The Cause and Control of Defoliation in Cut Holly

J. A. Milbrath
Henry Hartman

Oregon State System of Higher Education
Agricultural Experiment Station
Oregon State College
Corvallis
SUMMARY OF PROCEDURE FOR CONTROL OF DEFOLIATION IN CUT HOLLY

1. Use .003 per cent a-naphthaleneacetic acid, or one of the commercial preparations twice as strong as they are recommended for use on apples. These materials can be obtained from seed stores and the leading spray companies.

2. Prepare a dipping vat and fill with the proper concentration of the solution. One hundred gallons of solution should treat 3,000 or more pounds of cut holly. The material can be used over several days without losing its effectiveness, and can be used until depleted unless it becomes dirty.

3. One to two pints of summer oil to 100 gallons of solution is often used as a dip to improve the sheen on holly. This may be combined with the hormone dip, if the proper oil is used with the proper hormone preparation. These may not be compatible, however, and should not be mixed unless recommended by the manufacturer of the products. If the two are not known to be compatible, the holly should be dipped first in the oil, then in the hormone solution. No dip or wash should follow the hormone treatment.

4. Place the holly in baskets or crates and dip so that all of the holly is thoroughly wet by the solution. Holly made into wreaths can be handled best by dipping each wreath individually. The holly does not have to soak in the solution.

5. Remove and allow excess moisture to drain back into the tank.

6. Pack or store the holly with sufficient moisture to keep it in a fresh condition. The hormone will be effective either if it is allowed to dry on the holly or if the holly is packed before drying. The hormone is known to remain effective on the holly for 10 to 14 days after dipping, even when holly is subjected to the most severe conditions for defoliation. If the holly is held for a week or more after the first dipping it should be retreated before shipping.

7. Keep the holly cool and moist, and do not expose it to ethylene gas from ripening fruit, or to oil or gas stoves.
The Cause and Control of Defoliation in Cut Holly*

By

J. A. Milbrath, Assistant Plant Pathologist

Henry Hartman, Horticulturist

The production of English holly (Ilex aquifolium Linn.) for Christmas decoration is a new and growing industry in Oregon. Most of the cut holly shipped from this area has been obtained from pruning ornamental hedges or specimen trees about the home. Many holly orchards are now being established, however, and at present there are approximately 400 acres devoted to the growing of holly in the Willamette Valley. The majority of these orchards have not come into full production. As these young orchards, and the new ones that are being planted annually, come into production there will be a tremendous increase in the holly shipped from the state.

One of the most difficult problems of handling and shipping holly is to pack it in a suitable manner so that it will reach the market in first class condition. When holly is packed with sufficient moisture to retain its natural fresh appearance serious defoliation often results. The purpose of this bulletin is to report the cause of this defoliation and methods of preventing this loss.

WHY CUT HOLLY MAY LOSE ITS LEAVES

Growers and shippers of holly have observed that holly cut and packed during wet foggy days often reaches its destination completely defoliated, while holly cut and packed during dry weather seldom loses any of its leaves unless it is dampened before packing. To determine whether excess moisture was responsible for this loss of leaves, one lot of holly was dipped in water and packed wet; a similar lot was not dipped in water and was packed dry. After 7 days at room temperature (70°-80° F.) the wet holly had lost all of its leaves while the leaves were still tight on the lot packed dry. Obviously, this short period does not give sufficient time for the handling, selling, and utilization of holly.

The present investigation has shown that moisture is not the only cause of defoliation. The holly plant is extremely sensitive to ethylene gas, and the presence of this gas even in minute quantities may cause loss of foliage in a short period of time. In concentrations as low as one part of ethylene in 200,000 parts of air, complete defoliation may occur in 3 to 4 days. Results of previous investigations have shown that ethylene gas stimulates or hastens the growth of abscission layers, which are responsible for the shedding of leaves in many woody plants.

Ethylene gas is produced or released in various ways, and it is possible for holly to come in contact with it during handling and marketing operations. A number of fruits, including apples and pears, are known to give off ethylene.

