.

The refrigeration hook-up is standard in that two expansion valves are used (one for each bank of 12 lengths). The compressor control is pressure regulated. Dehydrators and the necessary fittings and valves are all standard equipment.

The larger tank is 7 ft. by 2 ft. by 31 inches deep. The size of the tank is determined by the size of the celery crates used, ample space being allowed for holding the necessary number of crates with sufficient depth for complete submergence.

Both tanks are similarly constructed, being sheathed on the outside with matched lumber. Corkboard was applied to the inner surface to a thickness of 4 inches in the smaller tank and 2 inches in the larger. Insulated covers were made to fit snugly on top of both tanks. The object of the covers is to conserve refrigeration during the cool-down period prior to precooling the celery.

The water is circulated by a centrifugal type pump with a capacity of 40 gallons per minute. The refrigerated water is drawn from the bottom of the smaller tank by means of a 1½-inch pipe extending the full length of the tank. This pipe has twelve ¼-inch holes spaced evenly throughout its length to ensure uniform draught throughout the length of the tank. The refrigerated water is sprayed into the larger tank by means of twenty-four $\frac{3}{16}$-inch openings distributed along a 2-inch pipe extending about two-thirds of the length of the tank and located 6 inches from the top. (Incidentally, this pipe assisted in keeping the celery crates submerged.) Twelve of the holes direct the water downwards, while the remainder (alternate holes) direct the water at a slight angle inwards. The water from this tank gains admittance to the refrigerated tank via two 5¾-inch-

square openings in the partition wall. Thus the water completes its circuit. These openings are covered with a heavy, fine mesh (about 40 mesh to the inch) copper screen. Under operation the screens collect leaves and other debris. By stopping the circulation momentarily, most of this debris floats to the surface and can be skimmed off. Sometimes the screens have to be scraped. Possibly some form of removable filter would be an improvement.

In general this precooler proved very satisfactory, although performance could be improved and construction cheapened by minor changes. The fin coils block with ice after a relatively short run and circulation is around rather than through the coil bank. This cuts down the rate of refrigeration. Ordinary piping spaced far enough apart to hold a good-sized ice bank and still permit circulation would probably be more efficient for commercial work.

Cooling rate measurements were made on five such crates of celery removed from storage during November, 1950, and warmed up to a temperature of over 50°F. These were placed in the precooler at 2-minute intervals.

At the beginning of the test the water temperature was 33.2°F. which increased to 34° by the time the last crate was placed in the tank and remained at this temperature throughout the test.

The method of determining all temperatures was by copper-constantan thermocouples. Some were placed in the hearts of celery in various positions in the crate. Four such thermocouples were used, one at either end, one at the side and one in the center of the crate. Constant records of the water temperature were made throughout the test. Temperature decline between the various positions in the crate differed only a fraction of a degree during the whole cooling phase.

