STORAGE OF ROOTED WOODY CUTTINGS

by

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INTRODUCTION

Many nursery crops are propagated under glass. Some require only a few weeks to root. Rooted cuttings are usually handled in one of two methods. They may be held over winter in the propagation bench or, in most instances, removed from the propagation bench, potted or flatted, and held under glass until spring. At this time they are usually planted in the field or sold as liners. There is a possibility that certain kinds of plants could be stored, thereby eliminating costly handling and maintenance operations, as well as making available for re-use additional greenhouse space.

The purpose of this investigation was to determine whether certain rooted cuttings stored at various low temperatures will survive. Further, will the plants be of comparable quality to those removed from the propagation bench, potted, and held in the greenhouse.

REVIEW OF LITERATURE

On the basis of preliminary investigations by Snyder and Hess (12), long term storage of rooted cuttings of certain ornamental plants at low temperatures may be advantageous to nursery production. Low temperature storage of rooted cuttings in closed polyethylene bags has been demonstrated as a satisfactory method of handling cuttings of several nursery crops prior to field planting. Rooted cuttings of Germander, _Teucrium chamaedrys_, stored at 34° F for periods up to 167 days made growth in the field equal to control plants which had been maintained at a low temperature in the greenhouse. Cuttings stored at 31° F did not survive. Rooted cuttings of _Taxus cuspidata_ stored at 39° F produced plants comparable to those potted and maintained at a low temperature in the greenhouse prior to field planting. Rooted cuttings of Juniperus communis hibernica and two varieties of Thuja occidentalis (pyramidalis and globosa) stored at 31° F, 35° F, and 39° F did not grow as well as those handled by usual nursery practices.

Studies made in Michigan by Widmoyer (2) on rooted cuttings of Salix purpurea nana, Taxus cuspidata, and Buxus sempervirens were stored bare root in polyethylene bags at temperatures of 32° F, 40° F, and 50° F from July 25th until November 19th -- a total of 117 days. Storage of Taxus in non-perforated bags resulted in 100 per cent survival; at 40° F, 80 per cent survival. Storage of Buxus cuttings at 32° F resulted in 100 per cent survival, but made poor growth. Storage of Buxus cuttings at 40° F resulted in 100 per cent survival and made very vigorous growth. All plants stored at 50° F died.

Investigations by Mastalerz (6) showed rooted and unrooted cuttings of several English ivy varieties were stored successfully for five weeks at 31° F. Stored cuttings became established in soil and developed new shoot growth as fast as unstored cuttings.

Mastalerz found that Philodendron cordatium, Grape ivy (Cissus rhombifolia), Kangaroo Vine (Cissus antarctica), Prayer Plant (Maranta leuconeura Kerchoveana), Rex Begonia, and Peperomia minima did not survive storage treatment at 31° F to 40° F.

Cuttings should not be stored beyond an optimum length of time, which for ivy appears to be five weeks.

Widmoyer (14) has worked with various chemicals to prevent mold on stored cuttings; however, his results have not been published. Chemicals used include sodium o-phenyl-phenate as a 20 to 30 second dip on the cutting at a concentration of between .1-.25 per cent keeping the roots free of the chemical; borax in a five to eight per cent solution which is composed of two parts of borax and one part boric acid; diphenyl impregnated filter paper using .08 milligrams of active ingredient per liter of water, (this is then dried and inserted in the package); Thiourea three per cent solution; Karathane one per cent solution, and Captan five per cent solution. The various chemicals seem quite promising both in the prevention of storage mold and upon further growth and development of the plant. Juniper cuttings that have been stored since last fall are being used. These have been inserted in the rooting medium from time to time to determine whether or not plant materials can be stored over a long period of time and still be expected to root and grow. These cuttings have been stored at a temperature of 40° F with added humidity. There is no indication of mold in the cuttings; however, they have not been stored in closed polyethylene bags, either rooted or unrooted.