*The authors express their thanks to the various holly growers for furnishing holly and for their assistance in these experiments; to J. S. Wieman, Oregon State Department of Agriculture, for his assistance and cooperation; to the Railway Express Company for furnishing shipping facilities; and to R. C. Wright, Physiologist, U. S. Department of Agriculture, for making record of his examination of the lot of holly shipped to Beltsville, Maryland.
and these studies have shown that ethylene emanated in this manner may bring about defoliation. This is true when holly is confined with fruit during transit or storage, or on display in retail markets where fruit is sold. Holly berries, fortunately, do not produce ethylene, at least they do not produce it in sufficient quantity to cause defoliation. Ethylene is one of the constituents of illuminating gas and may be given off to the atmosphere when gas escapes or is burned in open flames, and it is also a product of the combustion of certain fuel oils. Ethylene from these sources can be the cause of defoliation, especially after holly arrives on the market or after it reaches the consumer. Holly placed in floral arrangements in water often loses its leaves in a few days in homes using certain types of gas or fuel oil heaters.

**HOW TO PREVENT DEFOILIATION**

From these observations it is apparent that loss of leaves in holly after cutting may be caused by factors over which the grower or shipper has but little or no control. For this reason considerable attention has been given to methods of control or means of handling holly so that defoliation will not occur.

**Effects of cold storage.** Experiments have shown that refrigeration may be of considerable value in retarding or preventing defoliation. Holly packed wet and stored where ethylene gas was present did not lose its leaves when placed in a room held at 31° F. for 30 days, but lost 25 per cent of its leaves in a room held at 36° F. for 30 days, and was completely defoliated after 2 weeks in a room held at 42° F. Holly packed wet and stored where there was no ethylene gas present did not lose its leaves in 30 days at 31° F. or 36° F., but had started to lose a few leaves in 2 weeks when stored at 46° F. In another experiment holly was packed wet and stored in an open building during December 1941. The temperature varied from 20° to 60° F. during this period, but most of the time it was down in the lower half of the range. After 40 days the foliage and berries were still bright and fresh without any defoliation and the holly appeared to be in first class condition.

Refrigeration as a means of preventing defoliation has only limited use in handling cut holly. Holly wreaths and other decorative pieces could be prepared before the rush season and held in cold storage until shipping time. Holly could also be held in cold storage after it reaches its destination and is waiting to be placed on the market. This would not take care of all defoliation problems, however, as loss of leaves may take place quickly upon removal of the holly to high temperatures. From these studies it is clear that every attempt should be made to keep holly as cool as possible during all handling operations.

**Partial dehydration.** Loss of leaves may be prevented when holly is subjected to partial dehydration after cutting. Apparently, partial dehydration brings about a condition where the holly plant is no longer able to develop the abscission layers, and thus has lost its natural ability to shed leaves. Holly twigs that are kept in a dry room after cutting usually retain their leaves; in fact, they hold their foliage to the point where the leaves are completely dried. Wetting of the leaves, or subjecting them to ethylene gas, does not cause defoliation in such cases. If this dehydration, however, proceeds to the point where it would be safe from all defoliation processes the holly often has lost much of its luster and fresh appearance.

Partial dehydration probably plays a part in all cases where cut holly is successfully handled without loss of foliage. During handling operations under
usual conditions some dehydration doubtless occurs, without which defoliation would proceed as a normal plant function. While partial dehydration appears to be a vital factor in the retention of leaves, complications arise when one attempts to use it as a means of controlling defoliation. It is difficult to provide suitable drying conditions when large quantities of holly must be handled in a few days' time, and it is almost impossible to determine how far dehydration should proceed. Obviously, one cannot dry holly to the point where visible wilt or loss of freshness becomes apparent, yet if dehydration is insufficient, the shedding process will not be stopped.

The use of hormone treatments. Certain hormone sprays, particularly a-naphthaleneacetic acid and a-naphthylacetamide, have been employed to prevent preharvest drop in apples and pears. These chemicals apparently have the ability to retard the growth of abscission layers, thus delaying the time when the fruit is naturally severed from the tree. When applied to cut holly it was found that these hormones have a similar effect on leaves. They retard defoliation even when holly is packed wet or even when exposed to high concentrations of ethylene gas.

