Turf and Landscape Research - - 1973

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
Wooster, Ohio
RESEARCH

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9-73-6M
In 1970, a trial including 14 Kentucky bluegrass varieties was planted on the OARDC grounds. Twelve of the varieties were seeded and the remaining two, A-20 and A-34, were laid as sod.

Each plot was split into 1-inch and 2-inch mowing heights. Plots were mowed as needed to remove no more than one-third of the leaf tissue from the low-cut portion of the plots. This meant that plots were mowed twice a week during most of the 1972 growing season.

Plots were further split into two fertility levels, with half receiving 3.5 lb. of N per 1,000 sq. ft. per year and half receiving 7 lb. per 1,000 sq. ft.

Data collected included quality scores and color. Quality scores were taken on the basis of the general appearance of the plot and included primarily density, color, and uniformity. It would ordinarily include weed invasion, but these plots were virtually weed-free in 1972. Disease notes are not included, but disease may have been a factor in the quality scores.

Because of good growing conditions in 1972, all plots looked good most of the time. No differences due to different fertility levels could be detected. Differences due to mowing height were small and difficult to include in ratings.

There were fairly large differences between varieties and these are shown in Table 1. Quality scores indicate that Belturf, A-20, and A-34 were superior. Another group which was nearly as good included Merion, Sodco, Nugget, Windsor, Fyliking, Cougar, and Pennstar. The remaining varieties, which were not outstanding, made a third group. In this group was Kenblue, which is similar to Kentucky grown common, a widely used type. Differences can be considered real only if they are larger than the 5% LSD values.

It should be noted that these data were taken from a trial that was in its second full growing season. As the trial gets older, the ranking of varieties can be expected to change. For example, Merion is known to be susceptible to leaf smuts, diseases which become damaging after about 4 years. To a lesser extent, the same is true of Windsor.

All of the varieties in the test except Ky. blend and Belturf are available. A-20 is available only as sod and A-34 primarily as sod. The rest are available as seed. Since this test was planted, several new varieties have been released and are included in a trial planted in 1972. These include Adelphi, Bonnieblue, Sydsport, Baron, Victa, and Vantage. These have all been reported to be superior varieties.

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<tr>
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<td>7.5</td>
<td>7.5</td>
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</table>

5% LSD     | 1.2  | 1.1 | 1.0  | 1.0  | 1.8  | 0.9   | 1.0  | 1.5  | -  | 1.9  | 1.2  | 1.3  | -  |

* Blend of several experimental strains.
The accepted definition of a turf mixture is a combination of two or more different species of turfgrass such as Kentucky bluegrass and perennial ryegrass. Combinations of varieties within a species are properly called blends.

Turf mixtures have been used as long as turf has been grown. The reasons for planting a mixture rather than a pure stand include wider adaptation, more pest tolerance, faster establishment, and lower seed costs. Common sense plus research indicate all these reasons are true in certain situations. However, there are some disadvantages, including lack of uniformity and dominance of the mixture by an unattractive component.

In practice two kinds of mixtures are used. One is a temporary mixture in which only one species is intended to survive after the first year or so. The other is a permanent mixture in which all components are permanent. Three or more species may be combined to give turf the characteristics of both a permanent and temporary mixture.

Temporary Mixtures

The primary reason for planting a temporary mixture should be to obtain a quick cover to help control weeds and erosion or for aesthetic reasons. The claim that one species acts as a nurse crop for the other is usually not considered valid. In fact, one species is likely to grow at the expense of the other.

The most common temporary mixture includes Kentucky bluegrass and annual ryegrass. Such a mixture can be of value because ryegrass germinates in only a few days and bluegrass can take as long as 21 days. However, it is likely that the fast-germinating ryegrass will dominate such a mixture. Later when the annual ryegrass dies, bare areas are left and weeds quickly invade.

Correct seeding rates can help alleviate this problem. In tests at Wooster, it has been shown that 1/2 lb. of ryegrass per 1,000 sq. ft. is adequate for quick cover, but still leaves room for the bluegrass to become established.

Common perennial ryegrass, redtop, and other pasture grasses should never be included in a temporary mixture. They will all persist for many years and will cause the turf to be uneven, difficult to mow, and generally unattractive.

Several new varieties of perennial ryegrass have been released which may have a place in turf mixtures. NK-200, Manhattan, and Pennfine are fine-leaved, winter-hardy ryegrass which are easy to mow. They blend well with bluegrass and so do not contribute to poor uniformity. They can be mixed with bluegrass with the expectation that quick cover will be achieved, followed by a gradual uniform transition towards bluegrass. It is not yet known how long such mixtures will last. This is not important if uniformity is not sacrificed.
Permanent Mixtures

Permanent mixtures are primarily planted to obtain tolerance to stress. They also can provide quick cover directly or by the inclusion of a fast-germinating component specifically for that purpose. Common examples of permanent mixtures are Kentucky bluegrass-red fescue, Kentucky bluegrass-tall fescue, Kentucky bluegrass-bentgrass, and other combinations of these species. Other species which might be included for specific uses include Poa trivialis, white clover, and redtop. The new and improved varieties of perennial ryegrass may also be considered components of permanent mixtures, although it is not known at present how long the ryegrass will persist.

Kentucky bluegrass-red fescue is perhaps the most commonly used mixture. The advantage of this mixture is that it does well on fertile or poor soils and in full sun or partial shade. Under optimum conditions, the bluegrass usually dominates. Under stress from poor soil or shade, the red fescue usually dominates. Data from trials grown at Wooster show that such a mixture provided a more dense weed-free turf than either of the species seeded alone. However, the uniformity of texture never equalled that of the pure stands.

Kentucky bluegrass-tall fescue mixtures proved difficult to manage in Ohio tests. The bluegrass tended to dominate, leaving scattered clumps of coarse and unattractive tall fescue. Such a mixture is commonly used on athletic fields. It must be managed for the tall fescue and should be overseeded as needed in order to maintain the mixture. The addition of one of the improved ryegrass varieties to athletic field mixtures appears to have merit. They may be particularly well suited to establishment from overseeding.

Kentucky bluegrass-bentgrass mixtures were once common, but most people now consider bentgrass to be a weed in a bluegrass turf. The same is true of clover and redtop. Poa trivialis or rough bluegrass is extremely shade tolerant and is included in some mixtures for use in shade. It is not a desirable species for general use and is considered a weed by many.

It is obvious that mixtures can be used advantageously, particularly if they are formulated with a specific objective in mind. They should not be used simply to reduce seed costs. Once a mixture is established, it is very difficult to return to a pure stand.

In summary, the bulk of data from Ohio indicates that temporary mixtures should be used only where erosion control or quick cover are essential. Annual ryegrass at 1/2 to 1 lb. per 1,000 sq. ft. can be used with Kentucky bluegrass if considered essential. Although they may last for several years, the improved ryegrass varieties can be used in place of annual ryegrass.

Permanent mixtures which have shown merit are few. Bluegrass-red fescue mixtures in shady areas or on poor soil have shown merit. There are some indications that mixing bluegrass with the new ryegrasses may be desirable in certain situations. For low maintenance areas or athletic fields, it is advantageous to include tall fescue in the turf mixture. However, it is difficult to surpass pure Kentucky bluegrass for a first-rate turf.

ROOTING AND ETHYLENE METABOLISM IN CUTTINGS

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Ethylene Stimulates Rooting of Cuttings

Zimmerman and Hitchcock first reported in 1933 that unsaturated hydrocarbon gases, including ethylene, stimulate initiation of roots in herbaceous and woody plants and the growth of latent root primordia in willow.

According to recent results, exposure of willow cuttings to ethylene gas stimulated root formation within an exposure time ranging from 0 to 30 minutes. Treatment longer than 30 minutes was less effective as shown in Figure 1.

To confirm the effect of ethylene on root formation, Ethephon, which releases ethylene gas in the plant tissue after absorption, was applied to willow cuttings. Results in Figure 2 indicate that Ethephon also stimulated root formation in willow cuttings.

Ethylene Concentration in Cuttings Increases When Submerged in Water

Recent studies indicate that when cuttings were submerged in water, ethylene concentration increased significantly. When cuttings of crabapple, chrysanthemum, and privet were completely submerged, ethylene concentration increased 5.2, 1.8, and 2.4

FIG. 1.—Effects of ethylene gas on root formation in Salix fragilis softwood cuttings. Cuttings were exposed to ethylene gas for 0, 10, 30, 60, or 120 minutes and then soaked upright in water 4 cm. deep until root formation.

FIG. 2.—Effects of Ethephon on root formation in Salix fragilis softwood cuttings. The basal 4 cm. of cuttings were soaked upright in 0, 440, 880, and 1760 mg./l. of Ethephon for 24 hours and then soaked in fresh water 4 cm. deep until roots formed.

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FIG. 3.—Effects of water soaking on ethylene concentration in *Salix fragilis* softwood cuttings. Cuttings were completely submerged upright in water, while in controls the basal 2.5 cm. of cuttings were soaked upright in water. After treatments of 10, 17, 21, and 22 hours, gas samples were collected from cuttings and their ethylene concentrations were measured.

FIG. 4.—Effects of soaking-water depth on root formation of *Salix fragilis* softwood cuttings. Cuttings 10 cm. long were soaked upright for 24 hours in water 1.25, 2.5, 5.0, 7.5, or 10 cm. deep and then transferred into water 4 cm. deep until roots formed.

TABLE 1.—Effects of Submersion of Ethylene Concentrations in Crabapple, Chrysanthemum, and Privet Cuttings. Cuttings were completely submerged in water at 24°C for 20 hours and controls were steeped upright in water 2.5 cm. deep.

<table>
<thead>
<tr>
<th>Cutting and Treatment</th>
<th>Before Treatment</th>
<th>After Treatment</th>
<th>5% LSD</th>
<th>1% LSD</th>
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<tr>
<td>Crabapple</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
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<td>0.32</td>
<td>0.13</td>
<td>0.23</td>
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<td>Submerged</td>
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<td></td>
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<td>Chrysanthemum</td>
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<td>Submerged</td>
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</tr>
<tr>
<td>Control</td>
<td>0.06</td>
<td>0.50</td>
<td>0.40</td>
<td>0.74</td>
</tr>
<tr>
<td>Submerged</td>
<td>0.06</td>
<td>1.20</td>
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</table>
FIG. 5.—Effects of water depth during centrifugation on root formation of *Salix fragilis* softwood cuttings. Except for non-centrifuged controls, cuttings 10 cm. long were centrifuged for 1 hour at 2,000 g with the basal 0, 1.25, 2.5, or 5 cm. soaked in water. After centrifugation, the basal 2.5 cm. of all cuttings, including controls, were cut back and the resulting 7.5 cm. portions were soaked in water 4 cm. deep until root formation. Dotted line indicates number of roots produced by controls.

FIG. 6.—Effects of flooding on ethylene concentrations in sunflower plants flooded up to midway between cotyledonary and first leaf node for 24 hours while controls were not flooded. Ethylene was extracted from lower portions (stems below first leaf node and roots) and higher portions (stems between first and third leaf nodes). White and black bars refer to controls and flood treatments, respectively.
times as high as controls within 20 hours (Table 1). However, the ethylene concentration in submerged cuttings started to decline after 20 hours (Fig. 3).

Under submersion, ethylene which is synthesized in the cuttings cannot escape from the cuttings because of the low solubility of ethylene in water. Thus, submerging the cuttings resulted in a high ethylene concentration. After the cuttings were submerged in water, residual oxygen trapped in them was exhausted by respiration. Since ethylene synthesis does not proceed without oxygen, ethylene concentration gradually declined after 20 hours.

**Submersion Enhances Rooting**

Since submersion increases ethylene concentration in cuttings and ethylene gas stimulates root formation, submersion may stimulate root formation in cuttings. Recent study indicates that submersion of willow cuttings stimulated root formation (Fig. 4). When cuttings 10 cm. long were soaked upright for 24 hours in water 1.25, 2.5, 5.0, 7.5, and 10 cm. deep, they produced 2.0, 2.3, 3.0, 3.9, and 6.3 roots, respectively.

Earlier it was found that when softwood cuttings of some woody species, including *Salix alba*, *S. ocutifolia*, *S. pentandra*, *S. fragilis*, *Viburnum dentatum*, and *Populus alba* were centrifuged in water, the cuttings rooted even better. During centrifugation, water was forced into the cuttings and the water content of the cuttings increased approximately 14%. This increased water apparently provided a barrier for diffusion of ethylene gas out of the cuttings, causing a high concentration of ethylene gas, which stimulated root formation. Centrifugation without water did not stimulate root formation. When cuttings were centrifuged with the same force, the deeper the cuttings were steeped in the centrifuge tube, the more water was forced into the cuttings, resulting in more roots (Fig. 5).

Ethylene concentration also increased when intact plants were flooded. For instance, ethylene concentration in the submerged portion of sunflower increased 48 times after 24-hour flooding (Fig. 6). Flooded sunflower and tomato plants produced adventitious roots from the stems above the ground.

It is interesting that there is a close similarity between damage symptoms caused by flooding and ethylene gas. The symptoms include wilted leaves, epinasty of leaves, leaf chlorosis, reduced stem elongation, enlarged stem diameter, and formation of new adventitious roots. Preliminary results suggest that increased ethylene concentration in flooded plants is mainly responsible for the flood damage symptoms.
Numerous factors are involved in the successful rooting of softwood and evergreen cuttings. Within each of these factors, such as media composition, media temperature, rooting powders, disease control, and spacing of cuttings, there are variables which must be controlled. In an attempt to assist commercial propagators of woody ornamental plants, a number of studies were conducted to provide information helpful in the control of variables influencing plant propagation. The results of these preliminary investigations are reported here as separate studies.

Study No. 1: Effects of Media on Rooting of Softwood Cuttings of Woody Ornamentals

Sand and the combination of peat and perlite are both commonly used media to commercially propagate cuttings of woody ornamentals. A concern is to determine which of the two result in optimum rooting of most plants. The objective of this study was to compare the effects of the two media on the rooting of softwood cuttings of nine species of woody ornamentals.

The rooting media were 100% coarse silica sand and the combination of 50% sphagnum peat moss and 50% horticultural grade perlite by volume. The cuttings were taken July 18, 1972, and placed under intermittent mist in the OSU greenhouses. Two flats containing 150 cuttings of each plant species were made for each of the two media. The plant materials included assorted ground covers, shrubs, and one tree species as listed in Table 1.

**TABLE 1:** Percent Rooting of Woody Ornamentals Propagated in Sand or Peat/Perlite. Figures Represent Data from 300 Cuttings per Species per Medium After 11 Weeks in the Rooting Media.

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Sand</th>
<th>Peat/Perlite</th>
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<tr>
<td></td>
<td>1</td>
<td>2</td>
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<tr>
<td>Juniper horizontalis 'Plumosa'</td>
<td>24%</td>
<td>17%</td>
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<tr>
<td>Buxus sempervirens</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Cotoneaster apiculata</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Euonymus alatus</td>
<td>11</td>
<td>14</td>
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<tr>
<td>Ilex opaca</td>
<td>5</td>
<td>78</td>
</tr>
<tr>
<td>Taxus media 'Browni'</td>
<td>2</td>
<td>88</td>
</tr>
<tr>
<td>Vinca minor</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Rhamnus frangula 'Tallhedge'</td>
<td>35</td>
<td>41</td>
</tr>
<tr>
<td>Viburnum rhytidophyllloides</td>
<td>15</td>
<td>15</td>
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</table>

*1 = dead; 2 = callus only or poorly rooted; 3 = well rooted.*

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The results after 11 weeks (Table 1) indicate that softwood cuttings of most species rooted faster in sand than in the peat/perlite combination. Although survival was approximately the same in both media, there were more well-rooted cuttings in the sand medium. *Rhamnus frangula* Tallhedge was the only species rooting faster in the peat/perlite combination. In summary, softwood cuttings of eight species of woody ornamentals rooted faster in a sand medium, while only one species rooted quicker in a peat/perlite medium.

**Study No. 2: Effects of Indole-Butyric Acid (IBA), Benomyl (Benlate), and Media on Rooting of Softwood Cuttings of Woody Ornamentals**

The use of Benomyl in the rooting powder used with softwood cuttings of woody plants has increased rooting for some growers but not others. This study was undertaken to determine the effects of IBA, Benomyl, and Benomyl mixed with IBA on the rooting percentage of several ornamentals propagated in two different media.

The rooting media were 100% coarse silica sand and a 1:1 by volume mixture of sphagnum peat moss and horticultural grade perlite. The rooting powder treatments were IBA at 0.2%, Benomyl at 12.5%, and a combination of these two. The IBA was prepared by mixing three parts of pulverized Barden clay with one part of Hormodin #3. The Benomyl was prepared by combining three parts of Barden clay with one part of Benlate 50WP fungicide. The combination was prepared by mixing two parts of Barden clay, one part Hormodin #3 and one part Benlate 50WP.

One hundred and fifty cuttings of *Viburnum lantana*, *Philadelphus coronarius*, and *Lonicera tatarica* were stuck per flat on June 29, 1972. Two flats of each plant were stuck for each treatment, for a total of 16 flats per plant type. The flats were placed under intermittent mist in a commercial greenhouse at New Carlisle, Ohio.

On July 31, 1972, 30 cuttings from the center of each flat were removed and evaluated. Approximately 76% of the cuttings rooted in sand, while 66% rooted in the peat/perlite medium. Approximate rooting percentages in peat/perlite were: check 56, Benomyl 67, IBA 70, and the combination of IBA and Benomyl 73.

In summary, the sand medium resulted in better rooting of softwood cuttings than the peat/perlite medium. All rooting treatments aided cuttings in peat/perlite but not those stuck in sand.

It appears that the inconsistencies of Benomyl as a rooting supplement may be due more to the medium than any other factor.

**Study No. 3: Effects of Fungicides Drenched on Prunus Cuttings**

A study was conducted to compare the effects of fungicide drenches on the rooting of softwood cuttings of three prunus species.

Three hundred cuttings each of *Prunus glandulosa rosea* (Pink Flowering Almond), *Prunus cerasifera* Newport (Newport Plum), and *Prunus Hally Jolivette* (Hally Jolivette Cherry) were stuck in flats on June 14, 1972, and kept under intermittent mist in a commercial greenhouse at New Carlisle. The medium was coarse silica sand.
The fungicide treatments included: Benlate 50WP (8 oz./100 gal.) in combination with Truban 30WP (4 oz./100 gal.), Dithane M-45 (8 oz./100 gal.), Captan 50WP (16 oz./100 gal.), and control-untreated. The fungicides were applied over the foliage as drenches on June 29 and July 29, 1972, at the rate of 100 gal. per 400 sq. ft. of flats.

Data were taken on August 10, 1972 on all cuttings in the flats and rated according to whether they were dead, callus but not well rooted, or well rooted and acceptable for transplanting.

The results as expressed in data in Table 2 indicate that a higher percentage of cuttings rooted in the Captan treatments for all species. Generally, the Benlate/Truban and Dithane M-45 drenches did not result in improved rooting.

Captan and Dithane improved rooting percentages of Hally Jolivette Cherry. Only Captan improved the rooting of the difficult-to-root Newport Plum. The Pink Flowering Almond rooted well without fungicide drenches; however, both Benlate/Truban and Dithane M-45 resulted in lower rooting percentages.

In summary, the rooting percentage of softwood cuttings of Hally Jolivette Cherry was increased with Captan and Dithane M-45 drenches, while only Captan increased rooting of Newport Plum.