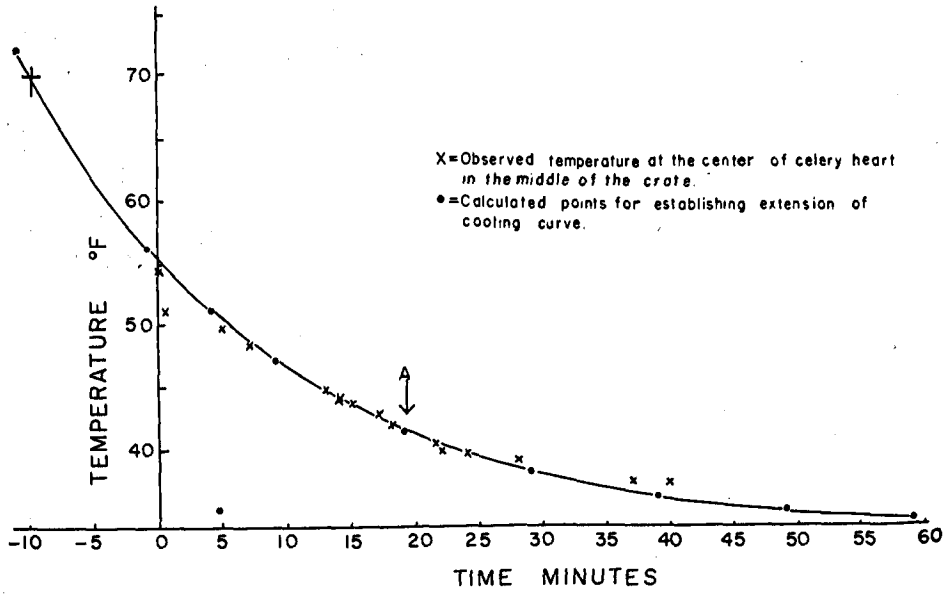


Fig. H-1—Cooling rate of celery immersed in flowing water at 34°F.

Fig. H-1 shows the temperatures of the center celery heart for a 40-minute period. As is normal, the cooling rate is more rapid at first and slows down as the celery approaches the water temperature.

From the temperatures found a mathematical relationship was established for the rate of cooling, and thus other points were established. A theoretical curve is shown extending to 20 minutes beyond the observed readings and for 10 minutes before the first reading. This gives the time and temperatures for 70 minutes covering a range of temperatures for 70°F. to 35°F. Previous and subsequent tests confirm this cooling trend.

It should be borne in mind that these temperatures represent the temperatures at the heart of the celery. At any position on the chart the leaves and smaller petioles will be at a lower temperature. As proof of this, heart temperature decreased 2 degrees after removal from the precooling tank, indicating a transfer of heat from the heart to external portions of the celery.

From a practical standpoint, the important feature is to leave the celery in the tank until point A on the curve is reached, for from this point on successively longer intervals are required to produce a proportional reduction in temperature. For example, the following suggested cooling times based on the initial temperature are calculated from Fig. H-1.

| *Initial heart temperature* °F. | *Time to reach point A* minutes |
|---|---|
| 70 | 29 |
| 65 | 26 |
| 60 | 23 |
| 55 | 19 |
| 50 | 14 |
| 45 | 6 |

During the 1950 harvest season (September 15 to 18) at Ste. Clothilde, several hundred crates of celery were precooled for twenty minutes and placed in storage. Several crates were also placed in storage without precooling. The storage room was refrigerated by direct-expansion, suspended, finned, coils. Pressure control valves were installed to maintain a close temperature differential between the coils and the air. During the season temperatures were controlled at 32°F. with humidities in excess of 90 per cent.

On November 21, 1950, observations were made on behavior of the celery. At this time all the precooled celery appeared to be in excellent condition. The non-precooled celery, although free of disorders, was generally more wilted with flaccid, rubbery stalks.

Three crates of Salt Lake variety of the precooled lot were selected at random. These compared with three crates of the same variety which were non-precooled, also selected at random. More detailed observations were made to evaluate more closely the precooling effects.

After determining the heart temperature, which ranged from 34° to 34.5°F. in all crates, the crates were unpacked and wastage was recorded. Wastages were made on a weight basis; heads were weighed, then trimmed and the heads re-weighed. In trimming all objectionable stalks were removed to produce a fresh attractive head, as practiced commercially.

Some petiole rots were present to the same extent in both lots, but these were not sufficient to affect celery marketability seriously. Therefore trimming wastage was mostly wilted stalks.