Grandfield (3) found that alfalfa seedlings stored well. Seedlings dug in June were washed, the tips cut off eight inches below the crown, and the tops trimmed so as to leave very little green material. The plants were hardened by placing them at 50° F for three days. They were then placed in storage at lower temperatures. Ninety-two per cent of the plants held at 40-42° F and 90 per cent of the plants held at 32-34° F survived five months. This method makes it possible to propagate two crops of alfalfa in the same greenhouse space in one winter for transplanting in the spring.

According to Thomas and Moore (13), tomato seedlings grown in Georgia were shipped to Indiana and stored at approximately 70° F for seven, five, three and zero days before being set in the field. All the plants were two days in transit except those set immediately which were three days in transit. For each storage period, one group of plants had the roots moistened by a daily dip of five to ten minutes in water and a second group which was not moistened.

The

The results obtained in 1942 showed that the early growth as measured by number of leaves per plant and early yield of those plants held longer than three days were significantly reduced when compared with those plants held for three days or set immediately. In total yields no significant differences between treatments were observed.

Worthington and Scott (15) evaluated the use of polyethylene liners for storing strawberry plants under commercial storage conditions. Storage rooms were maintained at 30° F, plus or minus one degree. Three kinds of packages were compared: (1) standard wire-bound crate packed with moist sphagnum moss, (2) standard wire-bound crate with polyethylene liner and moist sphagnum moss, and (3) standard wire-bound crate with polyethylene liner but no moss. Nine varieties were tested. The polyethylene liners were not perforated and were not sealed, merely overlapped upon completion of packing. The storage period ranged from eight to ten months. Plants stored in crates with polyethylene liners, with or without sphagnum, were superior in leaf and root appearance to plants stored in sphagnum moss in wire-bound crates without liners. No decay was found in any of the plants stored in polyethylene liners without moss.

According to Meder and Feldman (5), strawberry plants subjected to alternate freezing and thawing temperatures during storage will undergo carbohydrate conversion (starch to sugar) and apparent increased respiration. This led to a physical weakening or exhaustion of plants leading to ultimate death.

Neff and Loomis (10) stored French marigolds at 40° F and 33° F for 17, 21, and 23 days. Duplicate lots were wrapped as follows: (1) with waxed paper, (2) cloth, then moist moss, and finally covered with waxed paper, and (3) with brown paper. French marigolds stored better at 40° F than at 33° F. The flowers wrapped with waxed paper were best commercially. Low turger pressure brought about by storing without water slowed down maturity and increased the life of the flowers at room temperature.

Carnations were the flowers first studied in the research trials of Post and Fisher (11). They confirmed the findings of Neff that carnation flowers could be stored for periods of at least one month at low temperatures in dry pack; that is, wrapped without addition of moisture, with no essential reduction in quality. Several varieties stored in excellent condition in dry packs at 31° F for at least one month. Pompom chrysanthemums stored at 31° F in dry packs for a month or more, and flowers kept from seven to ten days following removal from storage. Roses, variety Better Times, stored for periods of 18 or less days under the low temperature-dry storage conditions, opened normally and lasted five days at room temperature. Other flowers stored successfully were Lily of the Valley for three weeks, Gardenia for three weeks or less, Tulips for eight weeks, Daffodils for two weeks, and others.

Mastalerz (7) found that rooted chrysanthemum cuttings held at 31° F for four to five weeks grew as well as unstored cuttings. No differences were noted after storage with several varieties grown as cut flowers. If stored longer than five weeks, decay of foliage became a problem.

No consistent differences in height or weight 30 days after planting and at maturity were noted between stored and unstored cuttings. Varietial differences or the type packaging material, cellophane or polyethylene, did not influence the slight variations between the stored and unstored cuttings.

Rooted cuttings of Chrysanthemum, Bonnaffon Deluxe, were wrapped in polyethylene and stored from three to five weeks. After storage five cuttings were planted per six-inch pot and grown at 60° F.

Differences with potted chrysanthemums between stored and unstored cuttings were similar to those for cut flowers and were not significant. Four additional groups were stored with results comparable to those already presented.

Mikkelsen (9) found that chrysanthemum cuttings held at 31-35° F could be held satisfactorily for two to five weeks.