<table>
<thead>
<tr>
<th>Plant and Treatment</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prunus 'Hally Jolivette'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>15</td>
<td>23</td>
<td>62</td>
</tr>
<tr>
<td>Benlate/Truban</td>
<td>25</td>
<td>28</td>
<td>47</td>
</tr>
<tr>
<td>Dithane M-45</td>
<td>17.5</td>
<td>8</td>
<td>74.5</td>
</tr>
<tr>
<td>Captan</td>
<td>16</td>
<td>3</td>
<td>81</td>
</tr>
<tr>
<td>Prunus cerasifera 'Newport'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>27</td>
<td>61.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Benlate/Truban</td>
<td>30</td>
<td>63</td>
<td>7</td>
</tr>
<tr>
<td>Dithane M-45</td>
<td>41</td>
<td>56</td>
<td>3</td>
</tr>
<tr>
<td>Captan</td>
<td>17.5</td>
<td>66.5</td>
<td>16</td>
</tr>
<tr>
<td>Prunus glandulosa rosea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>2</td>
<td>2</td>
<td>96</td>
</tr>
<tr>
<td>Benlate/Truban</td>
<td>11</td>
<td>16</td>
<td>73</td>
</tr>
<tr>
<td>Dithane M-45</td>
<td>25.5</td>
<td>18</td>
<td>56.5</td>
</tr>
<tr>
<td>Captan</td>
<td>4</td>
<td>2</td>
<td>94</td>
</tr>
</tbody>
</table>

*1 = dead; 2 = callused but not well rooted; 3 = well rooted.
Poor rooting of softwood cuttings of large leaved plants, such as Viburnums, has been observed. Excess foliage and close spacing leads to poor air circulation and subsequent foliage and stem decay which reduces rooting.

A study was initiated to determine the optimum number of cuttings per flat and the number of sets of leaves to remain on softwood cuttings of Viburnum lantana.

On July 10, 1972, 6-inch cuttings were stuck in flats containing coarse silica sand and placed under intermittent mist in a commercial greenhouse at New Carlisle. The treatments consisted of 150 cuttings per flat, 100 cuttings per flat, and 50 cuttings per flat. Within each spacing treatment were flats containing three sets, two sets, and one set of leaves. Two flats were established within each of the nine treatment combinations.

The rating was conducted on August 10, 1972, using the same system as reported in Study 3.

The results indicate a progressively higher rooting percentage with a decreasing number of cuttings per flat, as shown in Table 3. Although slightly higher rooting percentages were noted with three sets of leaves, the total difference between the three is probably not significant.

**TABLE 3.—Effects of Spacing and Foliage Density on the Rooting of Viburnum lantana. Figures Represent Percentages and Total Number of Rooted Cuttings Averaged from Two Flats 8 Weeks After Sticking in a Sand Medium.**

<table>
<thead>
<tr>
<th></th>
<th>Rooting Percentages</th>
<th>Total No. of Cuttings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>150 cuttings per flat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 sets of leaves</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>2 sets of leaves</td>
<td>18.5</td>
<td>22.5</td>
</tr>
<tr>
<td>1 set of leaves</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>12.6</td>
<td>23.2</td>
</tr>
<tr>
<td>100 cuttings per flat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 sets of leaves</td>
<td>8.5</td>
<td>22</td>
</tr>
<tr>
<td>2 sets of leaves</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>1 set of leaves</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>7.2</td>
<td>16.3</td>
</tr>
<tr>
<td>50 cuttings per flat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 sets of leaves</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>2 sets of leaves</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>1 set of leaves</td>
<td>13</td>
<td>22.5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>6.6</td>
<td>14.5</td>
</tr>
</tbody>
</table>

*1 = dead; 2 = cuttings callused but poorly rooted; 3 = cuttings well rooted."
Although rooting percentage may be higher, too low a number of cuttings per flat is not economically feasible with most plants, including Viburnum lantana. Despite the lower rooting percentage in flats containing 150 cuttings, considerably more cuttings per flat are well rooted than in the other treatments.

In summary, rooting percentages decreased as the number of cuttings per flat increased. However, the number of acceptable rooted cuttings in the flats containing 100 and 150 cuttings per flat offset the lower percentages. Rooting was only slightly better with three sets of leaves per cutting.

**Study No. 5: Effects of Temperature on Rooting of Evergreen Cuttings**

The temperature of the medium is an important factor in the rooting of evergreen cuttings. A study was designed to determine the optimum media temperatures for rooting cuttings of several evergreen species.

The media temperatures in a mist bed were maintained with heating cables set at 70, 75, and 80° F. A fourth treatment without heating cables was maintained at 65° F., the temperature of the greenhouse bench. The study was conducted in a commercial greenhouse at New Carlisle.

On Dec. 21, 1972, 150 cuttings were stuck per flat with coarse silica sand and placed under intermittent mist. Two flats of each plant species were examined at each temperature. The plant species included: Taxus media Anderson, Taxus media Hicksi, Buxus koreana Wintergreen, Juniperus chinensis Pfitzeriana Hills Blue, and Thuja occidentalis Techny.

The cuttings were rated as in the previous studies. Data were taken on Feb. 16, 1973, for Owens Juniper, Techny Arborvitae, and Wintergreen Boxwood and on April 19, 1973, for Hills Blue Juniper and the two Taxus cultivars.

Considering all plant species, the best medium temperature for rooting was 70° F. as shown in Table 1. Owens Juniper, a difficult-to-root cultivar, rooted better at 80° F. and was the only plant to root best at the highest temperature. Arborvitae rooted equally well at 65°, 70°, and 75° F. The Anderson Taxus rooted as well at 65° as 70°. The Boxwood rooted well at both 70 and 75° F.

In summary, good rooting of evergreen cuttings was observed for most species examined in a rooting medium maintained at 70° F., except Owens Juniper which rooted better at 80° F.

**Summary**

In conclusion, all studies considered, softwood cuttings rooted faster in sand than in peat/perlite. However, IBA and Benomyl aided the rooting of cuttings in peat/perlite. Captan is an effective fungicide drench and increased the rooting of some Prunus species. Spacing of cuttings in a flat should be adjusted to reduce losses and maximize rooting.

Evergreen cuttings rooted best in a medium maintained at 70° F.
TABLE 4.—Effects of Medium Temperature on Rooting of Evergreen Cuttings. Figures Represent Average Percentages of 300 Cuttings Rooted in Coarse Silica Sand Under Intermittent Mist on Benches Maintained with Electric Heating Cables.

<table>
<thead>
<tr>
<th>Plant and Medium Temperature</th>
<th>Rooting Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1*</td>
</tr>
<tr>
<td><strong>Taxus media 'Anderson'</strong></td>
<td></td>
</tr>
<tr>
<td>80° F.</td>
<td>1%</td>
</tr>
<tr>
<td>75</td>
<td>4.5</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>65</td>
<td>0</td>
</tr>
<tr>
<td><strong>Taxus media 'Hicksi'</strong></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>4</td>
</tr>
<tr>
<td>75</td>
<td>4</td>
</tr>
<tr>
<td>70</td>
<td>1</td>
</tr>
<tr>
<td>65</td>
<td>0</td>
</tr>
<tr>
<td><strong>Juniperus chinensis 'Pfitzeriana'</strong></td>
<td></td>
</tr>
<tr>
<td>80 'Owens'</td>
<td>49</td>
</tr>
<tr>
<td>75</td>
<td>66</td>
</tr>
<tr>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td><strong>Juniperus chinensis 'Pfitzeriana'</strong></td>
<td></td>
</tr>
<tr>
<td>80 'Hills Blue'</td>
<td>31.5</td>
</tr>
<tr>
<td>75</td>
<td>35</td>
</tr>
<tr>
<td>70</td>
<td>16.5</td>
</tr>
<tr>
<td>65</td>
<td>46</td>
</tr>
<tr>
<td><strong>Thuja occidentalis 'Techny'</strong></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>65</td>
<td>0</td>
</tr>
<tr>
<td><strong>Buxus Koreana 'Wintergreen'</strong></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>9</td>
</tr>
<tr>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>70</td>
<td>2</td>
</tr>
<tr>
<td>65</td>
<td>8.5</td>
</tr>
</tbody>
</table>

*1 = dead; 2 = callused but not well rooted; 3 = well rooted.

WINTER STORAGE OF CONTAINER-GROWN ORNAMENTALS

F. K. Buscher and C. C. Powell
Departments of Horticulture and Plant Pathology
Ohio Agricultural Research and Development Center

The commercial nursery production of woody ornamentals has increased yearly in Ohio. Nurseries producing container-grown ornamentals need to provide some form of winter protection. Without protection, few container-grown plants would survive the winter to continue growing the following spring.

Most nurserymen today use plastic film-covered structures to safely overwinter container plants. These structures may be either unheated or minimally heated to maintain the air temperature at 32° or above. Such freeze protection results in plants which survive the winter better, and initiate new growth earlier in the spring.

Above-ground storage diseases can be serious within the overwintering structures. When the relative humidity is high, weak pathogens such as Botrytis, Penicillium, and Rhizopus may attack the dormant buds, tender shoots, and any leaf tissue present. Information is sparse on the potential for disease in unheated vs. minimally heated structures. Furthermore, the best fungicidal protection programs are not known.

The present report summarizes findings to date on continuing investigation of winter protection programs. Plant response and condition in the spring was noted in the unheated and minimally heated structures. The presence of disease was observed under the two temperature programs. The effects of various fungicides were also examined.

Materials and Methods

Two 10 x 16-foot storage structures were constructed at OARDC. Both houses were covered with an inner layer of clear 4-mil plastic and an outer layer of white 4-mil co-polymer film. Small Dayton-shaded pole blowers were used to force air between the plastic layers to separate them. One structure was heated with an electric forced air heater to maintain a minimum temperature of 32°-34° within the house.

One hundred and twenty each of four cultivars of container-grown ornamentals in 2-gal. containers were obtained from nurserymen. Cultivars used were Azalea Cascade, Hydrangea macrophylla Nikko Blue, Chamaecyparis cyano virdis, and Cotoneaster apiculata. Sixty plants of each cultivar were placed in each house in two blocks of 30 plants.

Fungicides were applied to the plants three times during the storage period. The first application was made when the plants were placed in the houses Dec. 5, 1972. The second application was applied Jan. 3, 1973, and the third application was sprayed March 5, 1973.

Five fungicide programs and an unsprayed check were tested in each of the two storage structures. The programs were: Chlorothalonil 75WP (Daconil 2787, Diamond Shamrock Co.) at 1.5 Ib. per 100 gal. on Dec. 5 and captan 50WP (Chevron Chemical Co.) at 2 lb. per 100 gal. plus PCNB 75 WP (Terraclor, Olin Chemical Co.) at 2 lb. per 100 gal.,

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on Jan. 3 and March 5, captan and PCNB for all three applications, captan for all three applications, PCNB for all three applications, chlorothalonil (Daconil) for all three applications, and unsprayed checks. Triton B-1956 (Rohm and Haas Chemical Co.) at 4 oz. per 100 gal. was used as an adjuvant in all except the chlorothalonil treatments. Five plants in each block were sprayed with each treatment. A Hudson 2-gal. compression type sprayer was used.

Results

On April 13, 1973, the plants were removed from the overwintering structures and observed. From Dec. 4, 1972 to April 9, 1973, the minimally heated house required heating on 53 nights, using 831 kw. of electricity. Air temperature in the unheated house reached 18° F. on Jan. 10, 11, and 12; 20° F. on Feb. 9, 10, 18, and 19; 24° F. on Feb. 28; and 26° F. on April 12.

Soil thermometers in containers were observed each morning at 8 a.m. in each house. On Feb. 12, soil temperature in the unheated house was 21° F., the lowest reached all winter.

Hydrangeas in the heated house had good overall appearance. This appearance rating included new growth, leaf retention, amount of stem die-back, and presence of white root tips (Table 1). Hydrangeas in the unheated house showed severe stem die-back, smaller and fewer shoots, sparse foliage, and no white root tips.

Azaleas exhibited no difference in overall appearance or leaf condition between the heated or unheated house (Table 2). Azaleas in the heated house were 50% in full bloom

<table>
<thead>
<tr>
<th>Fungicide Program*</th>
<th>Unheated House Appearance†</th>
<th>Heated House Appearance</th>
<th>Percent Blighted Shoots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorothalonil, then PCNB and Captan</td>
<td>4.1</td>
<td>1.7</td>
<td>55</td>
</tr>
<tr>
<td>Captan and PCNB</td>
<td>3.5</td>
<td>2.1</td>
<td>39</td>
</tr>
<tr>
<td>Captan</td>
<td>3.4</td>
<td>2.4</td>
<td>49</td>
</tr>
<tr>
<td>PCNB</td>
<td>3.5</td>
<td>1.6</td>
<td>85</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>4.1</td>
<td>2.5</td>
<td>46</td>
</tr>
<tr>
<td>Check</td>
<td>2.9</td>
<td>2.5</td>
<td>63</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>3.7</strong></td>
<td><strong>2.1</strong></td>
<td><strong>56</strong></td>
</tr>
</tbody>
</table>

*See text for list of fungicide programs.
†Appearance of plants visually rated on a 1 to 5 scale and averaged.
TABLE 2.--Appearance and Leaf Condition of Cascade Azalea.

<table>
<thead>
<tr>
<th>Fungicide Program*</th>
<th>Heated House</th>
<th>Unheated House</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appearance‡</td>
<td>Leaf Condition‡</td>
</tr>
<tr>
<td>Chlorothalonil, then PCNB and Captan</td>
<td>3.0</td>
<td>3.2</td>
</tr>
<tr>
<td>Captan and PCNB</td>
<td>3.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Captan</td>
<td>3.8</td>
<td>4.7</td>
</tr>
<tr>
<td>PCNB</td>
<td>3.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Check</td>
<td>3.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Average</td>
<td>3.4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

*See text for list of fungicide programs.
†Appearance of plants visually rated on a 1 to 5 scale.
‡Leaf condition visually rated on a 1 to 5 scale.

TABLE 3.--Appearance and Root Condition of Chamaecyparis Cyano Viridis.

<table>
<thead>
<tr>
<th>Fungicide Program*</th>
<th>Heated House</th>
<th>Unheated House</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appearance‡</td>
<td>Root Condition‡</td>
</tr>
<tr>
<td>Chlorothalonil, then PCNB and Captan</td>
<td>2.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Captan and PCNB</td>
<td>2.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Captan</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>PCNB</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Check</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Average</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*See text for list of fungicide programs.
†Appearance of plants visually rated on a 1 to 5 scale.
‡Root condition of plants (number of white roots seen) visually rated on a 1 to 5 scale.
by April 13. Azalea flower buds in the unheated house had just started to show color by this date.

Chamaecyparis appeared slightly better in the heated house (Table 3). White root tips were present on plants in the heated house on April 13, but not on plants in the unheated house.

Cotoneasters in the heated house initiated new short growth, averaging about 4 in. per shoot by April 13. Plants in the unheated house had not begun to initiate new shoots at this time. There was no difference between development of new roots in either house.

Disease, primarily Botrytis blight, was evident only on the hydrangea and Chamaecyparis. Shoot blight was almost absent on the hydrangea in the heated house, but it was quite severe in the unheated house (Table 1). None of the chemicals provided good control of the hydrangea shoot blight. PCNB was slightly worse than the others. Blighted foliage was also worse on the Chamaecyparis in the unheated house. Again, none of the chemicals provided good control, with PCNB resulting in poorer plants (Table 3).

Although no disease was evident on the Cascade Azaleas, the PCNB-treated plants in the unheated house had damaged foliage. A yellow leaf mottling could be seen on almost every plant.

This study indicates that minimally heated storage houses increase the survival rate and result in larger, more valuable plants at the end of the winter storage period. Hydrangeas in the unheated house were totally unsaleable in the spring, compared to hydrangeas stored in the heated house. The earliness of bloom for azaleas in the heated house may be ideal for early spring sales, but may be a disadvantage for later sales. The Chamaecyparis initiated new root tips earlier in the heated house. This indicates that growth processes are further advanced under this temperature treatment. Cotoneasters in the heated structure were larger compared with plants in the unheated house and were probably of greater sales value.

Disease was more severe in the unheated house. Additionally, none of the chemicals provided good protection. This may indicate that disease followed after shoots or foliage had been damaged due to cold weather. Badly damaged tissue and high humidity would provide ideal conditions for disease development.

The PCNB treatments appeared to be phytotoxic to the plants. This was especially severe on the Cascade Azalea. Therefore, even though the best fungicide programs were not determined, it was seen that PCNB should not be used alone.

The results presented here are of this year's investigation at the OARDC. The overall study is being conducted to determine the most meaningful winter storage programs for Ohio producers of woody ornamentals in containers. Work is continuing both at the Research Center, Wooster, and at The Ohio State University, Columbus, to further examine factors contributing to increased winter storage success.


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EFFECTS OF TWO COMPOUNDS AS CHEMICAL PINCHING AGENTS ON COTONEASTER APICULATA

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Ohio Agricultural Research and Development Center

Many industries, including the nursery industry, are plagued by increasing production costs due to rising costs of land, labor, and materials. In an effort to reduce these costs, plant scientists have experimented with many new production techniques.

Among the new ideas which have proved successful is the removal of stem tips by spraying a selective chemical on the plant. Tao (3) in 1964 found that some fatty acids and their analogs killed the axillary shoots of tobacco without damaging the remaining parts of the plant. Cathey, Steffens, Stuart and Zimmerman (1) in 1966 reported that these effects were not limited to tobacco, but caused similar responses on a wide range of plants. Kozel and Reisch (2) further expanded this work on many woody ornamental plants.

This research was undertaken to evaluate the effectiveness of two chemicals, TD-6773 and Off-Shoot-O, on Cotoneaster apiculata.

Materials and Methods

Cotoneaster apiculata cuttings were potted using a mix of one part peat, one part perlite, and one part soil, and grown under long days. Five oz. of gypsum per 2.5 bu. of mix was added as a source of calcium and five oz. of superphosphate per 2.5 bu. was added to compensate for a low phosphorus level. The plants were then spaced on a bench in a fiberglass house and pinched manually. Next the plants were divided into groups, to be sprayed with 8, 4, 2, 1, and 0% concentrations of two chemicals, TD-6773 and Off-Shoot-O, at three different times. Each treatment consisted of four replications. Four plants were manually pinched a second time to act as a standard along with the control (0%) at each application time. Plants were fertilized at each watering with 200 p.p.m. of nitrogen, phosphorus, and potassium. Temperature and relative humidity were not controlled during growing of the plants but were monitored at the time of application.

Discussion

It was concluded after evaluation of this test that the 2% level of TD-6773 and the 4% level of Off-Shoot-O showed the greatest commercial potential. Therefore, the following discussion will deal primarily with these two rates.