TABLE H-2.—WASTAGE IN STORED CELERY

| Treatment | Crate No. | Number of heads | Weight before trim | Weight of trim |
|---|---|---|---|---|
| | | | lb. | lb. |
| Precooled | 1 | 14 | 46·5 | 0 |
| | 2 | 15 | 46·5 | 0 |
| | 3 | 16 | 49·5 | 1·25 |
| Non-precooled | 1 | 16 | 37·0 | 8·12 |
| | 2 | 16 | 41·5 | 10·75 |
| | 3 | 15 | 42·5 | 14·50 |

Table H-2 shows that precooling was responsible for a large saving in trim. By calculation losses were 0.9 per cent for precooled and 27 per cent for non-precooled. It should be kept in mind that this does not represent a true loss in weight but gives an idea of saving in trimming wastage, for unfortunately the crates were not weighed when placed in storage. It is reasonable to assume that variations between crates would not exceed 4 pounds. Since the mean weight of the three precooled crates was 47.5 pounds and the non-precooled was 40.3 pounds then at least 3 pounds more of the harvested weight per crate were saved by precooling.

The most obvious possible deleterious effect of water precooling would be the development of rots. In the six years of work on various forms of water cooling no evidence suggesting increase in the amount of rot has been found. As a matter of fact, in earlier work, where conditions were not so well controlled, a reduction in rot wastage was found. Thus no evidence has suggested that water precooling either increases the development or the spread of disorders normally found in celery.

***Apples***

In 1951 the precooler was used in a cooling trial with Lobo apples. All the apples required for the trial were picked from one tree at normal picking maturity. Time from picking to placement in storage or beginning the run through the precooler was approximately one hour. Since the entire procedure was completed during the early part of the day at temperatures between 50 and 60°F., fruit temperature between picking and placement in storage did not increase. The temperature remained between 55 and 60°F. according to the position of the fruit on the tree; that is, whether on the sunny or shady side.

Four bushels of these apples were placed in storage at 32°F. and another four bushels were immersed in the precooler in rapidly circulating water at 33°F. Temperature changes in the apples were determined by copper-constantan thermocouples inserted in the cores of 3-inch apples. Four contacts were made in each bushel, one in an apple at each side of the crate and two in the center. The initial cooling rate was fast; thermocouple connections were down to 35°F. in 16 minutes. Although the water remained at 33°F., further drop in apple temperature was very slow. The crates were removed from the cooler at apple core temperatures of 35°F., and were placed in 32°F. storage. Core temperature dropped slowly to 34°F.

Non-precooled apples held at 32°F. air temperature required eleven days for temperature to even out and core temperature to reach 34°F. Thereafter throughout the storage period core temperature of both lots changed very little. Center temperature gradually dropped to 33°F. where it remained practically constant.

On February 2, two bushels from each lot were removed to 45°F. for four days then examined. The precooled lot was still quite firm and crisp with the ground color still green and the flavor good. However, four apples were infected with fungal rot which apparently had started early in the storage period. With the non-precooled lot many apples were on the verge of breakdown and all were rather soft. The ground color was decidedly yellow and the flavor poor, indicating the end of storage life.

The remaining two bushels of precooled apples, held at 32°F., were examined on March 2. The apples were still in fair condition and could be marketed readily. Fungal rots had not increased.

A repeat trial with McIntosh apples was conducted in 1952. Again, the apples were picked from one tree on September 16.

In general the results were similar to those for Lobo apples in 1951. At harvest, core temperature was 64°F. Drop to 35°F. in the hydro precooler required 16 minutes. Both the precooled and non-precooled lots reached a constant core temperature of 34°F. in 14 days after placement in storage at 32°F.

When examined on February 4, 26 per cent of the apples in the precooled lot were at or beyond the end of their storage life and of this 9 per cent could be considered spoiled. With the non-precooled lot 36 per cent could be rejected, 7 per cent of which was definitely spoiled. However, in this lot core flush was under way in 27 per cent while with the precooled lot it was evident in only 13 per cent.

With both varieties quick hydro precooling can definitely increase the storage life of the fruit. The length of the increased storage period would vary with conditions. If apples were picked during cool, cloudy weather the core temperature would be correspondingly low and the benefit of quick precooling problematical. However, apples are usually picked with a core temperature of 55 to 65°F. At this temperature hydro precooling may extend the storage life of late varieties up to one month.