According to Mastalerz (8), polyethylene is the most suitable of all the plastic films tested for holding carnation cuttings. It is flexible, easily sealed with Scotch tape, and does not absorb water from the cuttings. The outstanding feature of polyethylene is the fact that gasses readily pass through it while the escape of water is prevented. Scorching, due to lack of oxygen, and drying out of plant tissues because of moisture loss do not occur. Polyethylene bags are re-useable while packages made from sheets sealed with tape are normally discarded.

Curtis and Rodney (1) found that traces of ethylene, on the order of one p.p.m. in the atmosphere of the storage room, can do serious damage to dormant nursery stock of apples or pears and perhaps other species at cold storage temperatures. Damage consists in characteristic lesions, abscission or death of buds, and death of stems. Pears are particularly susceptible to damage.

A temperature of 35° F for about two months is required for symptoms on pears. Differences in ethylene concentration between one p.p.m. and ten p.p.m. do not greatly alter the required exposure period.

In the range of cold storage temperatures used, the temperature factor has great effect. As compared to slow development at 35° F, lesions develop about four times as fast at 45° F and seven times as fast at 55° F.

Wright, et al. (16) has given the recommended temperatures, relative humidity, and approximate length of storage periods for cut flowers, florist greens and both rooted and unrooted chrysanthemum and carnation cuttings. Storage and packing recommendations and related information for rhizomes, tubers, roots, bulbs, corms, and nursery stocks are given. Nursery stocks stored include deciduous fruit trees, shrubs, and rose plants.

Kiplinger (4) found it necessary to maintain a light intensity of about 50 foot candles to reduce leaf drop on azaleas during storage at 45° F.

METHODS AND MATERIALS

Seven species of plants were used in the tests. These included Taxus media clon Hicks, Euonymus kiautchovicus, Ilex convexa clon bullata, Azalea hinodegiri, Pyracantha coccinea lalandi, Juniperus horizontalis, and Taxus cuspidata. The euonymus, pyracantha, and juniper cuttings were taken from plants located on the campus. These were inserted into a rooting medium September 17th, September 30th, and November 6th, 1956, respectively. The azalea, Taxus media clon Hicks, and Ilex cuttings were imported from New Jersey and inserted into the rooting medium on September 20th, 1956. The Taxus cuspidata were purchased as rooted cuttings from a nursery in Maryland.

All cuttings, with the exception of the azaleas and Taxus cuspidata, were treated with Dow Number 1 Hormone powder and inserted in vermiculite. The azaleas were not treated with a hormone and were rooted in peat moss (Plate I).

The Taxus media clon Hicks cuttings became infested with a fungus, Rhizoctonia solani, which was determined by a culture test. They were treated with a Captan solution (two tablespoons per gallon of water) by drenching the rooting medium. The plants were retarded, but 80 per cent of them rooted well.

As the varieties of cuttings rooted, they were processed and stored. The rooted cuttings were stored in four storages, plus a control plot held in

EXPLANATION OF PLATE I

Cuttings inserted in rooting medium.

PLATE I

the greenhouse (Table 1). Storage included the following: (1) apple storage room held at 36-38° F, (2) agronomy storage room held at 39-41° F, (3) common storage in a storage cellar held at 36-54° F (Table 2), (4) buried in the soil at a 12 inch depth at varying soil temperatures in a lath house (Table 2), and (5) control group held in greenhouse space.

Processing for storage was as follows: Each species of 250 plants tested was divided into five groups of 50 plants each. These groups of 50 plants were subsequently divided into two lots of 25 plants each. Twenty-five plants were immersed in a dilute solution of Captan (one tablespoon per gallon of water) to control fungi. The remaining 25 plants in each group were not treated with Captan. All of the rooted cuttings, with the exception of the azaleas, were stored "bare root;" that is, without material surrounding the roots. The azalea cuttings were stored with the peat moss rooting medium intact since it was impossible to remove it without injury to the root system. Twenty-five plants treated with Captan were placed along with a marker in a polyethylene bag and tightly tied with twine; the 25 non-Captan treated plants were placed in a polyethylene bag without a marker and similarly tied. These bags then were put into storage (Table 1 and Plate II).