In relation to tip kill, the 2% TD-6773 gave 100% tip kill as compared to the 86% at the 4% level of Off-Shoot-O (Tables 1 and 2). However, phytotoxicity at the 2% level TD-6773 was 15% as opposed to 4% phytotoxicity at the 4% concentration (Tables 1 and 2) of Off-Shoot-O, leading one to favor Off-Shoot-O. As expected, manually pinched plants had 100% kill with no phytotoxicity and 0% treated plants had no tip kill or phytotoxicity.
TABLE 1.--Effects of Varying Concentrations of Off-Shoot-0 on Cotoneaster apiculata.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tip Kill* (%)</th>
<th>Phytotoxicity† (%)</th>
<th>Fresh Weight* (g.)</th>
<th>Av. No. of Breaks**</th>
<th>Av. Shoot Length†† (cm.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Pinch</td>
<td>100.00</td>
<td>0.00</td>
<td>9.70</td>
<td>11.20</td>
<td>6.40</td>
</tr>
<tr>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>12.90</td>
<td>5.10</td>
<td>3.80</td>
</tr>
<tr>
<td>1%</td>
<td>0.00</td>
<td>0.30</td>
<td>12.80</td>
<td>5.20</td>
<td>2.80</td>
</tr>
<tr>
<td>2%</td>
<td>51.00</td>
<td>1.50</td>
<td>12.80</td>
<td>11.60</td>
<td>4.60</td>
</tr>
<tr>
<td>4%</td>
<td>86.00</td>
<td>4.00</td>
<td>9.10</td>
<td>10.00</td>
<td>5.10</td>
</tr>
<tr>
<td>8%</td>
<td>100.00</td>
<td>18.00</td>
<td>8.70</td>
<td>10.00</td>
<td>4.80</td>
</tr>
<tr>
<td>LSD .05</td>
<td>8.50</td>
<td>5.20</td>
<td>2.00</td>
<td>9.50</td>
<td>1.45</td>
</tr>
</tbody>
</table>

*Tip killed.
†Percent of foliar damage 6 weeks after treatment.
‡Fresh weight of plant severed at soil line.
**Average number of breaks with at least five expanded leaves 6 weeks after treatment.
††Average length of shoot 6 weeks after treatment.

TABLE 2.--Effects of Varying Concentrations of TD-6773 on Cotoneaster apiculata.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tip Kill* (%)</th>
<th>Phytotoxicity† (%)</th>
<th>Fresh Weight* (g.)</th>
<th>Av. No. of Breaks**</th>
<th>Av. Shoot Length†† (cm.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Pinch</td>
<td>100.00</td>
<td>0.00</td>
<td>9.70</td>
<td>10.60</td>
<td>6.50</td>
</tr>
<tr>
<td>0%</td>
<td>0.00</td>
<td>0.00</td>
<td>10.50</td>
<td>3.70</td>
<td>2.60</td>
</tr>
<tr>
<td>1%</td>
<td>39.00</td>
<td>1.50</td>
<td>9.70</td>
<td>6.50</td>
<td>4.90</td>
</tr>
<tr>
<td>2%</td>
<td>100.00</td>
<td>15.00</td>
<td>7.30</td>
<td>11.00</td>
<td>7.10</td>
</tr>
<tr>
<td>4%</td>
<td>100.00</td>
<td>41.00</td>
<td>4.10</td>
<td>4.50</td>
<td>3.90</td>
</tr>
<tr>
<td>8%</td>
<td>99.00</td>
<td>70.00</td>
<td>2.80</td>
<td>5.20</td>
<td>1.70</td>
</tr>
<tr>
<td>LSD .05</td>
<td>8.50</td>
<td>5.20</td>
<td>2.00</td>
<td>9.50</td>
<td>1.45</td>
</tr>
</tbody>
</table>

*See footnotes in Table 1.
When considering fresh weight, Off-Shoot-O, even at the lower concentrations, yielded significantly greater fresh weight than plants treated with TD-6773 (Tables 1 and 2). At the 2% level, the average plant treated with Off-Shoot-O weighed 12.8 g. in contrast to 7.3 g. of those treated with TD-6773. This was a 43% reduction in fresh weight when comparing 2% TD-6773 with 2% Off-Shoot-O. The 4% level of the two compounds showed a greater reduction (55%). Off-Shoot-O treated plants weighed 9.10 g. in contrast to TD-6773 treated plants, which weighed 4.10 g. The 4% Off-Shoot-O and the manually pinched plants were not significantly different from each other, while the TD-6773 treated plants did exhibit such a difference from the manually pinched plants.

Finally, in discussing the number of breaks (Table 1 and 2) and the average length of the breaks, the 2% level of TD-6773 caused enough tip damage to insure bud break, but excess phytotoxicity to the foliage was also observed. Off-Shoot-O at the 4% level exhibited the same number of breaks as plants manually pinched. Breaks produced at the 0% level of either chemical were significantly shorter than those at the 2% TD-6773 or 4% Off-Shoot-O levels. However, the average length of those breaks at 2% TD-6773 was significantly longer than on those plants treated with 4% Off-Shoot-O, the control plants, and those plants manually pinched.

Summation

1. Off-Shoot-O produced 86% tip kill with only 4% phytotoxicity at the 4% rate.
2. Off-Shoot-O was far more consistent than TD-6773 and had a wider margin of safety.
3. Off-Shoot-O yielded a greater fresh weight at the 4% level than TD-6773 at the 2% concentration.
4. Off-Shoot-O is better at 4% in relation to TD-6773 when considering the average number of breaks, but not the average length of breaks.

References

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EFFECTS OF HERBICIDES ON THE ROOTING RESPONSE OF CONTAINER-GROWN AZALEAS

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Ohio Agricultural Research and Development Center

While herbicides are an important tool in the production scheme of container-grown nursery stock, nurserymen have often expressed an interest in the effects of these materials on the use of treated plants as stock for future propagation material. At the present time, little information is available in the literature on the effects of various herbicides on rooting of cuttings taken from herbicide-treated stock plants. With this in mind, the following study was established to evaluate the effects of several herbicides commonly used on container-grown nursery stock on the future rooting response of two azalea cultivars.

Uniform plants of Coral Bells and Pres. Clay azaleas were planted in 1-gal. nursery containers in a medium of equal parts of loam, pine bark, and sand.

Each herbicide treatment was replicated three times with three plants per replicate. The herbicides and formulations employed are listed in Table 1. Two rates of application were employed for each herbicide; a normal rate (X) which was within the range normally required to control weeds, and either a 3X or 4X rate to ascertain information on crop tolerance.

All of the herbicidal sprays were applied in 1.5 gal. of water, equivalent in volume to 0.1 acre-inch of water with a CO₂ constant-pressure small-plot sprayer, and were incorporated immediately after application with 1 in. of irrigation water to act as a water seal. Following herbicide application, the plants were placed in a shade house (50%) for the remainder of the experimental period. Standard nursery practices were employed in the fertilization and maintenance program.

<table>
<thead>
<tr>
<th>Common Name*</th>
<th>Trade Name and Formulation</th>
<th>Chemical Name*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trifluralin</td>
<td>Treflan-4EC</td>
<td>α, α, α-trifluoro-2,6-dinitro-N,N-di-propyl-p-toluidine</td>
</tr>
<tr>
<td>EPTC</td>
<td>Eptam-6EC</td>
<td>S-ethyl dipropylthiocarbamate</td>
</tr>
<tr>
<td>Chlorpropham</td>
<td>Chloro-IPC-4EC</td>
<td>isopropyl-m-chlorocarbanilate</td>
</tr>
<tr>
<td>Simazine</td>
<td>Princep-80%WP</td>
<td>2-chloro-4,6-bis(ethylamino)-s-triazine</td>
</tr>
<tr>
<td>Diphenamid</td>
<td>Enide-50%WP</td>
<td>N,N-dimethyl-2-2-diphenylacetamide</td>
</tr>
<tr>
<td>Dichlobenil</td>
<td>Casoron-50%WP</td>
<td>2,6-dichlorobenzonitrile</td>
</tr>
</tbody>
</table>

*Common and chemical names accepted by the terminology committee of the Weed Science Society of America.
Data on the effects of these herbicides on control of weed growth have previously been reported (2).

Eighty days after application of the herbicides, 10 softwood tip cuttings were taken from each treatment replicate, immediately re-cut on the basal end, treated with Hormodin No. 1, and stuck in a peat-sand (1:1) medium in a ground bed equipped with intermittent mist.

Root development was evaluated 60 days later, and an index number for each cutting was obtained. To obtain an index number, each cutting was assigned to one of four rooting classes (no roots, light, medium, and heavy rooting). The number of cuttings in each class was multiplied by 0, 1, 3, or 5, respectively, and all figures totalled to give the index value for the treatment replicate. With 10 cuttings in each treatment replicate, possible values ranged from 0 to 50, with 0 indicating no rooting and 50, heavy rooting.

Analysis of variance and Duncan’s Multiple Range Test were performed to delineate any treatment differences.

The root-response index values taken from the herbicide-treated and control plants are presented in Table 2. No significant differences in rooting response of the Coral Bells azaleas as a result of normal herbicide rates were observed when compared to the untreated control plants. However, when Casoron was employed at the 12-lb. ai/A rate, a significant reduction in rooting response was observed. All cuttings taken from the Coral Bells azaleas treated with Eptam at the 20-lb. ai/A rate exhibited a severely reduced rooting response. Previously published data showed that severe injury in the

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate 1b. ai/A</th>
<th>Mean Rooting Response*</th>
<th>Coral Bells</th>
<th>Pres. Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casoron</td>
<td>4.0</td>
<td>38.7 ab†</td>
<td>15.0 de</td>
<td></td>
</tr>
<tr>
<td>Casoron</td>
<td>12.0</td>
<td>10.0 c</td>
<td>10.3 e</td>
<td></td>
</tr>
<tr>
<td>Treflan</td>
<td>2.0</td>
<td>33.7 b</td>
<td>43.9 ab</td>
<td></td>
</tr>
<tr>
<td>Treflan</td>
<td>8.0</td>
<td>43.3 ab</td>
<td>43.3 ab</td>
<td></td>
</tr>
<tr>
<td>Chloro-IPC</td>
<td>2.0</td>
<td>43.3 ab</td>
<td>35.3 ab</td>
<td></td>
</tr>
<tr>
<td>Chloro-IPC</td>
<td>8.0</td>
<td>40.3 ab</td>
<td>45.3 a</td>
<td></td>
</tr>
<tr>
<td>Eptam</td>
<td>5.0</td>
<td>39.9 ab</td>
<td>36.3 ab</td>
<td></td>
</tr>
<tr>
<td>Eptam</td>
<td>20.0</td>
<td>5.0 d</td>
<td>18.9 cde</td>
<td></td>
</tr>
<tr>
<td>Princep</td>
<td>1.0</td>
<td>44.7 ab</td>
<td>33.3 abc</td>
<td></td>
</tr>
<tr>
<td>Princep</td>
<td>4.0</td>
<td>41.9 ab</td>
<td>29.0 bcd</td>
<td></td>
</tr>
<tr>
<td>Dymid</td>
<td>5.0</td>
<td>48.9 a</td>
<td>37.9 ab</td>
<td></td>
</tr>
<tr>
<td>Dymid</td>
<td>20.0</td>
<td>39.9 ab</td>
<td>42.7 ab</td>
<td></td>
</tr>
<tr>
<td>Non-treated Control</td>
<td>-</td>
<td>45.3 ab</td>
<td>40.7 ab</td>
<td></td>
</tr>
</tbody>
</table>

*Rooting Index: 0= no rooting; 50= all cuttings heavily rooted.
†Means in a column followed by the same letter or letters are not significantly different at P = .05.
form of necrosis and stunting occurred when high rates of either Eptam or Casoron were used on container-grown nursery stock (2).

Pres. Clay azaleas, treated with both the 4- and 12-lb. ai/A rate of Casoron, exhibited significant reductions in rooting response when compared to the untreated controls. Similarly, the Pres. Clay azaleas treated with the 20-lb. ai/A rate of Eptam exhibited a reduced rooting response. None of the other herbicides rates showed any reduction in rooting response.

Princep at the 4-lb. ai/A rate exhibited a trend toward some reduction in rooting response on the Pres. Clay azalea cuttings, although it was not significant when compared to the non-treated controls.

In general, the data agree with previously published research by Ahrens (1) that when herbicides are employed at the normal rates, some reduction in rooting response may occur.

**Literature Cited**


GALINSOGA CONTROL IN NURSERY PLANTINGS

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Ohio Agricultural Research and Development Center

Galinsoga, or Cincinnati Weed, is a serious problem in certain areas of Ohio. An experiment was designed to determine the most effective pre-emergence herbicide or herbicide combination to control this invasive weed.

The study was conducted on silt-loam soil in a commercial nursery in Clark County. The herbicides were applied and irrigated in April 18 and July 11, 1972. The lining-out stock from cuttings taken the previous summer was planted April 12, 1972. As shown in Table 1, good to excellent results were obtained with Lasso, Princep, and all Princep combinations after 2 months. Acceptable results were noted with Dymid and Chloro IPC. Lasso, Princep, and Princep combinations were still effectively controlling Galinsoga after 3 months. Weed control in September, following July re-treatment, corresponded similarly to the June treatment above.

The least amount of injury in conjunction with acceptable galinsoga control occurred with Dymid and Lasso, as shown in Table 1.

The selection of the proper herbicide to control galinsoga must be based on ornamental crop tolerance. Since Lasso is not labeled for ornamentals, it can only be suggested on a trial basis. Princep and its combinations, although injurious to certain deciduous items, could be used for galinsoga control in conifers and selected deciduous plants. Dymid is safe to use on most crops, but is only fair in control of galinsoga and is effective for only 8 weeks. Chloro IPC is somewhat more effective than Dymid in weed control, but injurious with several species. KERB (not registered for ornamentals), treflan, and ornamental weeder did not satisfactorily control galinsoga.

Dymid and Treflan are the only herbicides used in this study which are available to the general public through retail outlets.

### TABLE 1. Herbicide Evaluation for Galinsoga Control and Phytotoxicity in Lining-out Stock of Woody Ornamentals.

<table>
<thead>
<tr>
<th>Herbicides</th>
<th>Formulation</th>
<th>Rate al/A (2 Months)</th>
<th>Percent Control</th>
<th>Crop Injury (0 = No Injury, 100 = Kill)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td></td>
<td>0 0 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Princep</td>
<td>G</td>
<td>1 100 20 10</td>
<td>30 10 30 70 40 10</td>
<td></td>
</tr>
<tr>
<td>Lasso</td>
<td>E</td>
<td>2.5 90 10 10</td>
<td>0 10 20 30 10</td>
<td></td>
</tr>
<tr>
<td>Princep + Lasso</td>
<td>G 1+4</td>
<td>100 30 10 10</td>
<td>10 10 40 70 60 10</td>
<td></td>
</tr>
<tr>
<td>Dymid</td>
<td>G</td>
<td>8 70 10 10</td>
<td>0 0 20 20 0</td>
<td></td>
</tr>
<tr>
<td>KERB</td>
<td>W</td>
<td>1.5 30 10 10</td>
<td>10 10 20 20 0</td>
<td></td>
</tr>
<tr>
<td>Chloro IPC</td>
<td>E</td>
<td>10 80 10 0</td>
<td>0 50 40 30 40</td>
<td></td>
</tr>
<tr>
<td>Treflan</td>
<td>G</td>
<td>2 50 10 0</td>
<td>0 0 10 0 0</td>
<td></td>
</tr>
<tr>
<td>Princep + Treflan**</td>
<td>W+E 1+2</td>
<td>100 40 0</td>
<td>30 10 40 90 30 10</td>
<td></td>
</tr>
<tr>
<td>Ornamental Weeder</td>
<td>G 4.3</td>
<td>40 0 0</td>
<td>10 20 0 30 20</td>
<td></td>
</tr>
</tbody>
</table>

* --- Values 30 or above are too injurious and considered unacceptable.
† --- Values 70 or above are acceptable.
** --- Incorporated.
A SURVEY OF THE FOLIAR MINERAL ELEMENT CONTENT
OF NURSERY-CROWN ORNAMENTALS

Elton M. Smith
Department of Horticulture
Ohio Agricultural Research and Development Center

Leaf analysis is used as a standard method of diagnosing plant nutrient disorders and making fertilizer recommendations for many agronomic and horticultural crops. In the area of landscape horticulture, leaf analysis is not utilized extensively, since research has been limited and has related to only a few species (1-6). In Lake County, Ohio, 1,400 different types of ornamentals are commercially available, thus indicating the magnitude of the problem.

A survey of the foliar mineral element content of 30 species and cultivars of woody ornamentals was undertaken to determine: if appreciable differences exist in the levels of 12 mineral elements in deciduous trees and shrubs and broadleaf and narrowleaf evergreens; the average mineral element values which could be used to diagnose nutritional problems and serve as base points for research in woody ornamentals; and the most satisfactory time of year to obtain samples.

The survey was conducted between 1968 and 1971 in five commercial nurseries in Clark and Lake counties, Ohio. The average soil pH for evergreens was 5.7 and for deciduous plants 6.1. Fifty to 100 leaves were collected monthly, from May through October, from 50 different plants of a species or cultivar. These samples were collected from recently expanded leaves of trees, shrubs, and broadleaf evergreens while terminal cuttings, 2 to 3 inches in length, were removed from narrowleaf evergreens. The leaves were dried and ground in a Wiley mill to pass a 40-mesh screen. Nitrogen was analyzed initially by macro-Kjeldahl and more recently by the micro-automated Kjeldahl process. The 11 other mineral elements were determined on the direct reading emission spectrophotograph. The species and cultivars of field-grown stock in assorted sizes sampled included:

### Trees
- Betula pendula
- Cornus florida
- Crataegus phaenopyrum
- Liquidambar styraciflua
- Prunus subhirtella Pendula
- Pyrus calleryana Bradford
- Sorbus aucuparia

### Shrubs
- Rhododendron Cascade
- Chaenomeles speciosa
- Cotoneaster apiculata
- Euonymus alatus Compacta
- Syringa vulgaris Edith Cavell
- Viburnum plicatum

### Broadleaf Evergreens
- Euonymus fortunei vegetus
- Hedera helix
- Ilex crenata Convexa
- Ilex opaca
- Leucothoe catesbei

### Narrowleaf Evergreens
- Juniperus chinensis Pfitzeriana
- Picea omorika
- Pinus strobus
- Taxus media Browni
- Taxus media Hicksi
The foliar mineral element values for deciduous trees and shrubs were about the same for most elements. Values for deciduous plants were higher than evergreens for most elements, and significantly so at the 5% level in respect to nitrogen, potassium, calcium, magnesium, molybdenum, and aluminum as shown in Table 1.

The mineral element values of broadleaf evergreens, except for nitrogen, phosphorous, and potassium, were slightly higher than those of narrowleaf evergreens, particularly in respect to calcium, iron, molybdenum, zinc, and aluminum as shown in Table 2.

With certain elements, the levels showed marked changes with time. For example, nitrogen and potassium values generally decreased throughout the summer. Increased values with time were noted with calcium, magnesium, iron, and aluminum. The levels of phosphorous, manganese, iron, copper, molybdenum, and zinc remained relatively constant throughout the season.

As expected, levels of nitrogen, phosphorous, and to a lesser extent potassium, were considerably higher in May and June while calcium and magnesium were lower during these months.

The most satisfactory time of year to sample is July-September based on greater stability in mid-summer vs. the fluctuations which occur in May and June, and to some extent October as indicated in Table 3.

The values in Table 4 may be used to assist in diagnosing nutritional disorders, and as a guide for fertilizer studies if similar analytical techniques are involved. The figures are based on averages during the months of July-September only, and are similar to those of Davidson (3).

The values for deciduous plants only average slightly higher than those in Table 4, while evergreens are somewhat lower, particularly with respect to nitrogen, potassium, calcium, magnesium, molybdenum, and aluminum.