In a series of preliminary experiments, pieces of holly were dipped in solutions containing .01, .005 and .001 per cent of a-naphthaleneacetic acid. Check lots were dipped in water. These lots were then sealed in large glass jars after placing water and wet paper towels in each jar to insure high humidity.
and one ripe apple to provide ethylene contamination. (Figure 1.) The jars were kept at a temperature ranging between 70° and 80° F. Table 1 gives the data from this series of tests.

Table 1. Effect of Various Concentrations of A-naphthaleneacetic Acid on Defoliation

<table>
<thead>
<tr>
<th>Number of days</th>
<th>.01 per cent</th>
<th>.005 per cent</th>
<th>.001 per cent</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>70.7*</td>
</tr>
<tr>
<td>3</td>
<td>0.0</td>
<td>0.0</td>
<td>20.0</td>
<td>100.0</td>
</tr>
<tr>
<td>4</td>
<td>0.0</td>
<td>0.0</td>
<td>82.8</td>
<td>......</td>
</tr>
<tr>
<td>5</td>
<td>0.0</td>
<td>0.0</td>
<td>85.7</td>
<td>......</td>
</tr>
<tr>
<td>6</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
<td>......</td>
</tr>
<tr>
<td>8</td>
<td>0.0</td>
<td>74.2</td>
<td>100.0</td>
<td>......</td>
</tr>
<tr>
<td>14</td>
<td>0.0</td>
<td>91.4</td>
<td>100.0</td>
<td>......</td>
</tr>
</tbody>
</table>

* Per cent of shattering after number of days designated.

It will be noted that even the weakest solution of a-naphthaleneacetic acid had a marked retarding effect on defoliation, while the strongest solution (.01 per cent) completely prevented defoliation over a period of 14 days. The severity of this test is indicated by the fact that the checks, not treated with the hormone, showed complete defoliation at the end of 3 days.

In order to determine the effect of hormone sprays on holly under severe transit conditions, two trial express shipments were made during December 1940. One shipment was made to Beltsville, Maryland, where the holly was examined 13 days after packing.* Another consignment went to Los Angeles, California, and then returned to Corvallis, Oregon. (Figure 2.) Examinations in the latter case were made 11 days after packing. Each of these shipments contained the following treatments:

**Lot 1.** Holly packed wet after treatment with "Fruitone" in concentrations of ½ pound, 1 pound, and 2 pounds to 100 gallons of water. One-half of the lot packed with apples.

**Lot 2.** Holly packed wet after treatment with a-naphthaleneacetic acid in concentrations of .001 and .005 per cent. One-half of the lot packed with apples.

**Lot 3.** Holly packed wet after treatment with a-naphthylacetamide at a concentration of .001 per cent. One-half of lot packed with apples.

**Lot 4.** Check. Holly packed wet but receiving no hormone treatment. One-half of lot packed with apples.

The results of these shipping tests are tabulated in Table 2. These clearly show beneficial effects wherever the hormones were used. It is true that some of the treated holly packed with apples showed defoliation at the time of examination, but the conditions induced by the combination of high humidity, high temperature, and high ethylene contamination were much more severe than any conditions likely to be encountered in commercial handling.

In all the experiments thus far conducted, no injury has been noted from hormone sprays, except in cases where the hormones were used at concentrations much higher than required to prevent defoliation. Where very high concentrations were used some blackening or browning of the foliage took place. Hormone sprays used at the proper strengths leave no objectionable residues or deposits on the foliage.

*Records made by R. C. Wright, Physiologist, U. S. Department of Agriculture.
Figure 2. Two lots of holly taken from a package of holly packed wet and shipped to Los Angeles, California, and returned to Corvallis, Oregon. The holly was shipped by Railway express and examined 11 days after packing. A. Holly treated with Fruitone 1 pound to 100 gallons showed no defoliation when unpacked. B. Holly not treated showed 81 per cent defoliation in the same pack.
Table 2. RESULTS OF EXPRESS SHIPMENTS OF HOLLY TREATED WITH HORMONE SPRAYS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Defoliation found in Beltville shipment</th>
<th>Defoliation found in Los Angeles shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without apples</td>
<td>With apples</td>
</tr>
<tr>
<td>Fruitone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 pound to 50 gallons</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1 pound to 100 gallons</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1 pound to 200 gallons</td>
<td>0.0</td>
<td>41.0</td>
</tr>
<tr>
<td>A-naphthaleneacetic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.001 per cent</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>.005 per cent</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>A-naphthylacetamide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.001 per cent</td>
<td>10.0</td>
<td>15.5</td>
</tr>
<tr>
<td>Water check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot 1</td>
<td>50.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Lot 2</td>
<td>44.5</td>
<td>48.5</td>
</tr>
<tr>
<td>Lot 3</td>
<td>44.5</td>
<td>86.0</td>
</tr>
</tbody>
</table>