## Potassium and Phosphorus Accumulation in Organic Soil

*H. Hill and F. S. Browne*

In the virgin state most of the organic soils in Eastern Canada are deficient in potassium and phosphorus. Also, for the first few years of cropping this soil may require applications of potassium in excess of crop reqirements because much of it may be rendered unavailable by fixation. For these reasons, when a potassium-hungry crop such as celery is grown on newly-broken organic soil it is necessary to use midseason applications of potassium in addition to the initial application at the time of planting. This practice may be necessary for several years in order to build up potassium in the soil until fixation is no longer a problem. However, many growers have continued to apply the nutrient beyond this point and thus accumulation in the upper portion of the soil becomes harmful.

The first indication of this condition in organic soil in southwestern Quebec was in a field of celery in 1950 which exhibited unmistakable signs of magnesium deficiency. Since this soil had contained a relatively high supply of magnesium in the virgin state, and very liberal applications of potassium had been used for several years, it was thought that the apparent deficiency of magnesium had been caused by excessive potassium. Subsequently it was deter-

mined that exchangeable potassium in the soil was very high and magnesium in the plant tissue low. In order to secure definite information on this point an analysis of the deep muck soil was made from several locations on the Substation property where records had been kept of crop production and fertilizer application. An analysis of the soil in its virgin state had also been made.

In an area that had been previously cropped to onions for a period of 10 years and fertilized annually with a 2-12-10 fertilizer at 1200 pounds per acre, exchangeable potassium in the top soil amounted to 601 pounds per acre. Analysis at the beginning of the period showed a content of only 82 pounds of the exchangeable form of this element. At the same time the level of available phosphorus rose from 11 pounds per acre in the virgin soil to 100 pounds with 10 years of cropping.

In this area no response in yield of onions resulted from the application of fertilizer in 1951. Because of an attack of Fusarium rot which is a soil-borne disease it was necessary to use potatoes for subsequent studies.

Table H-3 indicates the fertilizer treatments, soil analyses in p.p.m. at the 0- to 6-inch and 6- to 12-inch depths, analyses in p.p.m. of the plant petioles extracted by 2 per cent acetic acid and crop yields in 1952.

TABLE H-3.—FERTILIZER TREATMENTS, SOIL AND PETIOLE ANALYSES AND YIELDS OF POTATOES, 1952

| Treatments lb./ac. | Phosphorus, Bray method | | Exchangeable K | | Petiole levels | | | Yield bu./ac. |
|---|---|---|---|---|---|---|---|---|
| | 0-6 in. | 6-12 in. | 0-6 in. | 6-12 in. | N | P | K | |
| 1. 24, N | 107 | 25 | 286 | ..... | 290 | 96 | 5,940 | 543 |
| 2. 96, $P_2O_5$ | 103 | 61 | 286 | 178 | 90 | 100 | 5,850 | 550 |
| 3. 192, $K_2O$ | 114 | 48 | 552 | 295 | 170 | 80 | 6,150 | 519 |
| 4. 24 N, 96 $P_2O_5$ | 98 | 103 | 540 | 565 | 160 | 152 | 5,190 | 543 |
| 5. 24 N, 192 $K_2O$ | 129 | 87 | 477 | 203 | 150 | 120 | 5,820 | 566 |
| 6. 96 $P_2O_5$, 192 $K_2O$ | 121 | 46 | 344 | 170 | 40 | 96 | 5,130 | 590 |
| 7. Control | 151 | 46 | 428 | 174 | 50 | 126 | 5,400 | 607 |
| 8. 24 N, 96 $P_2O_5$, 192 $K_2O$ | ..... | ..... | ..... | ..... | 180 | 132 | 5,550 | 532 |

The soil analyses show the relatively high concentrations of phosphorus and exchangeable potassium in the experimental area. The given determinations for phosphorus may be even lower than the actual, since later laboratory investigations revealed considerably higher values when the ratio of soil to extracting solution is 1 to 20 instead of 1 to 10, especially when high soil values exist. The yield from the unfertilized plot is equally as high as from any fertilizer treatment.