In summary, the survey results indicate only a slight variation in mineral-element levels between species, although evergreen levels were lower than deciduous plants. Levels in samples taken during the period July to September were the most uniform. Values are suggested as a base for future work and as guidelines in diagnostic procedures.

**Literature Cited**

Table 1.--Average Foliar Mineral Element Values for 14 Deciduous and 16 Evergreen Species and Cultivars Sampled Monthly from May through October.

<table>
<thead>
<tr>
<th>Percent</th>
<th>p.p.m.</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Mn</th>
<th>Fe</th>
<th>B</th>
<th>Cu</th>
<th>Mo</th>
<th>Zn</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av. for Deciduous Plants</td>
<td>2.56a</td>
<td>33a</td>
<td>1.27a</td>
<td>1.80a</td>
<td>.39a</td>
<td>222a</td>
<td>277a</td>
<td>37a</td>
<td>21a</td>
<td>3.60a</td>
<td>52a</td>
<td>463a</td>
<td></td>
</tr>
<tr>
<td>Av. for Evergreen Plants</td>
<td>2.17b</td>
<td>30a</td>
<td>1.06b</td>
<td>1.21b</td>
<td>.25b</td>
<td>249a</td>
<td>263a</td>
<td>35a</td>
<td>21a</td>
<td>2.37b</td>
<td>61a</td>
<td>380b</td>
<td></td>
</tr>
</tbody>
</table>

*Means in each column followed by a different letter are significantly different at the 5% level.

Table 2.--Average Mineral Element Values for Nine Broadleaf and Seven Narrowleaf Species and Cultivars of Woody Plants Sampled Monthly from May through October.

<table>
<thead>
<tr>
<th>Percent</th>
<th>p.p.m.</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Mn</th>
<th>Fe</th>
<th>B</th>
<th>Cu</th>
<th>Mo</th>
<th>Zn</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadleaf Evergreens</td>
<td>2.16a</td>
<td>.27a</td>
<td>1.09a</td>
<td>1.49a</td>
<td>.29a</td>
<td>300a</td>
<td>338a</td>
<td>39a</td>
<td>23a</td>
<td>3.00a</td>
<td>66a</td>
<td>469a</td>
<td></td>
</tr>
<tr>
<td>Narrowleaf Evergreens</td>
<td>2.18a</td>
<td>.33a</td>
<td>1.05a</td>
<td>.89b</td>
<td>.19a</td>
<td>197a</td>
<td>189b</td>
<td>34a</td>
<td>18a</td>
<td>1.66b</td>
<td>56b</td>
<td>279b</td>
<td></td>
</tr>
</tbody>
</table>

*Means in each column followed by a different letter are significantly different at the 5% level.

Table 3.--Average Monthly Foliar Mineral Element Values for 14 Deciduous Woody Plants.

<table>
<thead>
<tr>
<th>Month</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>4.25</td>
<td>.61</td>
<td>1.61</td>
<td>.95</td>
</tr>
<tr>
<td>June</td>
<td>2.63</td>
<td>.31</td>
<td>1.22</td>
<td>1.26</td>
</tr>
<tr>
<td>July</td>
<td>2.30</td>
<td>.26</td>
<td>1.25</td>
<td>1.32</td>
</tr>
<tr>
<td>August</td>
<td>2.16</td>
<td>.32</td>
<td>1.46</td>
<td>2.05</td>
</tr>
<tr>
<td>September</td>
<td>2.22</td>
<td>.28</td>
<td>1.09</td>
<td>2.16</td>
</tr>
<tr>
<td>October</td>
<td>2.14</td>
<td>.27</td>
<td>1.14</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Table 4.--Average Mineral Element Values of 30 Species and Cultivars of Woody Ornamentals Sampled Monthly from July through September.

<table>
<thead>
<tr>
<th>Woody Ornamentals</th>
<th>Percent</th>
<th>p.p.m.</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Mn</th>
<th>Fe</th>
<th>B</th>
<th>Cu</th>
<th>Mo</th>
<th>Zn</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.15</td>
<td>.30</td>
<td>1.25</td>
<td>1.56</td>
<td>.34</td>
<td>237</td>
<td>284</td>
<td>37</td>
<td>21</td>
<td>3.43</td>
<td>56</td>
<td>410</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-31-
   element status of some ornamental trees. J. Amer. Soc. Hort. Sci., 76:
   661-666.


4. Furuta, T., F. Perry, and H. P. Orr. 1963. Leaf position and nutrient
   82: 526-531.

   composition of leaves and stems of Taxus media. J. Amer. Soc. Hort. Sci.,
   86: 809-814.

   composition of leaves and stems of Taxus media. J. Amer. Soc. Hort. Sci.,
   87: 545-550.
The black vine weevil (BVW), *Otiorhynchus (Brachyrhinus) sulcatus*, has been a serious pest of *Taxus* and *Rhododendron* in Ohio for many years. Ohio nursery inspectors restrict sale and shipment of infested nursery stock annually, although growers spend thousands of dollars each year to implement control programs. Studies on this pest were started recently because Ohio nurserymen have been unable to combat it successfully.

The BVW overwinters in the larval stage beneath the ground near infested plants. They resume feeding the following spring as rising temperatures warm the ground. Since overwintering larvae are large (3/8 in. long), their spring feeding is quite destructive, especially on newly transplanted cuttings. In fact, one Lake County grower lost his entire 1-year-old crop of *Taxus* in the spring of 1973. Some damage was evident the previous fall, but most of it occurred this spring. Larger, established plants which have suffered extensive root damage break bud later in the spring than healthy plants.

Larvae finish feeding and begin pupating in the soil in mid-May. Adults begin emerging 2 to 3 weeks later. Emergence was essentially complete in Lake County by mid-June. All adults are flightless females. Reproduction is parthenogenetic. Dispersal is slow and high population density can occur in a short time (2 to 3 years), since most progeny remain near their birthplace to deposit eggs. High population density is reached rather quickly when preferred hosts are plentiful in loose (sandy) soil.

When adults emerge from the pupal cells and crawl above ground, their guts are empty and they are little more than hollow shells. During the next few weeks, their eggs mature as they feed on plant foliage, usually at night. Most adults hide in the plant canopy during the day. While larval hosts are limited in the nursery, adults feed on many woody ornamental plants.

Although Smith (1932) observed that a few adults overwinter successfully out of doors, it was believed there was no need to apply adulticides until mid-June, when new adults crawl to the ground surface to begin feeding (Anonymous 1973). However, this spring (May 7), two live adult BVW's which were duller than newly emerged females were found. This was a month before new adults emerge. One of the beetles was squeezed and well-developed eggs, which probably would have been deposited within a week or two, were found. The other beetle was taken to the laboratory and fed *Taxus* foliage. She produced eggs after feeding for 2 weeks. It now appears likely that some adults overwinter.

Although it is not known what percentage or number of beetles overwinter here, it is possible that enough do to keep infestation at a damaging level. These beetles and their progeny would not be affected by adulticides which are not applied until mid-June or later. This overwintering of adults may help explain part of the BVW problem in northeastern Ohio. Study of the biology and seasonal history of this pest is continuing.
During the past few years, growers and nursery inspectors from the Ohio Department of Agriculture (ODA) noted that dieldrin, used as recommended, no longer gave acceptable control of adult BVW's. Other accounts indicated that soil treated with from 3 to 5 lb. of active dieldrin contained living BVW larvae. These observations led the OARDC and the ODA to initiate a cooperative study to determine if BVW had or was developing resistance to cyclodienes, and to develop new recommendations for control of BVW in nurseries. Governmental restrictions on some of the so-called hard pesticides demanded evaluation of other classes of insecticides for their toxicity to BVW.

Two black vine weevil populations have been tested for their susceptibility (or resistance) to technical dieldrin. This work has done during 1973 in the new Pesticide Testing Laboratory at the Department of Entomology, OARDC. Preliminary data indicate that BVW's from different parts of Ohio react differently to dieldrin. Weevils from Lake County were much more resistant to dieldrin than were those from Mahoning County. This work will continue, using both local populations and weevils from other parts of the U.S. A final report should be ready for publication by 1975.

The first field evaluation of insecticides for control of BVW will be conducted later this year. The goal is to develop a new control program which can be directed against larvae, both prior to and after establishment of a planting. Other studies may lead to development of new recommendations for controlling adults, giving the grower two chances to kill this highly destructive weevil.

References Cited


THE CHEMICAL CONTROL OF APPLE SCAB ON ORNAMENTAL CRABAPPLES

Charles C. Powell, Jr.
Department of Plant Pathology
Ohio Agricultural Research and Development Center

Use of resistant cultivars is the most successful way to combat apple scab on ornamental crabapples. However, there are still many susceptible cultivars grown by nurseries and in landscapes throughout Ohio. Chemicals must be used to control scab on these cultivars.

The 1973 Commercial Fruit Spray Recommendations for Ohio (Bulletin 506) lists 12 fungicides which control apple scab. For orchardists, one or more of these materials are generally used in spraying programs of 11 or more applications a season. Such an effort results in almost complete control of the disease. An apple with even one scab lesion is unusual.

Such intensive chemical control programs are not too useful for nurserymen or landscape maintenance people. First, they need not achieve the same degree of control as an orchardist. Susceptible crabapple cultivars can be grown acceptably with a few lesions on leaves or fruit. But if the disease causes extensive defoliation, the lack of vigor or the unsightliness of the tree will be of concern to the ornamentalist. Second, economics will generally prevent extensive spray programs. Nurserymen cannot apply fungicides weekly in the early spring when other production tasks must be done. Landscapers cannot recover the cost involved in treating trees several times each spring.

New systemic fungicides are not as subject to weathering. Thus, there exists the possibility of lengthening the interval between sprayings. Oil adjuvants have also been shown to increase the efficacy of systemic fungicides. Finally, variation in the timing of these newer fungicides may make possible reasonable scab control on ornamental crabapples with one or two applications.

Materials and Methods

Two blocks of 6-year-old Hopa crabapples were selected at Cole Nursery Co., Circleville, Ohio. Eight trees per block were sprayed with each treatment. Spraying began on April 26, 1972, when the trees were at 25% full bloom. The latest sprays were applied on June 26, 1972. Two-gallon Hudson Favorite Sprayers were used.

The following spray materials were used: benomyl 50WP (Benlate, DuPont Chemical Co.), thiophanate-m 70WP (Topsin-m, Pennwalt Chemical Co.), triarimol 7.2EC (Bloc, Elanco Products Co.), and a 70-second paraffinic oil (Sunspray 7E, Sun Oil Co.). Spray programs were set up to compare materials, test the effect of the oil adjuvant, study the spray interval, examine the effects of varying spray-cutoff-dates, and evaluate the success of one-spray-only programs.

On August 21, 1972, the trees were observed and treatments were evaluated. Percent defoliation was estimated using the 0-11 Elanco scale: 0 = 0%, 1 = 0-3%, 2 = 3-6%, 3 = 6-12%, 4 = 12-25%, 5 = 25-50%, 6 = 50-75%, 7 = 75-87%, 8 = 87-93%, 9 = 93-97%, 10 = 97-
After the ratings were made, the numbers were converted to midpoints of the percentage ranges indicated and statistically analyzed.

Results

Treatments which resulted in average percent defoliation under 12% were considered satisfactory. Such a small amount of defoliation would probably not be objectionable on ornamental crabs in the nursery or landscape. Using these criteria, it can be seen that all of the chemicals tested out satisfactorily controlled scab in the comparative tests at either 10- or 20-day spray intervals (Table 1). Further, the use of Sunspray 7E increased the control achieved with both the benomyl 50WP and the thiophanate-m 70WP (Table 2).

<table>
<thead>
<tr>
<th>TABLE 1.--Apple Scab Control: Comparison of Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials and Rate/100 gal.</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Benomyl 50WP, 4 oz.</td>
</tr>
<tr>
<td>Thiophanate-m 70WP, 4 oz.</td>
</tr>
<tr>
<td>Triarimol 7.2EC, 8 oz.</td>
</tr>
<tr>
<td>Thiophanate-m 70 WP, 4 oz.</td>
</tr>
<tr>
<td>Triarimol 7.2EC, 8 oz.</td>
</tr>
<tr>
<td>Check</td>
</tr>
</tbody>
</table>

*Spraying was done from April 26, 1972, (25% full bloom) to June 16, 1972; 10-day intervals = six sprays; 20-day intervals = three sprays.

†Treatments followed by the same letter (in each experiment) are not significantly different at the 95% probability level (Duncan's New Multiple Range Test).

<table>
<thead>
<tr>
<th>TABLE 2.—Apple Scab Control: Effects of Oil Adjuvant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials and Rate/100 gal.</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Benomyl 50WP, 4 oz.</td>
</tr>
<tr>
<td>Benomyl 50WP, 4 oz. + Sunspray 7E, 32 oz.</td>
</tr>
<tr>
<td>Thiophanate-m 70WP, 4 oz.</td>
</tr>
<tr>
<td>Thiophanate-m 70 WP, 4 oz. + Sunspray 7E, 32 oz.</td>
</tr>
<tr>
<td>Thiophanate-m 70WP, 4 oz.</td>
</tr>
<tr>
<td>Thiophanate-m 70 WP, 4 oz. + Sunspray 7E, 32 oz.</td>
</tr>
<tr>
<td>Check</td>
</tr>
</tbody>
</table>

*Spraying was done from April 26, 1972 (25% full bloom) to June 16, 1972; 10-day intervals = six sprays; 20-day intervals = three sprays.

†Treatments followed by the same letter (in each experiment) are not significantly different from one another at the 95% probability level (Duncan's New Multiple Range Test).
Benomyl 50WP with Sunspray 7E was used in all of the timing experiments. It was found that increasing the period between sprays to 30 days (two sprays only per season) resulted in satisfactory control (Table 3). A two-spray program also worked well in the spray-cutoff-date experiment (Table 4). Two sprays, 10 days apart in the early season, resulted in only slightly more scab than that seen on blocks given more sprays later in the season. In fact, for the 1972 season, a single spray applied on May 5 provided acceptable, although not outstanding, control (Table 5).

**TABLE 3.—Apple Scab Control: Effects of Spray Interval**

<table>
<thead>
<tr>
<th>Material and Rate/100 gal.</th>
<th>Spray Interval*</th>
<th>Percent Defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benomyl 50WP, 4 oz. + Sunspray 7E, 32 oz.</td>
<td>10 days</td>
<td>2a†</td>
</tr>
<tr>
<td></td>
<td>20 days</td>
<td>1a</td>
</tr>
<tr>
<td></td>
<td>30 days</td>
<td>4b</td>
</tr>
<tr>
<td>Check</td>
<td>---</td>
<td>90c</td>
</tr>
</tbody>
</table>

*Spraying was done from April 26, 1972 (25% full bloom) to June 16, 1972; 10-day intervals = six sprays; 20-day intervals = three sprays; 30-day intervals = two sprays.

†Treatments followed by the same letter (in each experiment) are not significantly different from one another at the 95% probability level (Duncan's New Multiple Range Test).

**TABLE 4.—Apple Scab Control: Effects of Earlier Spray Cutoff Dates**

<table>
<thead>
<tr>
<th>Material and Rate/100 gal.</th>
<th>Number of Sprays and Cutoff Date*</th>
<th>Disease Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benomyl 50WP, 4 oz. + Sunspray 7E, 32 oz.</td>
<td>1-April 26</td>
<td>25f†</td>
</tr>
<tr>
<td></td>
<td>2-May 5</td>
<td>1a</td>
</tr>
<tr>
<td></td>
<td>3-May 16</td>
<td>2a,b</td>
</tr>
<tr>
<td></td>
<td>4-May 26</td>
<td>3a,b</td>
</tr>
<tr>
<td></td>
<td>5-June 6</td>
<td>1a</td>
</tr>
<tr>
<td></td>
<td>6-June 16</td>
<td>2a,b</td>
</tr>
<tr>
<td>Check</td>
<td>---</td>
<td>90d</td>
</tr>
</tbody>
</table>

*The trees were at full bloom on April 26, 1972. Spraying was done at 10-day intervals.

†Treatments followed by the same letter (in each experiment) are not significantly different from one another at the 95% probability level (Duncan's New Multiple Range Test).
**TABLE 5.--Apple Scab Control: Effects of a Single Fungicide Application**

<table>
<thead>
<tr>
<th>Materials and Rate/100 gal.</th>
<th>Spray Date</th>
<th>Percent Defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benomyl 50WP, 4 oz. + Sunspray 7E, 32 oz.</td>
<td>April 26</td>
<td>25c†</td>
</tr>
<tr>
<td></td>
<td>May 5</td>
<td>5b</td>
</tr>
<tr>
<td></td>
<td>May 16</td>
<td>4a</td>
</tr>
<tr>
<td></td>
<td>May 26</td>
<td>45c</td>
</tr>
<tr>
<td></td>
<td>June 6</td>
<td>50c</td>
</tr>
<tr>
<td></td>
<td>June 16</td>
<td>82d</td>
</tr>
<tr>
<td>Check</td>
<td>---</td>
<td>90e</td>
</tr>
</tbody>
</table>

*The trees were at 25% full bloom on April 26, 1972.
†Treatments followed by the same letter (in each experiment) are not significantly different from one another at the 95% level (Duncan's New Multiple Range Test).

**Discussion**

All of these experiments were carried out in the spring of 1972 at Cole's Nursery. The results must be verified at other nurseries in future years before definite recommendations are made. For instance, the one-spray-only experiment showed that good control resulted from a single treatment on May 5. However, if sprays were applied only 10 days on either side of May 5, control was unsatisfactory. A recommendation to spray once only on May 5 would doubtless be of little value in other locations. Even at this location, it may be inadvisable in some years.

Two-spray programs, using benomyl plus a paraffinic oil adjuvant, may eventually become meaningful approaches to fungicidal scab control on ornamental crabapples. Of the two-spray programs which were successful here, the monthly sprays on April 26 and May 26 would probably be most meaningful. This program should be less subject to seasonal variation than the early cutoff two-spray program (April 26 and May 5).

Sunspray 7E was the only 70-second paraffinic oil tested as an adjuvant. Additionally, benomyl was the only fungicide tested in the timing experiments. Most probably, other closely related materials could be used with similar results. However, they should be evaluated before being used in such programs.

EFFECTS OF FERTILIZER PLACEMENT ON TREE GROWTH

Elton M. Smith
Department of Horticulture
Ohio Agricultural Research and Development Center

The application of fertilizer is an accepted method of improving tree health and vigor. However, the best placement of the fertilizer has been a point of dispute among research workers and arborists. The Technical Service Center staff of the Davey Tree Expert Company initiated a fertilizer trial to determine the growth response of four tree species to placement of fertilizer over a 5-year period. The study was conducted in Wooster silt loam at Shalersville, Ohio.

A minimum of 40 trees per species was planted in April 1963 at 15 by 20 foot spacings. Each tree trunk was marked with white paint 6 inches above ground level to insure annual measurements at the same location. Caliper measurements were conducted and fertilizer applied each year from 1965 through 1970 during November. An area of 36 sq ft around each tree comprised the treated area.

The trees included were: Quercus palustris (pin oak), Fraxinus pennsylvania lanceolata (green ash), Liquidambar styraciflua (American sweet gum), and Acer saccharinum (silver maple). The randomized fertilizer placements and rates of application are in Table 1.

Results and Discussion

A significant increase in caliper of all four species was obtained with most fertilizer placements.