The rooted cuttings used for the controls were potted in three-inch rose pots (Plate II). The controls were held in a 70° F greenhouse. A soil mixture of two parts sterilized soil, one part peat, and one part sand was used. The azaleas were planted in three parts peat moss and one part soil. Daily watering and one liquid fertilizing was given the control plants. The potted azaleas received an application of iron and sulfur to prevent chlorosis. The plants in storage were inspected frequently by observing them through the clear polyethylene bags.

Table 1. Temperatures and storage dates.

Rooted cuttings	F temp. ranges	Date stored	Days in storage
	Common storage		
Euonymus kiautchovicus	36-52	12-16-56	133
Pyracantha coccinea	36-52	12-16-56	133
Ilex convexz clon bullata	36-54	12-29-56	127
Azalea hinodegiri	36-54	1-25-57	102
Juniperus horizontalis	36-52	1-25-57	91
Taxus cuspidata	36-54	2-6-57	93
Taxus media clon Hicks	36-54	3-2-57	63
	Apple storage		
Euonymus kiautchovicus	36-38	12-16-56	133
Pyracantha coccinea	36-38	12-16-56	133
Ilex convexa clon bullata	36-38	12-29-56	127
Azalea hinodegiri	36-38	1-25-57	102
Juniperus horizontalis	36-38	1-25-57	91
Taxus cuspidata	36-38	2-6-57	93
Taxus media clon Hicks	36-38	3-2-57	63
	Agronomy grain cooler		
Euonymus kiautchovicus	39-41	12-16-56	133
Pyracantha coccinea	39-41	12-16-56	133
Ilex convexa clon bullata	39-41	12-29-56	127
Azalea hinodegiri	39-41	1-25-57	102
Juniperus horizontalis	39-41	1-25-57	91
Taxus cuspidata	39-41	2-6-57	93
Taxus media clon Hicks	39-41	3-2-57	63
	Burying at 12" depth		
Euonymus kiautchovicus		12-16-56	133
Pyracantha coccinea		12-16-56	133
Ilex convexa clon bullata		12-29-56	127
Azalea hinodegiri	None buried	---	---
Juniperus horizontalis		1-25-57	91
Taxus cuspidata		2-6-57	93
Taxus media clon Hicks	None buried	---	---
	Greenhouse control		
Euonymus kiautchovicus	70-90	12-16-56	133
Pyracantha coccinea	70-90	12-16-56	133
Ilex convexa clon bullata	70-90	12-29-56	127
Azalea hinodegiri	70-90	1-25-57	102
Juniperus horizontalis	70-90	1-25-57	91
Taxus cuspidata	70-90	2-6-57	93
Taxus media clon Hicks	70-90	3-2-57	63

Table 2. Common storage and outside temperatures.

Day	Outside maximum F. temp.	Outside minimum F. temp.	Common storage in cave	Day	Outside maximum F. temp.	Outside minimum F. temp.	Common storage in cave
Dec.				Jan.			
16	55	23	38	26	11	4	38
17	47	21	38	27	29	6	38
18	45	10	38	28	30	16	38
19	45	34	38	29	25	10	38
20	51	27	38	30	35	-4	38
21	58	31	38	31	34	23	38
22	45	30	38				
23	38	25	38	Feb.			
24	37	17	38	1	39	25	38
25	49	16	38	2	36	22	38
26	58	28	38	3	35	28	38
27	59	30	38	4	35	20	38
28	50	37	38	5	38	30	38
29	60	30	38	6	43	28	38
30	63	24	38	7	43	33	38
31	48	25	38	8	50	36	37
				9	68	35	37
Jan.				10	58	30	37
1	37	24	38	11	51	21	37
2	46	19	38	12	57	29	37
3	54	33	38	13	68	25	37
4	35	27	38	14	50	29	37
5	37	24	38	15	53	35	37
6	45	30	38	16	53	20	36
7	47	21	38	17	63	25	36
8	44	33	39	18	57	31	36
9	39	5	39	19	40	22	36
10	18	-1	39	20	43	25	36
11	38	15	39	21	42	20	36
12	39	16	41	22	20	13	36
13	17	10	42	23	27	15	36
14	26	4	42	24	46	27	36
15	22	8	42	25	57	33	36
16	19	4	42	26	50	28	36
17	33	13	42	27	53	20	36
18	52	15	42	28	55	24	36
19	43	23	42				
20	54	30	42	Mar.			
21	61	31	37	1	58	24	36
22	31	13	37	2	47	29	36
23	28	4	38	3	51	19	37
24	29	15	38	4	47	36	38
25	21	2	39	5	50	30	38