Plant analyses from all plots show that the levels of plant phosphorus and potassium are higher than necessary for maximum production.

As a result of this preliminary study, permanent plots were established in the same general area in the spring of 1953. Treatments 1 to 8 were the same as in 1952. The two treatments (in pounds per acre) added in 1953 were:

9. 24 N, 48 $P_2O_5$, 96 $K_2O$
10. 48 $P_2O_5$, 96 $K_2O$

Table H-4 gives the soil analyses in p.p.m. of each plot sampled at two levels in the fall of 1953 after the potato crop was harvested, plant analyses in p.p.m. and yields in bushels per acre.

TABLE H-4.—FERTILIZER TREATMENTS, SOIL AND PLANT ANALYSES IN P.P.M. AND POTATO YIELDS, 1953

| Treatment | Soil analyses | | | | | | Plant analyses | | | | | | Yield bu./ac. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Phosphorus, Bray method | | Exchangeable Potassium | | Total Nitrogen | | Solubles as fresh wt. | | | | | | |
| | | | | | | | Petioles | | | Leaf blades | | | |
| | 0-6" | 6-12" | 0-6" | 6-12" | 0-6" | 6-12" | N | P | K | N | P | K | |
| Virgin Soil.... | 15 | 8 | 199 | 82 | 2·52 | 2·56 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 1..... | 228 | 75 | 469 | 325 | 2·17 | 2·35 | 490 | 301 | 5,700 | 190 | 243 | 3,760 | 492 |
| 2..... | 360 | 155 | 274 | 235 | 2·00 | 2·11 | 250 | 338 | 6,200 | 150 | 301 | 3,900 | 424 |
| 3..... | 232 | 44 | 352 | 262 | 2·06 | 2·45 | 510 | 256 | 6,600 | 50 | 252 | 4,220 | 453 |
| 4..... | 325 | 47 | 207 | 176 | 2·10 | 2·45 | 130 | 306 | 7,000 | 130 | 254 | 4,100 | 450 |
| 5..... | 284 | 46 | 457 | 274 | 1·98 | 2·08 | 120 | 241 | 5,900 | 130 | 269 | 3,600 | 566 |
| 6..... | 354 | 44 | 309 | 160 | 2·03 | 2·47 | 130 | 256 | 5,900 | 120 | 259 | 3,740 | 522 |
| 7..... | 341 | 84 | 418 | 289 | 2·09 | 2·52 | 390 | 400 | 7,140 | 110 | 295 | 3,600 | 522 |
| 8..... | 413 | 113 | 485 | 231 | 2·03 | 2·23 | 270 | 315 | 5,580 | 120 | 296 | 3,480 | 529 |
| 9..... | 306 | 78 | 227 | 149 | 2·12 | 2·44 | 70 | 352 | 6,480 | 170 | 290 | 3,460 | 525 |
| 10..... | 198 | 32 | 145 | 74 | 2·09 | 2·49 | 50 | 381 | 5,800 | 50 | 320 | 2,560 | 395 |

The soil analyses show the relatively high concentrations of exchangeable potassium that have accumulated in the experimental area over a period of ten years. There is no apparent reduction in yield from the plot not receiving fertilizer even after the second crop year. The levels of potassium in the plants from all treatments are well beyond the critical level of 4000 p.p.m. associated with maximum yield.

It is apparent that the continued application of potassium at the rate necessary for virgin soil will result in a marked accumulation of that element. Preliminary analyses have also indicated that a similar condition of phosphorus may arise.

Periodical assessment of fertilizer requirements is therefore necessary, and the plot established in 1953 will be maintained in order to determine soil test values and plant content associated with maximum yield and quality. The no-fertilizer plot will serve especially to determine soil levels of phosphorus and potassium associated with decreasing yields.