The data in Table 2 indicate the growth response by species to fertilizer placement during the period 1965 to 1970.

<table>
<thead>
<tr>
<th>Placement</th>
<th>Description</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>No treatment</td>
<td>No fertilizer</td>
</tr>
<tr>
<td>Drill holes only</td>
<td>2-inch diameter holes drilled</td>
<td>No fertilizer</td>
</tr>
<tr>
<td></td>
<td>12 inches apart over 36 sq.ft.</td>
<td></td>
</tr>
<tr>
<td>Broadcast</td>
<td>Surface application of inorganic 12-4-4 fertilizer</td>
<td>5.5 lb.N/1000 sq. ft.</td>
</tr>
<tr>
<td>Drilled holes plus 12-4-4</td>
<td>Fertilizer equally distributed in 2-inch diameter, 18 inches deep on center holes</td>
<td>5.5 lb.N/1000 sq. ft.</td>
</tr>
<tr>
<td>Drilled holes plus 4-1-2 and ground corncobs*</td>
<td>Fertilizer equally distributed in 2-inch diameter, 18 inches deep on center holes</td>
<td>5.5 lb.N/1000 sq. ft.</td>
</tr>
</tbody>
</table>

*Available commercially as Davey Arbor Green
TABLE 2.—Growth Response by Species to Fertilizer Placement. Figures Represent Average Caliper Increase in Inches After 5 years of Annual Treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pin Oak</th>
<th>Green Ash</th>
<th>Sweet Gum</th>
<th>Silver Maple</th>
<th>All Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>1.72</td>
<td>1.38</td>
<td>1.44</td>
<td>2.40</td>
<td>1.75</td>
</tr>
<tr>
<td>Holes only</td>
<td>1.69</td>
<td>0.99</td>
<td>1.27</td>
<td>2.22</td>
<td>1.54</td>
</tr>
<tr>
<td>Broadcast</td>
<td>2.09</td>
<td>1.59</td>
<td>2.26</td>
<td>3.04</td>
<td>2.25</td>
</tr>
<tr>
<td>Holes + 12-4-4</td>
<td>2.56</td>
<td>1.87</td>
<td>1.88</td>
<td>3.44</td>
<td>2.44</td>
</tr>
<tr>
<td>Holes + 4-1-2</td>
<td>2.62</td>
<td>1.73</td>
<td>1.97</td>
<td>3.28</td>
<td>2.40</td>
</tr>
</tbody>
</table>

L.S.D. at 5% is 0.31

The holes-only treatment did not result in a diameter increase in comparison with the check trees of any species. The broadcast placement significantly increased growth in comparison to the check treatment with all trees except green ash. The holes plus 12-4-4 with inorganic nitrogen treatment resulted in a significant caliper increase with all species when compared to check trees. The holes plus 4-1-2 with ground corncob treatment also yielded a significant increase when compared to check trees.

Except in the case of sweet gum, the broadcast method did not result in the caliper increases of the holes-plus-fertilizer treatments.

There were no consistent growth differences between trees in the holes with 12-4-4 and holes with 4-1-2 fertilizer.

From a species standpoint, the sweet gum responded more positively to broadcast applications, while pin oak, green ash, and silver maple increased in caliper more with the drill holes plus fertilizer.

Conclusions

1. All species responded significantly to fertilizer treatments.

2. The drill hole treatment without fertilizer did not increase the growth of any species.

3. The broadcast placement significantly increased caliper of pin oak and silver maple, and was the most effective treatment with sweet gum.

4. The drill-hole placement with fertilizers incorporated resulted in the greatest overall caliper growth with all species considered.
Pin oaks, growing in the poorly drained and alkaline soils of central and western Ohio, often exhibit typical foliage chlorosis. In early summer, the interveinal areas of the leaves turn from green to yellow and sometimes white followed by small circular brown spots. In the most severe cases, foliage may drop and twig and branch die-back follows.

In 1971, a study was initiated to determine the effects of iron compounds applied on the foliage, to the ground, or in the trunk of pin oaks. The specific objectives were to determine visual color differences in the foliage and changes in iron levels in the leaves and soil as a function of treatment.

The study was conducted in a nursery at The Ohio State University with pin oaks averaging 5 inches in diameter, measured 1 foot from the soil line. The average pH reading in the clay-loam soil was 7.1. In order to work with trees exhibiting some chlorotic symptoms, treatments were delayed until July 13, 1971, and July 17, 1972. Evaluations of visual differences of the foliage were conducted periodically, and leaf and soil samples were taken Sept. 22, 1971, and Sept. 28, 1972.

The treatments and rates were as follows:

**Soil Applied**
- Iron Chelate (Sequestrene 138 Fe)
  - Applied at the rate of 8 oz. per tree broadcast within the 12-ft. diameter dripline.
- Micronized Iron (GU-49)
  - Applied at the rate of 1 tablespoon per inch caliper, with 1 teaspoon per 18-inch drilled hole evenly spaced within the dripline.

**Foliar Sprayed**
- Iron Chelate (Sequestrene 138 Fe)
  - Applied at the rate of 25 lb. per 100 gal. of water plus spreader sticker. The foliage was sprayed to point of runoff.

**Trunk Injected**
- Iron Sulfate
  - Injected into the trunk at the rate of 4 g. dissolved in 50 ml. of distilled water per hole spaced 6 inches apart in a circular pattern around the base of the trunk.

**Results and Discussion**

Soil analysis data indicated no appreciable increase in the soil of available iron either year, from the surface-applied iron chelate or the drilled GU-49.
TABLE 1. --Effects of Treatment on Iron Levels in Pin Oak Foliage. Figures Represent Data from 50 Leaves Removed from a Total of Three Trees on Sept. 28, 1972.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Iron p.p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control—no treatment</td>
<td>200</td>
</tr>
<tr>
<td>Iron chelate (Sequestrene 138 Fe) soil applied</td>
<td>184</td>
</tr>
<tr>
<td>Iron chelate (Sequestrene 138 Fe) foliar applied</td>
<td>238</td>
</tr>
<tr>
<td>Micronized iron (GU-49) soil applied</td>
<td>242</td>
</tr>
<tr>
<td>Iron sulfate---trunk injected</td>
<td>268</td>
</tr>
</tbody>
</table>

Leaf analysis data revealed the greatest increase in iron levels with the trunk-injection treatment, followed by the soil-applied GU-49 and the foliar-applied iron sulfate, as shown in Table 1.

The visual response both years was greatest with the trunk-injection treatment. The trunk-injection treatment corrected the yellowing to a greater degree, and more consistently, than other treatments.

Summary

During two growing seasons, soil treatments did not result in an increase of soil iron levels. There were some iron level increases in the foliage from iron sulfate trunk injection, GU-49 drilled into the soil, and iron chelate applied to the foliage. Only the trunk-injection treatment resulted in appreciable greening of the foliage from the time of treatment. Research is continuing to further evaluate methods of preventing iron chlorosis of pin oak.
With the rapid increase in city growth, trees have become a great environmental asset. Trees in a city soften the harsh lines of buildings, as well as adding contrast to the monotony of asphalt and concrete. Trees add value which cannot be measured.

Emphasis in street tree planting should be placed on the proper tree for each location. Careful attention should be paid to the ultimate height and width of the tree. In addition, the presence of overhead utility lines should be carefully considered when planting a street tree.

A shade tree evaluation project was undertaken in 1966 by OARDC under the sponsorship of Ohio utility companies. The project was designed to conduct a nonbiased scientific evaluation of new introductions for street tree use. Most of the selections for street tree use mentioned in this publication can be found in the Shade Tree Evaluation Plot at the OARDC in Wooster.

The intention here is not to mention all trees suitable for street planting, but to bring attention to some shade trees which are relatively new to suburban and city arboriculture.

**Acer platanoides -- Norway Maple**

This plant has been used extensively in suburban and municipal plantings. The species which reaches heights of 65-75 feet is generally believed to be round headed, but is quite variable in overall shape. Trees grown from seed vary markedly in size, shape, and resistance to leaf scorch under conditions of water stress.

**Improved Introductions**

a. Cleveland -- A compact, upright oval selection similar in habit to Emerald Queen. It does not grow as rapidly and is more resistant to winter bark injury as a young tree than Emerald Queen. The mature height is 50 ft.

b. Emerald Queen -- This is a consistent, upright, oval-headed, rapid-growing selection achieving a mature height of 60 feet.

c. Greenlace -- A cultivar with light green, deeply lobed foliage. It is also noted for its upright habit. The mature height is between 50 and 60 feet.

d. Jade Glen -- A selection with a rapid growth rate, straight stems, and a spreading branching habit. It has a golden fall color.

e. Olmsted -- A wide columnar cultivar which is not as erratic a grower in youth as some other columnar varieties.
f. Royal Red — A maroon leaf variety more resistant to heat damage than other red leaf maples.

g. Summershade -- A seedling selection of *A. platanoides erectum* which is broader than Emerald Queen. It develops caliper quickly and achieves a mature height of 65 feet. It is noted for leaf scorch resistance in hot summer weather, in addition to having a strong central leader and dark green foliage.

*Acer rubrum* — Red Maple

The species is frequently a plant with poor yellow fall color, probably due to natural hybridization with the silver maple (*Acer saccharinum*). Trees of this species are noted for their ability to withstand moist conditions. Recently, there has been interest in selecting superior types, especially those with good red fall colors. The mature height of this species is 60 feet.

**Improved Introductions**

a. Armstrong -- A selection upright in character and the narrowest of all red maples. It is noted for its rapid growth rate, with a maximum height of 30-35 feet. This is a good choice for a narrow tree lawn.

b. Autumn Flame -- A cultivar with smaller leaves than October Glory, but which colors up 2 weeks earlier and defoliates at a much earlier date. The maximum height is approximately 60 feet.

c. Gerling -- This is an upright pyramidal selection, but is not as narrow as Armstrong. The maximum expected height is between 30 and 35 feet.

d. October Glory -- Selected for its excellent glossy green leaves, which become a spectacular scarlet to crimson color in the fall. The foliage of this globe-headed type persists longer than others. The maximum height is 50-60 feet.

e. Red Sunset -- A rapid and vigorous grower, achieving a mature height of approximately 50 feet. In addition to its good red fall color, it has a natural pendulous leaf character which is less apparent in larger specimens. The foliage is persistent in the fall on this broad, upright selection.

*Acer saccharum* — Sugar Maple

This is a fine large tree species with generally excellent fall color which recently has been subject to decline due to pollution. The mature height is approximately 65 feet.

**Improved Introductions**

a. Columnare -- A tight columnar, slow-growing variety, achieving mature heights of only 35 feet.
b. Green Mountain -- A hybrid between the black and sugar maples. It has very leathery, dark green leaves which are resistant to leaf scorch. In addition, it has good oval form with excellent vigor and good fall color, with a mature height of approximately 65 feet.

c. Temples Upright -- Formerly known as Monumentale, this narrow upright selection is too slow a grower for practical street tree use.

*Fraxinus americana* -- White Ash

This is a native species with a rapid growth rate, achieving mature heights of approximately 70 feet, and has a variable yellow to purple fall color. The selected cultivars are more desirable.

**Improved Introductions**

a. Autumn Purple -- A seedless selection with a consistent good purple fall color and a mature height of approximately 65 feet.

b. Rosehill Ash -- A selection with light green foliage changing to consistent bronze-purple fall color. The mature height is 70 feet. It is a male clone, eliminating the normal seed problem.

*Fraxinus pennsylvanica lanceolata* -- Green Ash

This is a native species of rapid growth, achieving mature heights of 55-60 feet, but has the liabilities of a heavy seed crop and irregular, often weak, branches.

**Improved Introductions**

a. Marshall Seedless -- A seedless form of green ash chosen for its pyramidal oval-headed character. The dark green foliage provides a dense shade. This widely used cultivar achieves a mature height of approximately 55 feet.

b. Summit -- Not as vigorous as the species but it has a straighter upright growth habit with smaller leaflets. This male clonal cultivar reaches a mature height of 60 feet.

The green ash selections are good choices for street trees, as they are tough and drought-resistant and very tolerant of de-icing salts. They grow very well, even in very alkaline soils.

*Ginkgo biloba* -- Ginkgo

This species has a very uniform foliage character, excellent disease and insect resistance, and appears to be quite tolerant of various air pollutants. It has an extremely variable growth habit and objectionable fruit on female forms. The male species achieves a mature height of approximately 60 feet.
**Improved Introductions**

a. **Autumn Gold** — A male selection with a mature height of 45 feet and an excellent yellow fall color, in addition to an upright, more compact habit of growth than the species.

b. **Fairmount** — A good pyramidal male selection, densely clothed with foliage on ascending branches, with mature heights similar to the species. Young trees have a strong, straight, tapering leader.

c. **Lakeview** — A male selection achieving a mature height of 50 feet. It is noted for its compact, tight habit of growth.

d. **Princeton Gold** — A spreading upright male selection.

e. **Princeton Sentry** — A narrow columnar male selection.

**Gleditsia triacanthos inermis** — Thornless Honey Locust

**Improved Introductions**

a. **Imperial** — A selection with a mature height of 30-35 feet which has a denser foliage than the straight inermis.

b. **Majestic** — A tree with a more regular compact habit than inermis. It has dark green foliage with few seeds produced. The mature height is about 65 feet.

c. **Moraine** — A seedless selection with good green leaves. The spreading habit becomes vase-shaped with age. The mature height is 80 feet.

d. **Shademaster** — A symmetrical selection with a straight, strong trunk. It is disease-free, fairly drought-resistant, and has a mature height of 40 feet.

e. **Skyline** — A pyramidal form with leathery leaves and a mature height of 45 feet. The seeds are not a problem, since generally male flowers are borne.

f. **Sunburst** — A tree with bright yellow foliage on branch tips, along with thornless, seedless character. Mature height of 30 to 35 feet.

**Liquidambar Styraciflua** — American Sweetgum

Young trees are generally pyramidal but become broader with age. The fall color and growth habit are quite variable on species. This tree is generally considered problem free and reaches a mature height of 55 feet.

**Improved Introductions**

a. **Burgundy** — A cultivar with deep red to dark purple fall color which colors later but persists longer than other types. The mature height is 60 feet.
b. Festival — A narrow upright cultivar with light fall colors of many shades of red and yellow, achieving a mature height of 60 feet.

*Ostrya virginiana* — European Hop hornbeam

This is a suitable selection able to withstand dry city conditions. This spreading tree reaches a mature height of 50 feet and has an excellent yellow fall color.

*Platanus acerifolia* — Bloodgood Strain — Bloodgood London Planetree

This cultivar is fairly resistant to anthracnose and has a growth habit similar to the species.

*Quercus acutissima* — Sawtooth Oak

This is an excellent wide-spreading tree with chestnut-like foliage which is very glossy. It is usually as broad as high, which is about 45 feet at maturity.

*Quercus imbricaria* — Shingle Oak

Mature trees have oblong leaves, dense foliage, and broad spreading habit. A very hardy tree which needs a wide tree lawn. It grows to 75 feet at maturity.

*Quercus palustris* — Pin Oak

This is a commonly used species with pendulous lower branches, which limit its street tree use. Mature height is 75 feet.

**Improved Introductions**

a. Sovereign — A selection with only horizontal or ascending branches, making it very desirable for street tree use. Mature height is 75 feet.

b. Crownright — A similar selection to Sovereign, but perhaps even narrower and more upright.

*Quercus robur fastigiata* — Upright English Oak

This is a columnar selection with small dark green foliage, growing to 70 feet at maturity.

*Quercus shumardi* — Shumard Oak

Although not a new introduction, it makes a good street tree. It has few disease and insect problems. The mature height is 75 feet.

*Tilia cordata* — Littleleaf Linden

This species is highly variable in growth habit if grown from seed. This irregularity
of form has limited its use as a street tree. It grows to a mature height of approximately 50 feet.

**Improved Introductions**

a. Chancellor -- A selection characterized by a straight trunk, dense foliage, and a compact narrow upright growth habit. It is a symmetrical cultivar, growing to 50 feet at maturity.

b. Greenspire - A rapid growing selection with a narrow-oval form, straight trunk, and small leathery foliage, in addition to small fragrant flowers in spring. The mature height is 50 feet.

c. June Bride -- A new, narrow, upright selection with very attractive yellow flowers in spring. The mature height is 50 feet.

d. Select -- A special budded selection with an upright form, straight trunk, and very heavy dark green foliage. Mature heights reach 50 feet.

e. Rancho -- A narrow upright selection with small foliage. This is a vigorous grower. Heights are 50 feet.

*Ulmus* -- *Elms*

**Improved Introductions**

a. *Ulmus hollandica* Groeneveld -- A selection which has the general shape of English elm, but has good disease resistance.

b. *Ulmus parvifolia* - Chinese Elm -- A very hardy small tree (to 30 feet) and a round oval form. It has dark green foliage which holds late in the fall and then becomes reddish in color. In addition, it has attractive flaking bark on older trees.

c. *Ulmus carpinifolia* Christine Buisman -- A slightly irregular grower, but it is resistant to Dutch elm disease and phloem necrosis. Mature height is 60 feet.

*Zelkova serrata* -- Japanese Zelcova

This is a species with a general vase-shaped habit similar to the American elm. It is, however, highly variable from seed which has limited its use. At maturity it will reach 60 feet.

**Improved Introductions**

a. Parkview -- A selection with the consistent vase-shape form, good foliage, and disease resistance, with heights similar to the species.

b. Village Green -- A vigorous straight trunk with the desirable vase-shape form.
It is a rapid growing selection, disease resistant, and very hardy. Mature heights are similar to species.

**New Flowering Trees for Street Tree Use**

*Malus - Flowering Crabapples*

Unless otherwise specified, the types mentioned are resistant to apple scab and fire blight.

**Improved Introductions**

a. American Beauty -- An upright growing type with large double, red flowers. The foliage turns from a bronze to a bronzy green with maturity. The fruit is small and red and only sparsely produced. This selection is moderately susceptible to scab.

b. Coral Burst -- A dwarf type growing to only 8 feet at maturity. The flowers are a double rose-pink. This tree has an upright habit with an overall oval form. It has moderate to light scab susceptibility.

c. Golden Hornet -- An upright selection growing to 20 feet at maturity. This tree has white flowers with small persistent golden fruit.

d. Kilbele -- A dwarf selection growing to 8 feet at maturity. This compact grower is noted for its purple red foliage and attractive red fruit.

e. Liset -- A selection with purple red flowers, dark red fruits, and purple green foliage. The mature height is approximately 12 feet.

f. Mary Potter -- A cultivar with pink to white flowers and small red fruits. At maturity it will reach 15 feet.

g. Red Jewel -- An excellent red-fruitied, white-flowered selection. The small fruits are glossy red and very persistent. The foliage is a good, glossy green. This plant has a compact habit with horizontal branching. At maturity it will reach 15 feet.

h. Red Splendor -- A cultivar with foliage purple red to dark green. This plant has pink to rose-pink flowers. It is moderately susceptible to fire blight.

i. Royal Ruby -- A narrow upright selection which grows to 15 feet at maturity. It has large, double, cup-shaped flowers which are often 2 inches in diameter. This vigorous grower has glossy, dark green leaves with very few fruit produced. In addition, it has moderate to light scab and fire blight susceptibility.

j. Snowdrift -- A single white flowering selection which is pink in bud. This selection has tiny orange red fruit which is quite persistent. It is noted for its straight trunk and upright branching habit. At maturity it will reach 20 feet.
k. White Angel -- A heavy flowering single-white selection, noted for good red fruits persisting until spring. This plant flowers abundantly when young and has good glossy green foliage.

l. Winter Gold -- A small, yellow fruiting selection with white flowers and good green foliage. It reaches a height of 20 feet at maturity. It has slight fire blight susceptibility.

m. Zumi Calocarpa -- This cultivar has white flowers with bright red fruits persisting until spring. It has a dense upright growth habit with dark green fruit. The mature height is approximately 15 to 20 feet.