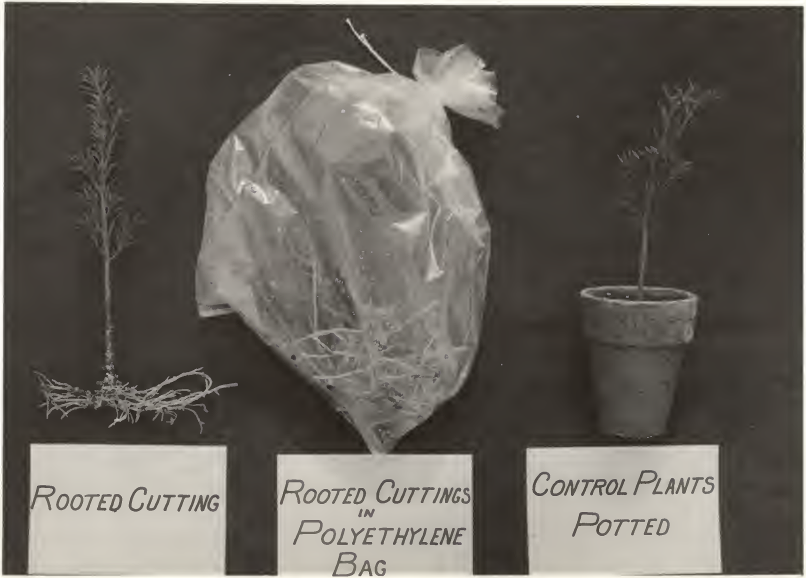
Table 2. (concl.)

Day	Outside maximum F. temp.	Outside minimum F. temp.	Common storage in cave
Mar.			
6	40	26	38
7	35	16	38
8	52	15	39
9	53	20	39
10	75	42	39
11	70	48	40
12	74	30	40
13	79	54	41
14	73	30	42
15	56	22	36
16	72	34	36
17	66	44	36
18	55	36	37
19	52	31	38
20	55	29	39
21	50	39	40
22	43	37	40
23	43	37	40
24	44	35	41
25	35	30	41
26	48	23	41
27	55	28	41
28	57	33	41
29	58	36	42
30	58	35	42
31	53	42	42
April			
1	52	46	42
2	51	40	42
3	41	37	42
4	43	33	43
5	48	28	43
6	56	28	41
7	50	36	42
8	53	24	42
9	56	30	42
10	72	37	42
11	62	28	38
12	38	21	41
13	44	23	41
14	56	34	42
Apr.			
15	53	42	42
16	61	41	42
17	63	52	42
18	80	52	42
19	78	63	42
20	75	47	42
21	70	56	44
22	77	57	46
23	71	52	48
24	77	58	48
25	80	52	50
26	73	56	52
27	71	47	52
28	74	56	52
29	70	50	52
30	78	58	52
May			
1	81	55	53
2	71	60	53
3	66	52	54
4	64	45	54
5	70	34	54
6	73	38	54
7	77	50	54
8	77	57	54
9	77	63	54
10	71	50	54
11	57	50	54
12	82	55	54

EXPLANATION OF PLATE II

From left to right: rooted cuttings of _Taxus media_ clon _Hicks_ when removed from rooting medium; rooted cuttings sealed in non-perforated polyethylene bag ready for storage; potted control plant.

PLATE 11


ROOTED CUTTING
ROOTED CUTTINGS IN POLYETHYLENE BAG
CONTROL PLANTS POTTED

The euonymus and pyracantha (stored for 133 days) and the juniperus (stored for 91 days) were planted in the field. The plants were spaced eight inches apart in rows 40 inches apart. The rooted cuttings from storage and the control plants were set out in a predetermined sequence. The rows were approximately 50 feet long. One Captan treated plant from each of the four storage conditions and a control plant were set out in a series of five plants. This was followed by a replication of five plants that were not treated with Captan. This procedure was repeated for all the plants giving 50 replications of each variety.