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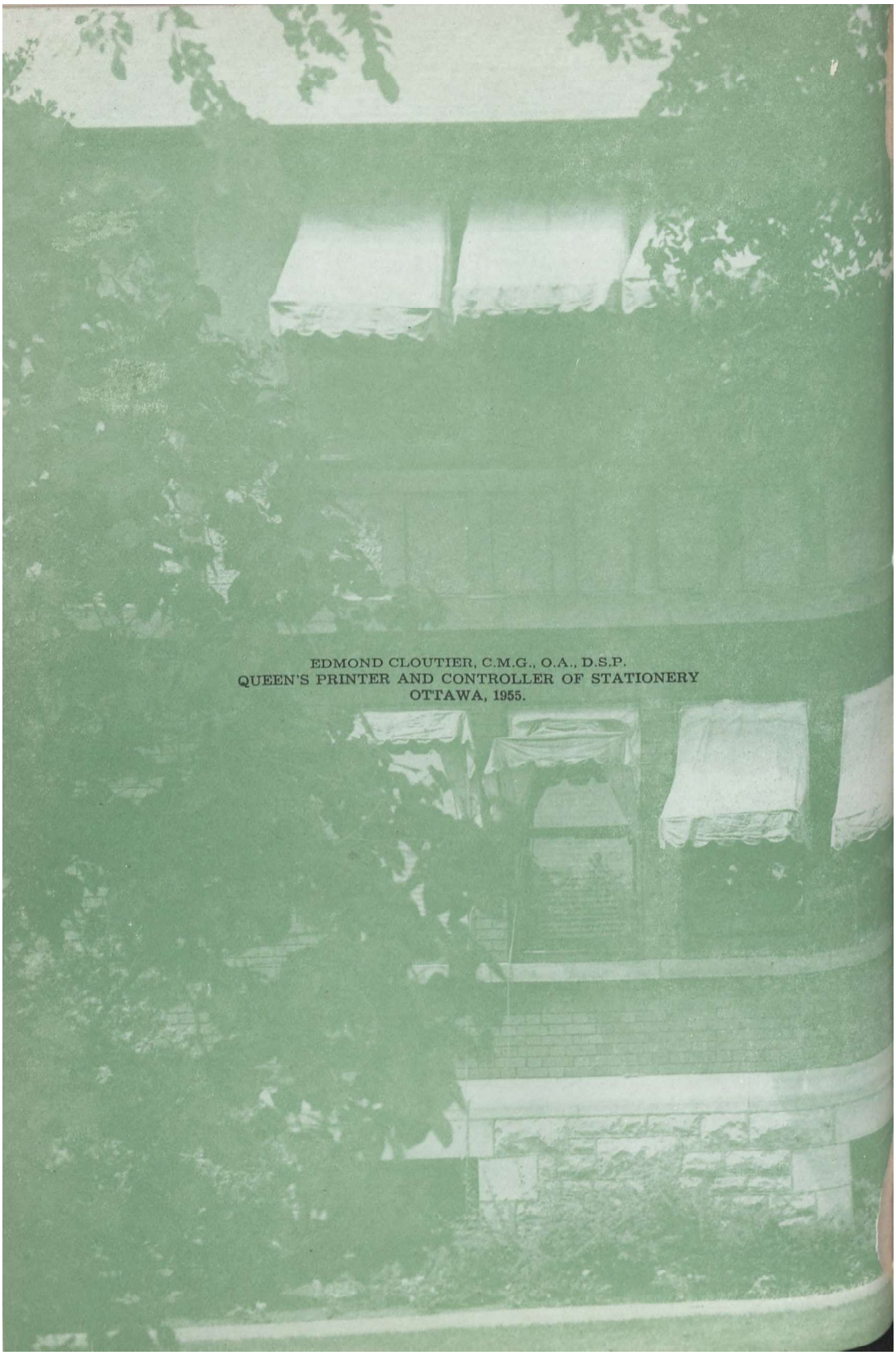

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