*Prunus sargenti Columnaris* -- Columnar Sargent Cherry

This is an excellent columnar type with deep pink flowers, polished red bark, and a good red fall color. It is very hardy and maintains its narrow habit through maturity, which is approximately 40 feet.

*Prunus sargenti Rancho* -- Rancho Sargent Cherry

This selection is similar to Columnaris, with the same narrow habit and sharply ascending branches.

*Prunus serrulata Kwanzan* -- Kwanzan Oriental Cherry

This selection has double pink flowers and a compact, upright, spreading habit of growth. Very formal in character and subject to salt damage and winter frost cracks in exposed areas. At maturity, this tree will reach 25 feet.

*Pyrus calleryana* -- Callery Pear

This species grows to approximately 30 feet and is very tolerant of city conditions and heavy soils. It has good, glossy green foliage, abundant early white flowers, and a good reddish fall color. Its thorns are a limiting factor in its use as a street tree.

**Improved Introductions**

a. Aristocrat -- A selection similar to Bradford in hardiness character, but more ovate in shape and with slightly larger leaves. In addition, the branches are at right angles to the stem.

b. Bradford -- A thornless selection with all the good qualities of the species. It has a broad oval form at maturity, to 40 feet., usually fruitless, with ascending branches and a crimson fall color.

c. Chanticleer -- A good, sharply pyramidal selection narrower in form than Bradford, with an excellent yellow fall color.
d. Fauriel -- A dwarf selection growing to 15 feet, with a round form at maturity similar to Bradford but smaller.

e. Rancho -- A cultivar with good red fall color and white flowers similar to other types.
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APPENDIX

PLANNING FOR MAINTENANCE IN THE LANDSCAPE DESIGN PROCESS

F. K. Buscher, Area Extension Agent, Horticulture
Ohio Cooperative Extension Service
and J. D. Carpenter, Chairman,
School of Architecture
The Ohio State University

The time to begin a successful care and maintenance program for the garden is when the landscape is first designed. Successful landscape planning analyzes the problems and assets of the land, buildings, and people. In the landscape design process, information should be gathered and recorded on the conditions of the site and the needs of those who will use the land. This information can be organized to develop a program of how land can best be used within the owner's requirements for maintenance of plants, lawns, flowers, and structures.

The extent to which the land is developed for plants, paved areas, and structures depends on the owner's attitude towards gardening, outdoor living, and his desire for comfortable and beautiful surroundings. The owner's income and available time for maintenance activities should influence the extent and type of landscape development. However, a limited budget should not prevent him from developing a plan he wants. If a person has the time, he can do a lot of installation himself. With proper design, it is possible to keep the maintenance within time and investment limits.

With careful thought, maintenance does not have to be drudgery. It can be an incidental part of enjoyment because the plan reduces the normal backbreaking work of yard care. Good mowing strips, proper drainage, and plants with similar drainage requirements in the same bed can eliminate many gardening headaches. Maintenance must be a major consideration at the start of the landscape design process. Many ambitious landscape designs can make unnecessary work if they are planned for maximum effect rather than minimum maintenance.

It is possible to design a landscape for either non-gardeners or enthusiastic horticulturists. A happy medium can be designed within this range to accommodate almost any maintenance specification. There will always be a certain amount of work required by any garden. The extremes of minimum maintenance for gardens range from gardens left totally to nature to a house surrounded by green concrete. An example of maximum maintenance would be a formal garden of perennial flowers bordered with small clipped boxwood or yew hedges.

An evaluation should be made of the kinds of maintenance required for the various plant materials and structural elements selected for the landscape design. An example could be in planting a hedge. Privet might be selected because it is relatively inexpensive. However, Privet requires pruning at least twice a year.
An alternative would be to plant a hedge of slightly more expensive Tallhedge. It may never need pruning. The initial expense may be greater for the Tallhedge, but the Privet would require at least 2 hours per plant in maintenance over a 10-year period—actually more costly in the final analysis.

The functional and maintenance requirements of plants are the starting points for landscape design. Selection of plants and their arrangement in the landscape must be first determined on the basis of their design function. For example, if a plant is needed to fill an area 3 feet high and 3 feet wide when the plant is mature, selection of a plant which grows up to 8 feet high and 10 feet wide is obviously a mistake.

Once the functional requirements have been determined, several plants fitting these requirements can be selected from a plant list or reference which includes the various quality attributes. Perhaps the designer wishes to select a plant growing within a size range of 4 to 6 feet. He might choose a Hetz Chinese Juniper or an Oregon Holly Grape. He must decide whether the Hetz Chinese Juniper would grow best in a particular sunny and dry soil situation, or whether the Oregon Grape requiring special care and maintenance would be best suited. When the amount of time for maintenance is limited, it is also possible to select one or two plants from this list which are the most maintenance-free and still fit the functional and design requirements.

Areas where walks, patios, steps, walls, fences, or shelters will be constructed must be monitored for periodic maintenance. A concrete patio or walk will not need maintenance for 12 to 15 years, whereas asphalt drives or walks should be sealed every 2 years. There is a maintenance cost associated with asphalt which is not required by concrete. Painted wood structures and fences need repainting every 3 or 4 years. However, wood suited for outdoor use can be bleached or stained with a preservative, or allowed to weather naturally. Such treatment usually lasts for the 20-year life span of the structure. The choice of stain, paint, or other finish will dramatically affect how much maintenance will be needed.

The landscape design should be carefully analyzed to be sure the finished plan will not require more maintenance than originally desired. This analysis should take into account the maintenance operations for the various elements in the design. Elements requiring increasing levels of maintenance are: (from least to most) pavements, structures, trees and shrubs, ground covers, lawns, annual and perennial flowers, and plants requiring special care.

**Pavements**

Bricks set in sand are less costly than bricks set on a concrete base. Bricks on concrete are good for 20 to 30 years, but bricks set on sand need to be re-set every 3-5 years. The decision for justification of the extra cost of brick on concrete instead of sand is on maintenance.

**Structures**

Structures such as fences, benches, trellises, walls, and shelters can provide as much use, screening, and privacy as woody plants and with less maintenance. There is also a difference whether these structures are built out of wood, brick, metal, or
concrete in terms of maintenance. A brick, metal, or concrete bench may be more expensive to build, but will last 60 years or more, whereas a wood bench may last only half this time as it will splinter, weather, and wear. A decision must be made in the choice of materials in relation to cost and level of maintenance as opposed to long-term cost.

Trees and Shrubs

Selection of plants for maintenance requirements should be based on a number of considerations. Most important is the functional use or purpose of the plant in the landscape design. Other criteria for plant selection are whether an evergreen or deciduous plant is needed; rate of growth; ultimate size at maturity; effects of flowers, fruit, and foliage; form and habit of growth; bark, twig, and branching characteristics. Most trees and shrubs require some periodic pruning. Fewer varieties, but more plants of the same variety, can result in easier maintenance and will help create continuity in the planting design. Special cultural requirements such as soils, water, fertilizer, exposure, pest problems, or pruning needs should be known.

Ground Covers

With ground cover plantings, maintenance is needed the first year until the plants are established and ground area between the plants is covered. Selection of varieties can be determined similar to trees and shrubs. Herbicides can be used for weed control. Applications of fertilizers, mulches, and water hasten establishment. Spacing plants 9 inches apart will give cover in 1 year. Spacing plants 18 inches apart will provide cover in 2 to 3 years. Close spacing will cost more the first year, but requires less maintenance than wider spaced plantings.

Most ground covers for Ohio grow best when fertilized annually. Although it costs more, fertilization is necessary or ground cover growth becomes sparse and weeds begin to appear.

Honeysuckle is an inexpensive, rank-growing ground cover which will cover the ground fast without fertilizer. However, it requires frequent pruning to keep it in bounds. English Ivy will not cover the ground as a thick, green carpet without fertilizer. However, it needs little trimming. One ground cover plant may be more desirable based on appearance, initial cost, and the small expense to fertilize, as compared to long-term maintenance in trimming required by another.

Lawnss

The variety of lawn grass, whether a blend or mixture, and its rate of growth will influence mowing, fertilization, irrigation, weed and pest control, development of thatch, and resistance to traffic and wear.

Lawn grasses which make the best lawns need the most care and should not be planted unless proper maintenance is intended. Table 1 gives information concerning lawn grasses and mixtures, their potential quality, and amount of care and cost of upkeep.

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TABLE 1.—Selected Lawn Grasses

<table>
<thead>
<tr>
<th>Grass or Mixture</th>
<th>Potential Quality of Lawn</th>
<th>Sun or Shade</th>
<th>Amount of Care and Cost of Upkeep</th>
<th>Seed per 1,000 sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Varieties or Blends of Ky. Bluegrass</td>
<td>Good to Excellent</td>
<td>Sun</td>
<td>Average to Above Average</td>
<td>1-3 lb.</td>
</tr>
<tr>
<td>40-50% Ky. Bluegrass—Red Fescue*</td>
<td>Good</td>
<td>Shade</td>
<td>Average</td>
<td>1.5-4 lb.</td>
</tr>
<tr>
<td>100% Red Fescue</td>
<td>Fair</td>
<td>Heavy Shade</td>
<td>Below Average</td>
<td>3-5 lb.</td>
</tr>
<tr>
<td>100% Tall Fescue†</td>
<td>Poor</td>
<td>Sun</td>
<td>Below Average</td>
<td>6-8 lb.</td>
</tr>
<tr>
<td>100% Bentgrass</td>
<td>Excellent</td>
<td>Sun</td>
<td>Much Above Average</td>
<td>0.5-2 lb.</td>
</tr>
</tbody>
</table>

*Red fescue alone or in mixture with Kentucky bluegrass may also be used for low maintenance lawns in sunny areas.
†Use tall fescue only where coarse grass is not objectionable.

Maintenance of lawn grasses can be eternal. Kentucky bluegrass varieties requiring high maintenance for good to excellent quality are A-20, Penn-star, Windsor, and Fylking. For medium to low maintenance lawns of acceptable quality, Kenblue Kentucky bluegrass and adapted common Kentucky bluegrass varieties have been adequate.

A third alternative for low maintenance, if the property is large enough, is to plant a portion of the property to a common bluegrass, but mow it only once or twice a year.

**Flowers**

More maintenance is required for flowers on a square foot basis than any other garden plant. However, flowers are usually the most desired plant in the landscape because of color. Flowers with low maintenance requirements, but still effective, are: daffodils, irises, peonies, day-lilies, tall summer phlox, and hardy chrysanthemums. They can provide spots of color without much work.

Most flowers or bulbs need to be planted, cultivated, irrigated, divided, dug, stored, replanted, and pest-controlled. With careful selection of flowering ground covers, shrubs, and trees, spring and summer blooms are possible without the high maintenance required by annual and perennial flowers.

**Special Plants**

Rhododendron and broadleaf evergreens require acid soils, good drainage, and adequate soil moisture for best growth. Other plants requiring special care may include hybrid tea roses because of extra fertilization, watering, and pest control problems.

Lombardy poplars and willows may provide an inexpensive, quick, and effective screen, but also take extra maintenance because of pests, litter, and trash problems. Plants and flowers in tubs and planters require extra water, fertilizer, and attention.
Garden work centers for the storage of tools, equipment, and materials should not be overlooked in the maintenance analysis of landscape design. The integration of a work center and equipment storage shelter can be built into an existing privacy fence or screen. They will save space and, when constructed of the same building materials, become a subtle sculptural extension of the fence.

Adequate and well-located exterior electrical outlets and hose bibs are time and labor savers. The additional cost for more convenient hose bibs eliminates the constant dragging of hoses to irrigate the garden.

More thought should go into the consideration of an underground sprinkler system in the maintenance analysis. The cost of an irrigation system, using the new durable plastic pipe, is within the reach of most home owners today. A well-designed system can pay for itself, even in Ohio, in 2 or 3 years in effort and time saved dragging hoses around to irrigate the lawns, shrubs, and flower beds.
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COTONEASTERS IN THE LANDSCAPE

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Cotoneasters are grown mainly for their delightful foliage and abundant berries. They burst forth into small pink or white blossoms in May and June. A member of the rose family, cotoneaster is pronounced ko-toe'-nee-aster, not cotton-easter.

Landscape Use

Among the tallest growing forms, Peking Cotoneaster is used for hedge or screen purpose. The Spreading Cotoneaster which reaches 6 feet in height and becomes twice as wide is an excellent plant for large-area use in screens, shrub borders, and background purposes for other plants. Rockspray Cotoneaster is an excellent choice for espalier use since modern architectural trends toward small windows spaced in irregular fashion leave considerable wall space. The mounded form of Cranberry Cotoneaster makes a perfect choice for use in entrance plantings. A ground cover is often used in foundation and other plantings to connect plants and objects together to give a finished look. The semi-evergreen Skogholmen Cotoneaster is a good choice, for its branches will spread 3 feet or more. Since nearly 40 species of birds feed on the fruit, most of the cotoneasters make excellent plants for bird sanctuaries.

Cultural Requirements

Cotoneasters, as a group, should be planted in full sun, although a few of the ground cover types may take partial shade. Most grow better in well-drained soil and will not thrive in water-logged soil. Cotoneasters grow well in a wide pH range, including slightly alkaline conditions which prevail in much of central and western Ohio.

Like most plants, certain pests are bothersome including fireblight, spider mites, and aphids. Fireblight causes tip or shoot die-back, and it should be pruned and burned although antibiotics can be sprayed. Spider mites and aphids can be controlled with malathion or diazinon, as needed.

Selected Species and Cultivars of Cotoneasters

Large Shrub Species

*Cotoneaster acutifolia* -- Peking Cotoneaster: The hardiest and best cotoneaster for hedging is Peking, which reaches 12 feet in height but makes a fine clipped hedge half that height or less. Its pointed dark green leaves and tiny pinkish flowers are quite attractive, though its black fruit is not admired until the leaves fall.

*Cotoneaster divaricata* -- Spreading Cotoneaster: This common ornamental reaches 6 feet at maturity and has arching branches; pink flowers; egg-shaped, dark red berries, and dull, red fall foliage.
Cotoneaster multiflora — Multiflora Cotoneaster: Maturing at the same height as the Spreading Cotoneaster, this graceful shrub also has arching branches. The display of clusters of white flowers in May make this one of the best in flower. The red fruit approximately 1 inch long drops in September after the leaves turn yellow.

Small Shrub and Ground Cover Species and Cultivars

Cotoneaster adpressa Praecox — Early Cotoneaster: This is an excellent ground cover similar to Cranberry Cotoneaster, but having orange-red fruit. The leaves are 1 inch long, oval in shape, and have wavy margins. This variety is not as abundant as other types.

Cotoneaster apiculata — Cranberry Cotoneaster: Maturing at 3 feet with mound-like habit and arching branches, this is the most common ground cover plant. The flowers in May are pink, followed by large red fruit which ripens in late summer and persists into winter.

Cotoneaster dammeri Skogholmen — Skogholmen Cotoneaster: This provides an excellent, semi-evergreen ground cover which seldom matures over 1 foot in height, but extends to a diameter of 6 feet or more. This extremely winter-hardy cultivar has glossy green foliage and red fruit.

Cotoneaster horizontals — Rock Spray Cotoneaster: Although one of the most useful and popular of all Cotoneasters, unfortunately it is somewhat less hardy than others. The spreading branches resemble fish vertebrae arching 2 or 3 feet above ground or 4 or 5 feet up against a building. It is used for espalier purposes as a specimen plant and ground cover. The fruit is bright red.

Cotoneaster salicifolia repandens — Dwarf Willowleaf Cotoneaster: Semi-evergreen to evergreen, this cotoneaster grows only 4 to 5 inches tall but spreads broadly. It will withstand some shade. Due to its rapid growth, some winter die-back can be expected at the ends of the branches.


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FLOWERING DOGWOODS IN THE LANDSCAPE

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Among the best known of all trees familiar to homeowners and horticulturists of North America is the flowering dogwood, Cornus florida. Known simply as dogwood, this small, versatile, ornamental tree is of interest during the entire year. One of the true harbingers of spring, it is followed by attractive green foliage which provides a pleasant light shade in summer. A brilliant show of red fruit appears in the autumn, accompanied by red to scarlet leaf colors. The truly year-round cycle of the dogwood’s beauty ends with its interesting branching habit and outstanding winter silhouette.

Landscape Use

The flowering dogwood is a small tree normally not more than 30 feet at maturity. Dogwoods can be grown either single or multiple stem.

The flowering dogwood has many uses in the home landscape. It can be used as a shade tree for the small property or patio area, casting welcome light shade on a hot summer day. Enframement or background can also be provided for the small property or ranch-style home. The dogwood provides an outstanding specimen or accent plant with its multiseason interest. Flowering dogwood, even in shady locations, can provide an interesting and useful screen planting. Wildlife also find this tree an excellent source of food. Flowering dogwoods are excellent companion plants in borders, as they cast light shade and do not have a fiercely competitive root system. They are especially useful companion plants for azaleas, rhododendron, and other ericaceous plants because of similar cultural requirements.

Culture

In general, the dogwoods are difficult to transplant. Therefore to insure success, they should be moved, balled, and burlapped. Pruning is seldom done except to remove injured, diseased, dead, or insect-infested tissue.

The dogwood borer larvae is one serious pest which will penetrate the bark and girdle the tree. Dogwood borers are mainly a problem to injured trees because the larvae need a weak spot to penetrate the bark. Bracing newly planted trees to prevent wind damage, and wrapping the trunks of newly transplanted trees with burlap or tree wrap paper for the first year of growth will reduce damage caused by these insects. For maximum protection, spray the trunk and lower branches with Dieldrin or Lindane monthly between April 15 and Oct. 15. Follow directions on the label for rates and precautions.

To reduce dessication of the flower buds, dogwoods should be planted in an area protected from winter winds. Dessication can result in flower bud kill or flowers with two rather than four bracts per flower cluster.
Selected Cultivars of Flowering Dogwood

Cultivars Grown for Their White Bracts

a. *Cornus florida*, Cloud Nine: Produces large white bracts at an early age. It has been reported that 1-year old trees will produce up to 20 flowers.


c. *Cornus florida*, Gigantea: Found wild in 1932 at Westbury, Long Island. White flower bracts are reportedly 6 inches from tip to tip.

d. *Cornus florida*, Pleuribracteata: A cultivar grown for its extra white flower bracts often numbering six to eight.

e. *Cornus florida*, Cherokee Princess: A selection of the white flowering dogwood, grown for its large white bracts. It has been observed to have a more vigorous habit than seedling selections.

f. *Cornus florida*, Fragrant Cloud: This cultivar is primarily grown for its reportedly fragrant flowers.

Cultivars Grown for Their Pink to Red Colored Bracts

a. *Cornus florida*, Rubra: First pink-bracted form to be observed in the wild, it was first observed by Marc Catesby in Virginia about 1731. In general, this cultivar is less cold hardy than the white-bracted types, and the color of the bracts varies from washed-out pink to deep red.

b. *Cornus florida*, Cherokee Chief: Found and named from a seedling found near Winchester, Tenn., in 1958, it is grown for its deep pink flower bracts and reddish colored new growth. This cultivar is also grown and distributed under the name Super Red.