Ilex (stored for 127 days), azaleas (stored for 102 days), _Taxus cuspidata_ (stored for 93 days), and _Taxus media_ clon _Hicks_ (stored for 63 days) were planted in the lath house. They were planted on a six-inch by six-inch spacing. The arrangement in the replication was the same as the euonymus, pyracantha, and juniperus. The azaleas were planted in a bed of peat moss. The _Taxus media_ clon _Hicks_ and the azaleas did not have plants in buried storage.

RESULTS AND DISCUSSION

Rooted cuttings of _Euonymus klautchovicus_ were stored for 133 days. When the cuttings were taken from storage, those that had been stored in the apple storage room at 36-38° F and those that had been stored in the agronomy storage at 39-41° F were defoliated. This was thought to be due to ethylene gas that had been given off by the apples in storage as reported by Curtis and Rodney (1). The rooted cuttings held in the agronomy storage had been held in the apple storage for 25 days awaiting the availability of the Agronomy storage. The roots and buds appeared quite healthy. While cuttings in common storage retained their leaves, they appeared slightly wilted at the time of planting. The root color of all stored plants was brown while those in buried storage and the potted controls remained white. Many of the brown roots showed white tips indicating some root growth had occurred during all storage. The control plants varied in the amount of growth made, from a few to several inches. The control plants at the time of planting had a decided advantage in size and vigor (Plate III). Sixty-two days after being planted, the plants were checked for survival, comparable size, and vigor. Survival of the plants in storage was fairly good (Table 3).

It was possible to identify the control plants in some instances. The plants taken from storage were vigorous in appearance and growth and in many instances were comparable to the control plants. Plants from common and buried storage seemed to have made the greatest amount of growth with the exception of the control plants. The ethylene gas may have retarded plants held in the apple and agronomy storages.

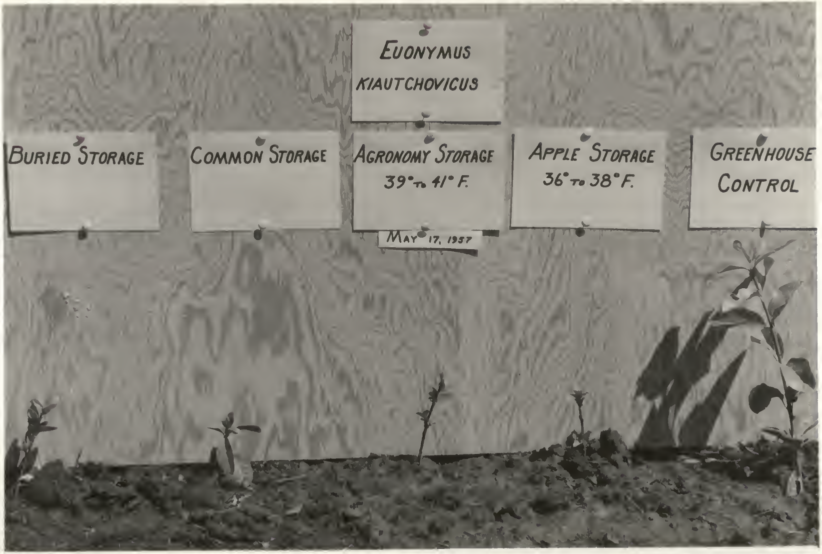
Since there is not a great difference in many instances between the stored and control plants, it may be they will be of comparable quality by the end of the current growing season. Storage of euonymus rooted cuttings then may be feasible.

Pyracantha coccinea lalandi rooted cuttings were stored for 133 days. When the cuttings were taken from the apple storage (36-38° F) and the agronomy storage (39-41° F), they were partially defoliated. Defoliation was thought to be due to the ethylene gas given off by the apples in storage. Rooted cuttings held in the agronomy storage had previously been held in the apple storage for 25 days awaiting the availability of the agronomy storage. Cuttings held in common and buried storage appeared to be in the best condition

EXPLANATION OF PLATE III

Rooted cuttings and a control plant of *Euonymus kiautchovicus* one week after planting. Note size of control plant. Plants from agronomy and apple storage have just leafed out.