PRACTICAL USE OF HORMONES

From the results thus far obtained it appears that hormone sprays may be of considerable value in the commercial handling of cut holly, and growers are advised to give these materials a trial, at least in a limited way. The details of how and when to apply hormones, however, must be worked out largely according to the grower's or shipper's specific needs. The following discussion is meant to convey only general information regarding the use of the hormone method.

Hormones in the pure crystalline form are difficult to use for the reason that they are applied in very minute quantities, which are difficult to measure without precision instruments. For this reason it is probably best to use the commercially prepared products now sold by spray and chemical concerns under various trade names. "Fruitone," "Stop-Drop," "Paramone," "Stay-Fast," etc., are examples of these materials.

Directions for the use of these products as given by the respective manufacturers apply principally to the use of hormones in the prevention of drop in deciduous fruits. The experiments with holly, however, indicate that the materials should be used at about twice the strength recommended for fruit. For example, if the directions say to use at the rate of 1 pound or one part in 200 gallons of water to prevent drop, the amount needed for holly should be one part or 1 pound to 100 gallons of water.

It appears that in the case of holly, dipping in some form is more efficient than application in the form of spray. A large vat or tank may be used for this purpose. The holly can be placed in wire baskets or slotted crates, dipped into the solution and then allowed to drain until the excess solution has been removed. A drainboard should be provided so that the excess solution will be returned to the tank. The holly should not be allowed to soak in the solution, but should be drained immediately after dipping. Solutions of a-naphthaleneacetic acid remain effective over a fairly long period and the same solution can be used for several days. With extensive use, however, the solution becomes contaminated with dirt and may leave a deposit of foreign matter on the foliage.

The possibility of spraying the holly trees with these materials before cutting the holly has not been investigated. If good coverage could be obtained,
this method should be effective. This spraying should not be done more than a
day or two before cutting and should not be applied during rainy weather.
Dipping the holly seems to be a more practical method of using the hormones
in most cases.

The use of hormone dips before packing will allow holly to be packed suf-
ficiently wet to maintain its freshness until it reaches its destination. The ques-
tion of how wet to pack the holly will have to be decided by each individual
grower to fit his method of handling. Small experimental lots of holly have
been packed while still dripping wet and wrapped in moist paper, and still did
not show any injury after several days even when held at room temperature.
These conditions are not comparable to the large commercial packs where
other factors may arise, but no harmful effects of moderately wet packs are
anticipated.

When holly is packed dry bruise marks are not so evident on the berries
and they remain plump and bright, but the foliage loses its fresh green luster
and if held at room temperatures turns black and becomes unsaleable. At its
best, holly packed dry does not have the quality of holly packed with sufficient
moisture to keep the foliage bright.

In summarizing the results of many experimental packs of holly treated
with hormones and not treated, packed wet and packed dry, the following recom-
mandations can be made: Dip the holly in the hormone solution as soon as it
is cut. Drain off the excess water. Pack with sufficient moisture to keep the
holly fresh until it reaches its destination. Ship immediately or store at tem-
peratures below 40° F. but do not allow the holly to freeze.

A word of caution is necessary regarding the use of oils or spreaders
with hormone solutions. Compatibility may be a factor in such cases, and
representatives of the manufacturers should be consulted before attempting to
use the hormones in combination with oil or fatty products.

While hormone sprays are generally effective in retarding defoliation in
the presence of ethylene gas, precaution against ethylene contamination should
be taken. Holly should not be shipped or stored along with fruit, and ethylene
from other sources should be excluded so far as possible.