Cultivars Grown for Other Reasons

a. *Cornus florida*, Fastigiata: An upright habit when young. After 15 to 20 years, the branches will gradually bend downward to the horizontal form similar to the native white-bracted type.

b. *Cornus florida*, Welchii: Selected and named in 1920, this cultivar is grown for its leaves which exhibit a combination of green, creamy-white, and pink colors. Overall, this plant is a sparse bloomer and has been observed to show foliage burn when planted under full-sun conditions. Two similar variegated forms, Kingsville and Aureo-variegata, are also available in the nursery trade.

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MALUS - FLOWERING CRABAPPLE

P. C. Kozel and Thomas Dugan
Department of Horticulture
Ohio Agricultural Research and Development Center
and The Ohio State University

There are few trees or shrubs which approach the beauty of a crabapple tree in full bloom. Ornamental crabapples are an outstanding group of small flowering trees for Ohio landscape planting. They are valued for foliage, flowers, fruit, and variations in habit or size. By using different varieties, the flowering period can be extended from mid-April to mid-May, with colors ranging from white through purplish red.

The small fruits, borne in the fall, are also effective, with colors of red, yellow, and green. Other features of this group are the small size (usually less than 20 to 25 ft. in height) and the variation in habit (rounded, horizontal, pendulous, fastigiate, and vase-shaped). Crabapples are suited for home grounds, schools, parks, commercial and public buildings, and highway plantings.

The genus Malus has held an important place in man's history for centuries dating back to the Romans. This genus belongs to the family Rosaceae and the subfamily Pomoideae. Members of the Rosaceae or rose family are usually characterized by having regular flowers with five sepals and five petals and numerous stamens; Pomoideae by the fruit being a pome. Malus includes the apple and crabapple, the main difference between them being the size of the fruit. Crabapple fruit is classified as being approximately 2 inches or less in diameter, with that of the apple being more than 2 inches.

Malus pumila, a native of eastern Europe, was probably the first crabapple. It had relatively small, sour-tasting fruits of little economic importance. Various seedlings of M. pumila and M. sylvestris occurred with larger fruits, comprising the first apple varieties. About 1600, the term crabapple came to include some native Malus species noted by Captain John Smith in Virginia, probably M. coronaria and M. angustifolia. He found these to have small, bitter-tasting fruit, but very beautiful flowers. The term crabapple gradually became associated with trees bearing small fruits, and was applied to the Siberian Crabapple (probably M. baccata) when it was introduced, when hybrids between it and the common apple appeared, and when the Asiatic species were introduced into Europe and North America (after 1850).

The species of Malus are rather widespread. Three, M. pumila, M. sylvestris, and M. florentina, are native to Europe. There are nine North American species, most with green fruits. Myriad crosses between them have produced the hundreds of clones in existence today.

Crabapples are valuable ornamental plants, with their beautiful floral display in the spring. There are single, semi-double, and double forms available, ranging in color from pure white to clear red. The beauty of the trees in bud is a show itself, many having pink or red buds which fade to white when the flowers open.
Most crabapples have two ornamental seasons, flowers in the spring and fruit in the fall. Fruits range from the size of a small pea to 2 inches in diameter, and come in colors from pure red to pure yellow (many native American species have green fruits of no ornamental value). Some varieties hold their fruits to late in the season. The fruit has an added value since it provides winter food for many species of birds.

Most crabapples are small trees up to 20 feet tall and therefore suitable for the small property. There is considerable variation in habit available (columnar, pendulous, mound-like, small and tall-growing, vase-shaped) to fit almost any situation. Some varieties are available with reddish to bronze colored foliage and a few crabapples have good autumn coloration.

**Breeding of Crabapples**

Crabapples are cross-pollinated and highly heterozygous. Crosses between species occur readily. Progress in breeding is slow and difficult to achieve.

Early breeding (prior to 1880) was mainly by chance (planting of hundreds of open-pollinated seeds and selecting out a few desirable types). The first real scientific work on hardiness was done by William Saunders in 1887, then Director of the Dominion Experimental Farms in Ottawa. He crossed *M. baccata* with the common apple varieties of Europe, coming up with several good crabapples. Dr. Niels E. Hanson of South Dakota State College also worked to obtain hardier varieties, making similar crosses and introducing several in the 1920's. In the early 1900's, ornamental and economic crabapples were equally valued, but by the 1940's ornamentals were demanded. Today's breeding is aimed toward disease resistance, better flower and fruit characteristics, annual blooming, and habit of growth.

**Propagation of Crabapples**

Propagation of all cultivars is accomplished by budding or grafting. Since crabapples are cross-pollinated and highly heterozygous, most will not come true from seed. Two notable exceptions are *M. toreoroides* and *M. hupehensis*, which come true to type due to apomictic reproduction.

Budding in August follows the general procedures used for fruit trees. Common apple seedlings can be used for the understocks. *M. robusta* and *M. Sieboldii* seedlings also have proven to be good. Where hardiness is a factor, *M. baccata* should be used since it is unusually hardy. Grafting is usually by whip graft during spring.

**Table Key**

*Name:* Names listed in the table are the same as those usually found in trade catalogues. Other names, however, may be encountered for the same trees in different catalogues or in common use.

Species of crabapples are given in this form:

*species, form and cultivar/common name*
The genus name, *Malus*, and common name crabapple have been left off each name for the sake of brevity.

Cultivars of crabapples are given in this form:

\[ x / \text{cultivar name} \]

Again, *Malus* and crabapple have been left off.

**Origin:** The symbol \( x \) is used to mean crossed with.

**Height:** Heights given are approximate mature heights as listed in the catalogues and literature listed in the source list.

**Foliage:** The following abbreviations are used:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>brt</td>
<td>bright</td>
</tr>
<tr>
<td>brnz</td>
<td>bronze color</td>
</tr>
<tr>
<td>drk</td>
<td>dark</td>
</tr>
<tr>
<td>fall col</td>
<td>fall color</td>
</tr>
<tr>
<td>glsy</td>
<td>glossy</td>
</tr>
<tr>
<td>grn</td>
<td>green</td>
</tr>
<tr>
<td>lobl</td>
<td>lobed</td>
</tr>
<tr>
<td>lrg</td>
<td>larger than most crabapple leaves</td>
</tr>
<tr>
<td>mix fall col</td>
<td>mixed fall color, several colors at once</td>
</tr>
<tr>
<td>orng</td>
<td>orange</td>
</tr>
<tr>
<td>pers</td>
<td>persistent, the leaves hold late into fall</td>
</tr>
<tr>
<td>prpl</td>
<td>purple</td>
</tr>
<tr>
<td>silv</td>
<td>silver color</td>
</tr>
<tr>
<td>semi cut</td>
<td>partially cutleaf</td>
</tr>
<tr>
<td>sm</td>
<td>smaller than most crabapple leaves</td>
</tr>
<tr>
<td>turn</td>
<td>leaves turn color during summer as indicated</td>
</tr>
</tbody>
</table>

**Flower Color:** The following abbreviations are used:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>prpl</td>
<td>purple</td>
</tr>
<tr>
<td>wht</td>
<td>white</td>
</tr>
</tbody>
</table>

**Flower Size:** The following abbreviations are used:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbl</td>
<td>The flower has ten or more petals (double).</td>
</tr>
<tr>
<td>lrg</td>
<td>The flower is exceptionally large.</td>
</tr>
<tr>
<td>semi-dbl</td>
<td>The flower has from five to ten petals (semi-double).</td>
</tr>
<tr>
<td>sing</td>
<td>The flower has five petals (single).</td>
</tr>
</tbody>
</table>

**Flowering Period:** Since time of flowering depends on many environmental factors associated with locality, the flowering period of each crabapple may be interpreted as indicated by Donald Wyman in *Crabapples for America*:

-67-
early, when *Magnolia stellata* usually blooms
med  medium, when *Prunus serrulata* usually blooms
late when *Caragana arborescens* usually blooms
very late when *Robinea pseudoacacia* usually blooms

**Fruit Size:** The fruit sizes listed are approximations. The following abbreviations are used:

- sm small, up to 3/4 inch or 1 inch
- med medium, from 1 inch to 1½ inches
- lrg large, from 1½ to 2 inches

(Any tree with fruit larger than 2 inches is generally considered to be an apple tree rather than a crabapple tree.)

**Fruiting Period:** The numbers listed in the table indicate the months over which the fruits of each crabapple are effective ornamentally. For example, the numerals, 8-1, indicate that the fruits have an ornamental effect from August until February of the following winter.

**Apple Scab and Fire Blight:** These are the two diseases of the most importance concerning the beauty and economics of crabapple production. The trees were rated as follows:

- hr highly resistant to infection or damage
- r resistant to infection or damage
- s susceptible to infection or damage
- hs highly susceptible to infection or damage

The ratings listed on the table were made by Elton M. Smith, Extension Specialist, Landscape Horticulture, O.S.U.


-68-
<table>
<thead>
<tr>
<th>NAME</th>
<th>ORIGIN</th>
<th>HEIGHT (ft.)</th>
<th>HABIT</th>
<th>FOLIAGE</th>
<th>FLOWER COLOR</th>
<th>FLOWER SIZE</th>
<th>FLOWERING PERIOD</th>
<th>FRUIT SIZE</th>
<th>FRUIT COLOR</th>
<th>FRUITING PERIOD</th>
<th>APPELS SCAB</th>
<th>FIRE BLIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>x/ 'Alsome'</td>
<td>baccata x</td>
<td>15</td>
<td>shrubby tree</td>
<td>grn sm</td>
<td>pink then wht</td>
<td>sing</td>
<td>med</td>
<td>sm</td>
<td>yellow</td>
<td>9-10</td>
<td>hs</td>
<td>r</td>
</tr>
<tr>
<td>Arnold</td>
<td>baccata x floribunda</td>
<td>20</td>
<td>round</td>
<td>grn sm</td>
<td>red then pink</td>
<td>sing</td>
<td>med</td>
<td>sm</td>
<td>red to yellow</td>
<td>8-10</td>
<td>hr</td>
<td>r</td>
</tr>
<tr>
<td>x/Bob White</td>
<td>unknown</td>
<td>12</td>
<td></td>
<td>wht</td>
<td>sing</td>
<td>med</td>
<td>sm</td>
<td>yellow</td>
<td>9-12</td>
<td>hr</td>
<td>r</td>
<td>r</td>
</tr>
<tr>
<td>baccata/siberian</td>
<td>wild seed from China</td>
<td>30</td>
<td>narrow upright</td>
<td>grn</td>
<td>wht</td>
<td>sing</td>
<td>erly</td>
<td>sm</td>
<td>red to yellow</td>
<td>8-10</td>
<td>r</td>
<td>r</td>
</tr>
<tr>
<td>x/coralburst</td>
<td>scions from korea</td>
<td>8</td>
<td>upright oval</td>
<td>pink</td>
<td>db1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>r</td>
<td>r</td>
</tr>
<tr>
<td>cornus/charlottae/</td>
<td>charlottae</td>
<td>25</td>
<td>lrg</td>
<td>pink</td>
<td>db1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>hs</td>
<td>r</td>
<td>r</td>
</tr>
<tr>
<td>x/Dolgo</td>
<td>robusta x unknown</td>
<td>18</td>
<td></td>
<td>wht to pink</td>
<td>sing</td>
<td>large</td>
<td>erly</td>
<td>med</td>
<td>red</td>
<td>8</td>
<td>r</td>
<td>r</td>
</tr>
<tr>
<td>x/Dorthea</td>
<td>baccataliana x halliana</td>
<td>15</td>
<td>spreading</td>
<td>grn</td>
<td>pink</td>
<td>semi-dbl</td>
<td>late</td>
<td>sm</td>
<td>bright yellow</td>
<td>9-11</td>
<td>vari</td>
<td>r</td>
</tr>
<tr>
<td>x/Ellen gerhart</td>
<td>halliana 'Parloani'</td>
<td>15</td>
<td>rounding</td>
<td>grn</td>
<td>pink</td>
<td>semi-dbl to db1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>floribunda/japanese</td>
<td>Japan</td>
<td>15</td>
<td>spreading</td>
<td>grn</td>
<td>pink</td>
<td>sing</td>
<td>med</td>
<td>sm</td>
<td>yellow red</td>
<td>8-10</td>
<td>hr</td>
<td>r</td>
</tr>
<tr>
<td>x/golden hornet</td>
<td>seedling of sumi 'calocarpa'</td>
<td></td>
<td></td>
<td>wht</td>
<td>sing</td>
<td>sm</td>
<td>yellow</td>
<td>8-1</td>
<td>hr</td>
<td>r</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAME</td>
<td>ORIGIN</td>
<td>HEIGHT (ft.)</td>
<td>HABIT</td>
<td>FOLIAGE</td>
<td>FLOWER COLOR</td>
<td>FLOWER SIZE</td>
<td>FLOWERING PERIOD</td>
<td>FRUIT SIZE</td>
<td>FRUIT COLOR</td>
<td>FRUITING PERIOD</td>
<td>APPLES</td>
<td>SCAB</td>
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</tr>
<tr>
<td>x/Hopas baccata x pumila var. niedzwetzkyana</td>
<td>20 upright</td>
<td>brnz grn</td>
<td>deep pink</td>
<td>sing</td>
<td>med</td>
<td>med</td>
<td>orange</td>
<td>red</td>
<td>8-10</td>
<td>hs</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>hupehensis/ Tea seed from china</td>
<td>20 vase</td>
<td>lrg glsy</td>
<td>wht</td>
<td>sing</td>
<td>med</td>
<td>sm</td>
<td>yellow</td>
<td>9-10</td>
<td>hr</td>
<td>r</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x/Indian Magic</td>
<td>15</td>
<td></td>
<td>red</td>
<td></td>
<td>med</td>
<td>red</td>
<td></td>
<td>orange</td>
<td></td>
<td>hr</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>Ioensis 'Plena'/ Bechtel</td>
<td>North America</td>
<td>dwarf</td>
<td>fall col. orng</td>
<td>pink</td>
<td>dbl</td>
<td>late</td>
<td>no fruit</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ioensis 'Prairie Rose'/ Prairie Rose</td>
<td>an American</td>
<td>15</td>
<td>pink</td>
<td>dbl</td>
<td>lrg</td>
<td>green</td>
<td>rarely</td>
<td>fruits</td>
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<td>r</td>
<td>r</td>
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<tr>
<td>x/Katherin halliana x baccata</td>
<td>12 to 15</td>
<td>drk grn</td>
<td>pink</td>
<td>to</td>
<td>dbl</td>
<td>med</td>
<td>sm</td>
<td>yellow</td>
<td>green</td>
<td></td>
<td>s</td>
<td>r</td>
</tr>
<tr>
<td>x/Klehm x/ Kles</td>
<td>15</td>
<td></td>
<td>pink</td>
<td>dbl</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>r</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>x/Klet</td>
<td>purpurea 'Lemoineii'/ x sieboldi</td>
<td></td>
<td></td>
<td>red</td>
<td>sing</td>
<td>sm</td>
<td>red</td>
<td></td>
<td>hr</td>
<td></td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>x/Mary Potter</td>
<td>pollen from atrosanguinea x seed from sargentii rosea</td>
<td>12 columnar</td>
<td>brnz grn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x micranus/ Midget</td>
<td>seedling from Japan</td>
<td>12 dense upright</td>
<td>gisly</td>
<td>wht</td>
<td>sing</td>
<td>erly</td>
<td>sm</td>
<td>green</td>
<td>yellow</td>
<td>9-10</td>
<td>hr</td>
<td>r</td>
</tr>
<tr>
<td>oekonomicrat echtermeyer/ Pink Weeping</td>
<td>Excellenz Thiel x pumila var. niedzwetzkyana</td>
<td>15 semi-weeping</td>
<td>brnz grn</td>
<td>pale</td>
<td>pink</td>
<td>sing</td>
<td>med</td>
<td>red</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>purpurea 'Eleyi'/ Eleys</td>
<td></td>
<td>15 round crowned</td>
<td>prpl red</td>
<td>turn</td>
<td>purp grn</td>
<td>red</td>
<td>sing</td>
<td>med</td>
<td>bright purple</td>
<td>red</td>
<td>9-10</td>
<td>hs</td>
</tr>
<tr>
<td>NAME</td>
<td>ORIGIN</td>
<td>HEIGHT (ft.)</td>
<td>HABIT</td>
<td>FOLIAGE</td>
<td>FLOWER COLOR</td>
<td>FLOWER SIZE</td>
<td>FLOWERING PERIOD</td>
<td>FRUIT SIZE</td>
<td>FRUIT COLOR</td>
<td>FRUITING PERIOD</td>
<td>APPLE SCAB</td>
<td>FIRE BLIGHT</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------</td>
<td>--------------</td>
<td>-----------</td>
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</tr>
<tr>
<td><em>purpurea</em></td>
<td><em>astrosanguinea</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>'Lemoinei'</td>
<td><em>x nutillia var.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemoine</td>
<td><em>niedzwetzkyana</em></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s/Radiant</td>
<td><em>Hops x unknown</em></td>
<td>18</td>
<td></td>
<td>grn</td>
<td>deep pink</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z/Red Jade</td>
<td><em>Ezellenz</em></td>
<td>10 to 15</td>
<td>weeping</td>
<td>grn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z/Red Jewel</td>
<td><em>Thiel x unknown</em></td>
<td>12 to 15</td>
<td>horiz.</td>
<td>grn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z/Red Silver</td>
<td><em>baccata x</em></td>
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American Holly (Ilex opaca) originally was not found growing in the Wooster area. The natural range of this tree barely enters the state in extreme southern and southeastern Ohio. It has been planted and grown in the Secrest Arboretum for more than 50 years. Other successful plantings have been made in Ohio well outside the natural growth range of this tree. In fact, the second largest American Holly on record in Ohio was brought from West Virginia in 1906 and set out near New Philadelphia which is well north of its range. In many places, seedlings are becoming established in the vicinity of some early plantings, showing that the tree is capable of becoming acclimatized outside its original range.

Although American Holly was occasionally set out around the grounds of the OARDC since 1922, it was not until 1952 that a sizeable planting was made in the Secrest Arboretum when 35 different cultivars of Ilex opaca were outplanted. The majority of these hollies grew in this location for up to 20 years before they were transplanted to other locations. A good many of these hollies survived temperatures of -20°F during January and February 1963.

A Holly Test Garden was started in 1969 when 53 different hollies were planted on a 12 x 12-foot spacing. By the spring of 1972, all spaces in this plot were filled. There are now 90 different hollies, including 50 cultivars of American Holly. The site selected for the test garden is more exposed to prevailing winds than where the former plot was located in 1952. Some of the hollies moved from the old holly plot into the new test plot have shown more winter damage than they did on the more protected site. Winter damage is showing up on some specimens, even after 4 growing seasons. Ilex opaca 'Elephant Berry' has been experiencing a progressive kill back of branch tips and a loss of leaves each winter since being moved into the new plot. To date, the coldest temperatures the hollies in the test garden have been exposed to was -12°F during January 1972.

Many hollies take 2 or 3 growing seasons to become established after transplanting or outplanting. They will often show some winter injury the first 2 or 3 winters, but after they have become re-established they are less affected by winter weather. Many hollies which show winter injury on leaves by the end of March will have completely recovered by the end of the spring growing season. American Holly should be given special winter protection during the first and possibly the second winter after being outplanted. This is especially so if planted on a site exposed to the wind.

Some American Hollies 1 foot or less in height have not survived when outplanted, even though plants of the same cultivar 2 to 3 feet in height have survived with no sign of injury. The ideal height for outplanting is from 2 to 4 feet.

Around Wooster, American Holly needs good drainage. Some sites were moist but well drained when hollies were planted 2 or 3 years ago, but have become wet and waterlogged this past year due to the continuing wet weather. These hollies are beginning to
show the effects of water standing around their roots. The leaves are turning yellow, and in many instances the tips of twigs and branches are beginning to die. In many cases, leaves are considerably smaller than usual. Before these areas became excessively wet, the hollies were growing very well.

American Holly cultivars which have grown well in the Arboretum when planted on favorable sites are:

*Ilex opaca* 'Angelica'. In test garden 4 years. Has been exposed to -12° F. Leaves hold dark green color all seasons. Fast growing. Female. Rated good.


*Ilex opaca* 'Arlene Leach'. In test garden 4 years. Has been exposed to -12° F. Leaves hold dark green color all seasons. Fast growing. Female. Rated good.

*Ilex opaca* 'Betsy'. In test garden 4 years. Has been exposed to -12° F. Leaves hold dark green color all seasons. Average growing. Female. Rated good.

*Ilex opaca* 'Betty Pride'. In test garden 4 years. Has been exposed to -12° F. Leaves hold dark green color all seasons. Average growing. Female. Rated good.


*Ilex opaca* 'Cape Cod'. Grown for 20 years. Has survived -20° F. on protected sites. Leaves hold green color except when exposed to severe winds. Wind tolerant. Average growing. Female. Rated good. One of the hardiest in the Arboretum.

*Ilex opaca* 'Carnival'. In test garden 4 years. Has been exposed to -12° F. Leaves hold dark green color all seasons. Fast growing. Female. Rated good.


*Ilex opaca* 'Cumberland'. In test garden 4 years. Has been exposed to -12° F. Leaves hold deep glossy green color all seasons. Fast growing. Female. Rated excellent.

*Ilex opaca* 'Draper'. In test garden 4 years. Has been exposed to -12° F. Leaves hold green color all seasons. Fast growing. Female. Rated good.


*Ilex opaca* 'Ling'. In test garden 4 years. Has been exposed to -12° F. Leaves hold green color all seasons. Average growth. Female. Rated good.

*Ilex opaca* 'Makepeace' (Ed Thomas). In test garden 4 years. Has been exposed to -12° F. Leaves hold green color all seasons. Fast growing. Male. Rated good.

*Ilex opaca* 'Mary Holman'. In test garden 4 years. Has been exposed to -12° F. Leaves hold green color all seasons. Average growth. Female. Rated good.


*Ilex opaca* 'Mrs. F. J. Close'. In test garden 4 years. Has been exposed to -12° F. Leaves hold green color all seasons. Average growth. Female. Rated good.


*Ilex opaca 'Valentine'.* In test garden 4 years. Has been exposed to -12° F. Leaves hold green color all seasons. Average growing. Female. Rated good.

*Ilex opaca 'Wyetta'.* In test garden 4 years. Has been exposed to -12° F. Leaves hold a good green glossy color all seasons. Very rapid grower. Female. Rated excellent.

*Ilex opaca 'Yule'.* Grown for 18 years. Has survived -20° F. Leaves winter burn slightly but color up again in spring. Female. Hardy.

*Ilex opaca 'Wyetta', one of the better new hollies in the Test Garden.*

BIRCHES IN THE LANDSCAPE

Elton M. Smith
Extension Specialist, Landscape Horticulture
The Ohio State University

Probably no group of ornamental trees is more widely used or better known than the birches. All species and cultivars are truly distinctive trees and possess many interesting features. Most outstanding is the bark, which ranges from pure white of the Paper or Canoe Birch to light mahogany of the River Birch. Their pendulous catkins are one of the first harbingers of spring when they start to elongate. The autumn color of the foliage is always a clear and brilliant yellow.

Landscape Use

Since the birches used for landscaping are small to medium in size, they are desirable for small properties and can be grown in spaces where other larger trees would not fit. They do not seriously limit the types of plants which can be grown nearby or under them, since they do not cast dense shade. Birches do not compete with grass nor do they create a serious leaf disposal problem in autumn.

It is common to see clumps of three or four birches growing together when used in the landscape to give the effect of a multiple-stemmed tree. Since very few other trees are used this way, it gives a pleasing change from the single-trunk tree.

White Birches are outstanding in winter, particularly when there is an evergreen background to accentuate the birches' white bark. For special effects, birches are used as a background for plantings of red-stemmed dogwoods like Cornus alba 'Sibirica'.

Culture

In general, birches are somewhat difficult to transplant. To insure transplanting success, they should be moved, balled and burlapped in spring. Pruning can be done at any time of year except early spring since they will bleed profusely.

Birches are susceptible to two serious insect pests which can mar their effective use as ornamentals. The first is the bronze birch borer, a small grub about 1 to 1 inch long which feeds just under the bark and if present in sufficient numbers can kill the tree. To prevent this insect, Meta-Systox-R should be sprayed during late May or early June and repeated twice at 3-week intervals. The entire tree, especially the upper part, is treated.

The other insect, the birch leaf miner, eats its way between the upper and lower epidermis of the leaf. The entire tree may turn brown during severe infestations. Either Malathion, Lindane, Sevin or Meta-Systox-R should be sprayed in mid-May and again in late June.

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Species and Cultivars of Birches

Betula maximo’wicziana, Monarch Birch:

The Monarch Birch’s trunk and principal branches are white. The leaves are largest of all the birches and the catkins are extremely long in comparison to other species. This birch is medium sized, approximately 45 feet in height, yet vigorous in growth rate.

Betula nigra, River Birch:

The River Birch is pyramidal while young with reddish-brown or mahogany colored bark which exfoliates or peels off in thin layers, producing a slightly shaggy appearance. This birch can be used in wet locations where other trees may not be satisfactory, although it does not require wet soils. Since the River Birch is somewhat more resistant to the birch borer than other species, it is suitable for moist areas and has exfoliating bark. It deserves to be planted more than it is.

Betula papyrifera, Paper or Canoe Birch:

Paper Birch has the whitest, smoothest bark of all the birches. Its branches are white and the leaves are slightly glossy which turn golden yellow in autumn. Paper Birch is the most popular of the birches for ornamental use and is less susceptible to severe attacks of the birch borer than European Birch.

Betula pendula (formerly B. alba and B. verrucosa), European Birch:

The European Birch is pyramidal in habit. Its trunk and older branches are white and lateral branches are slightly pendulous. The leaves are smaller and more triangular than Paper Birch. It is a short-lived tree, since it is susceptible to attack by the birch borer. It is often attacked high on the trunk and the top is completely killed.

A number of cultivars of Betula pendula are available, including:

B. p. 'Fastigiata', Fastigiate European Birch:

Columnar in habit and dense while young.

B. p. 'Gracilis', Cutleaf European Birch:

Quite pendulous in habit with leaves deeply cut.

B. p. 'Purple Splendor', Purple Splendor European Birch:

Leaves are purplish-colored.

B. p. 'Scarlet Glory', Scarlet Glory European Birch:

Young leaves very red in early spring, turning reddish-green in
summer and bright red again in the fall. This cultivar is not as readily available in the trade as the others.

B. p. 'Tristis', Slender European Birch:

A rounded form with slender, pendulous branches.

B. p. 'Youngi', Young's European Birch:

Quite small with an irregular growth habit and pendulous branches.
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It is frequently helpful to have access to brief comments on the identification and use of pines. Listed below are several of the common pines and a few comments on each.

**Five-Needle Pines**

*Pinus balfouriana* (Foxtail Pine)
- Intermediate in size, 40 feet, narrow, pyramidal when young, irregular and open with age.
- Dark red brown bark on older trees.
- Leaves entire, 3/4 to 1½ inches long, crowded, rigid usually incurved.
- Branches slightly pubescent.

*Pinus cembra* (Swiss Stone Pine)
- Usually about 40 feet in landscape situations.
- Native to the Alps, Central Europe, Russia, and Asia.
- Symmetrical, dense, narrow pyramidal tree.
- Slow growing, leaves toothed, branches quite tomentose.
- Leaves dark green, retains needles for 3 years.
- Good plant, not too common. It tolerates poor soil but is best in rich moist soils.
- Its slow growth rate allows for its use on small properties.
  - Cultivars: 'Pumila' - dwarf about 10 feet.
  - 'Siberica' - narrow, vigorous form
  - 'Aurea' - yellow foliage
  - 'Columnaris' - narrow upright.

*Pinus flexilis* (Limber Pine)
- Native to California east to Montana and Texas.
- About 50 feet in the landscape.
- Medium to slow growth, about 1 year.
- Narrow pyramidal when young, becoming broad and round topped with age.
- Leaves are entire while those of *Pinus Peuce*, with which it is often confused, are toothed.
- Branches are pubescent, tough and pliant.
- Leaves are slender, 1½ to 3 inches long, a good green color.
- Branches point up at the ends.
- Similar to White Pine but more adaptable to poor soils.

*Pinus griffithi* (Himalayan Pine)
- Introduced from the Himalayan Mountains in 1827.
- Large tree at maturity, rapid grower to 50 to 60 feet.
- Habit is graceful, leaves droop and hang; attractive.
- Loosest form of all five-needle pines.
- Leaves 4 to 7 feet long, toothed, slender, blue green.
Branches are bloomy and glabrous, acute buds.
May be injured by an early fall frost.
Large cones 6 to 10 inches in length.

*Pinus koraiensis* (Korean Pine)
- Introduced from Japan and Korea.
- Slow growing pyramidal to 75 feet, irregular with age.
- Leaves are toothed, bright green, 2-1/4 to 4-3/4 inches long.
- Longer and stiffer than those of White Pine.
- Branches yellow brown, tomentose.
- May be slightly damaged in severe winters.

*Pinus monticola* (Western White Pine)
- Native in Idaho and California, to 50 feet here.
- Similar to White Pine except narrower and denser.
- Slender branches, yellowish or reddish brown, slightly pubescent. Buds are acute, i.e., sharply pointed, whereas White Pine buds are ovoid and rounded.
- Leaves stiff, serrate, bluish green.

*Pinus parviflora* (Japanese White Pine)
- Introduced from Japan in 1861.
- Short leaved, variable form, picturesque, to 80 feet.
- Leaves toothed, branches greenish brown, with slight pubescence.
- Leaves bluish-green, white beneath, twisted and in tufts.
- Very hardy -- good landscape plant.

*Pinus peuce* (Balkan Pine)
- Introduced from the Balkan Mountains in 1863.
- Dense, narrow habit; slow growth rate.
- Leaves good green, toothed, straight, stiff, 3 to 4 inches long.
- Branches greenish, glabrous, terminal bud more rounded than that of White Pine.
- A good landscape plant.

*Pinus strobus* (Eastern White Pine)
- Native to North America -- wide spread.
- Only five-needle pine native to Ohio -- rapid grower.
- Young trees densely pyramidal, ascending branches.
- Old trees picturesque, broad, flat-topped to 75 feet.
- Leaves slender, soft, 2½ to 5½ inches long, toothed.
- Branches glabrous, occasionally hairy on young growth, bark purplish, holds leaves 3 years.
- Easily transplanted, best growth in well-drained soils.
- Good hedge plant, i.e., 4 to 5-foot hedge

**Cultivars:**
- 'Fastigiata' - narrow upright
- 'Glauca' - bluish light green foliage
- 'Nana' - compact, dense, mounded to 3 to 3½ feet
- 'Umbraculifera' - multi-stemmed, umbrella shaped, short leaves
- 'Globosa' - round, dense, compact, to 3½ to 4 feet.
Three-Needle Pines

*Pinus bungeana* (Lacebark Pine)
- Introduced in 1846 from N.W. China.
- Best of three-needle pines; to 35 feet, holds needles 5 years.
- Usually grows with several trunks, exfoliating bark, older stems chalky.
- White - attractive.
- Leaves 2 to 4 inches long, toothed, wide needle spread, leaf sheath deciduous, light green leaf color.
- Branches grayish-green, glabrous.

*Pinus jeffreyi* (Jeffrey’s Pine)
- Native to Oregon and California; to 60 feet.
- Similar to Ponderosa Pine except leaves are blue-green.
- Branches bloomy, buds not resinous.
- Narrow pyramidal head; short, spreading, often pendant branches; hardy.

*Pinus ponderosa* (Ponderosa Pine)
- Native pine in Western Mountains; to 60 to 65 feet in Ohio.
- Very hardy, rapid growth rate.
- Branches orange-brown, fragrant when broken.
- Older bark blackish and platy.
- Needles 2 to 3 per bundle, usually 3 to 5 to 8 inches long.

*Pinus rigida* (Pitch Pine)
- Native to North America from Ontario to Kentucky.
- Slow grower, to 30 feet, only three-needle pine native to Ohio. Habit loose, open, irregular.
- Loses lower branches early.
- Branches are light brown, buds ovoid, chestnut brown.
- Leaves spreading, not toothed, dark green.
- Not the best for ornamental use, but excellent in dry rocky soil.

Two-Needle Pines

*Pinus banksiana* (Jack Pine)
- Native, from Hudson Bay down to New York and over to Minnesota.
- Usually shrubby, slow growing, irregular, loose habit, to 25 feet.
- Branches purplish to yellowish brown. Buds obl ong, ovoid, light brown, very resinous.
- Leaves rigid, twisted, spreading, 3/4 to 1-3/4 inches long, acute, not toothed, bright or dark green.
- Not a good landscape plant, but excellent in dry and sandy soil.

*Pinus conforta* (Shore Pine)
- Native Alaska to California.
- A small pine to 25 feet, stout branches, dense head.
- Branches light orange or orange-brown, distinctive buds ovoid, dark chestnut brown, resinous.
Leaves rigid, twisted 1 to 2 inches long, acute, dark green. Hardy but not used in landscapes.

*Pinus densiflora* (Japanese Red Pine)
- From Japan, introduced in 1854; to 50 feet in Ohio.
- Horizontal branches, forms an irregular, rather broad head.
- Branches orange-yellow, bloomy, buds oblong to ovoid, chestnut-brown.
- Leaves slender, 3 to 5 inches long, bright bluish green.
- Old bark orange; similar to Scotch Pine.
  - Cultivars: 'Aurea' - yellow leaves
  - 'Oculus-draconis' - each leaf marked with two yellow bands
  - 'Umbraculifera' - multi-branched umbrella-like head.

*Pinus echinata* (Shortleaf Pine)
- A native pine to 40 feet. Not used ornamentally.
- Branches often pendant in regular whorls, bark light cinnamon-red.
- Leaves slender, 2 to 5 inches long, dark bluish green.
- Handsome tree with broad ovoid head when mature.

*Pinus mugo* (Swiss Mountain Pine)
- Introduced from mountains of Central and Southern Europe.
- Variable in height - from 4 to 25 feet, slow growing.
- Branches brownish; leaves crowded, stout, 1 to 3 inches long, bright green. Very waxy at leaf base.
- Little value ornamentally. Loose and irregular.

*Pinus mugo mughus* (Mugho Swiss Mountain Pine)
- Dwarf selection of *Pinus mugo*. Still variable from 1½ to 10 feet, broader than high, flat top, round head. Needle type varies from short to intermediate, light to dark green.
- It's necessary to select and graft to reduce variation.
- Low forms can be used as foundation plants.
- Extremely resistant to reflected light.

*Pinus nigra* (Austrian Pine)
- Introduced from Central and Southern Europe, Asia Minor.
- Large tree to 75 feet in Ohio. Spreading branches, open and picturesque with age, often flat headed.
- Bark striated, very ornamental as tree ages.
- Leaves good dark green, stiff, 4 to 7 inches long (they do not snap when bent in half; Red Pine needles do).
- Buds white to brownish, often resinous.
- Good landscape plant, resistant to salt spray.
  - Cultivars: 'Pendula' - pendulous branches
  - 'Pygmaea' - dwarf globose form
  - 'Prostrata' - prostrate form.
Pinus pungens (Table Mountain Pine)
Native pine from New Jersey to Georgia and Tennessee.
Medium sized pine to 30 feet, not cultivated.
Stout spreading branches, broad open head when mature.
Needles 2½ inches long, dark yellow green, rigid, often twisted.
Branches light orange, buds oblong, obtuse, dark chestnut brown.
Native on poor, dry, often rocky slopes.

Pinus resinosa (Red Pine)
Native pine from Nova Scotia to Pennsylvania, Michigan, and Minnesota.
Tree to 75 feet in Ohio, stout spreading, sometimes pendulous branches,
forming a broad pyramidal head.
Buds ovoid, acuminate, light brown, resinous.
Leaves flexible but break when bent in half, 4 to 6 inches long, toothed,
dark yellow green, persist for 4 to 5 years.
Does well in light sandy soils.
   Cultivar:   'Globosa' - dwarf, dense rounded form.

Pinus sylvestris (Scotch Pine)
Introduced from Europe and Siberia, long cultivated.
Tree to 75 feet, spreading branches, pyramidal when young, round-topped
and irregular with age.
Bark on trunk orange to red brown (very ornamental).
Branches dull grayish yellow; buds oblong, ovoid, brown, resinous.
Leaves blue-green, 1½ to 3 inches long, slightly twisted, sharp pointed.
Good landscape plant.
   Cultivars:   'Fastigiat'a - Columnar - ascending branches
               'Watereri' - dense columnar form with short, steel-blue leaves.

Pinus thunbergi (Japanese Black Pine)
Introduced from Japan in 1855.
Tree to 75 feet, often irregular in growth habit, slightly pendulous branches.
Branches orange yellow (distinctive); buds oblong, whitish, not resinous,
with firbriate scales free of the tips.
Leaves stout, 2½ to 5 inches long, sharp pointed, bright green.
Extremely resistant to salt spray.
Finer texture than Austrian Pine.

Pinus virginiana (Virginia Pine or Scrub Pine)
Small tree, 30 feet high, native to Ohio.
Characterized by its ability to grow in the poorest of heavy dry soils.
Needles 2 inches long, yellow-green, stout, usually twisted.
Slender horizontal or pendant branches. Branches bloomy, buds very resinous
with oppressed scales.
Not used ornamentally.

Turf and Landscape Research—1973. Research Summary 71, Ohio Agricultural
Research and Development Center, Wooster, Ohio, September 1973.
Ohio's major soil types and climatic conditions are represented at the Research Center's 13 locations. Thus, Center scientists can make field tests under conditions similar to those encountered by Ohio farmers.

Research is conducted by 15 departments on more than 6500 acres at Center headquarters in Wooster, nine branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres
Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres
Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 344 acres
Mahoning County Farm, Canfield: 275 acres
Muck Crops Branch, Willard, Huron County: 15 acres
North Central Branch, Vickery, Erie County: 335 acres
Northwestern Branch, Hoytsville, Wood County: 247 acres
Pomerene Forest, Laboratory, Keene Township, Coshocton County: 227 acres
Southeastern Branch, Carpenter, Meigs County: 330 acres
Southern Branch, Ripley, Brown County: 275 acres
Western Branch, South Charleston, Clark County: 428 acres