PLATE III


Euonymus
kiautchovicus
Buried Storage
Common Storage
Agronomy Storage
39° to 41° F.
Apple Storage
36° to 38° F.
Greenhouse
Control
May 17, 1957

of the stored plants at the time of planting to field conditions. Cuttings in these storages retained their leaves. Roots of all plants that had been stored except those buried appeared brown. No new root growth was noted.

Table 3. Survival of Euonymus kiautchovicus after 62 days in field.

Storage	Treatment	No. treated	No. survived	Total survival	Per cent survival
Control plot in greenhouse	None None	50	48	48	96[1]
Apple storage 36-38° F	Captan Non-Captan	25 25	22 22	44	88
Agronomy storage 39-41° F	Captan Non-Captan	25 25	21 22	43	86
Common storage 36-54° F	Captan Non-Captan	25 25	22 23	45	90
Buried storage	Captan Non-Captan	25 25	23 25	48	96

[1]Control plants broken off by watering and cultivation.

The control plants which were potted and held in the greenhouse had made vigorous top and root growth and were much larger in all instances than the rooted cuttings from all storage conditions (Plate IV).

It was observed that plants held in the apple storage (36-38° F) and the agronomy storage (39-41° F) had the highest mortality rate, possibly due in whole or in part to exposure to ethylene gas (Table 4).

After growing in the field 62 days, the control plants previously held in the greenhouse showed a distinct superiority in survival, vigor, and especially comparable size. It is indicated that storage under these

EXPLANATION OF PLATE IV

Cuttings and control plant one week after planting in the field. Note the large size of the greenhouse control.

PLATE IV


PYRACANTHA
COCCINEA
BURIED STORAGE
COMMON STORAGE
AGRONOMY STORAGE
39° TO 41° F.
MAY 17, 1957
APPLE STORAGE
36° TO 38° F.
GREENHOUSE
CONTROL

conditions is not a satisfactory method of handling pyracantha. It appears that pyracantha cuttings should be handled in the usual manner; that is, planted in containers and held over winter under glass until the following spring.

Table 4. Survival of Pyracantha coccinea lalandi after 62 days in field.

Storage	Treatment	No. treated	No. survived	Total survival	Per cent survival
Control plot in greenhouse	None None	50	48	48	96[1]
Apple storage 36-38° F	Captan Non-Captan	25 25	19 8	27	54
Agronomy storage 39-41° F	Captan Non-Captan	25 25	14 7	21	42
Common storage 36-54° F	Captan Non-Captan	25 25	22 22	44	88
Buried storage	Captan Non-Captan	25 25	24 24	48	96

[1]Control plants broken off during cultivation.

Juniper rooted cuttings were stored for 91 days (Table 1). Cuttings from all storage conditions retained their leaves. The roots of the stored cuttings appeared to be brittle as many of them had broken off during the time of storage, possibly due to handling. The control plants had made root growth while being held in the greenhouse although little top growth was noted.

Sixty-two days after being planted in the field, it was noted that plants from all storages had approximately the same percentage of survival and size (Table 5 and Plate V). Juniper cuttings stored at 39-41° F had the highest per cent survival.

Table 5. Survival of Juniperus horizontalis after 62 days in field.

Storage	Treatment	No. treated	No. survived	Total survival	Per cent survival
Control plot in greenhouse	None None	50	49	49	98
Apple storage 36-38° F	Captan Non-Captan	25 25	18 20	38	76
Agronomy cooler 39-41° F	Captan Non-Captan	25 25	20 21	41	82
Common storage 36-54° F	Captan Non-Captan	25 25	13 14	37	74
Buried storage	Captan Non-Captan	25 25	15 13	38	76

The control plants in most instances appeared superior in vigor to the rooted cuttings that had been stored. With careful handling, it may be feasible to store juniper rooted cuttings at temperatures between 36-41° F.

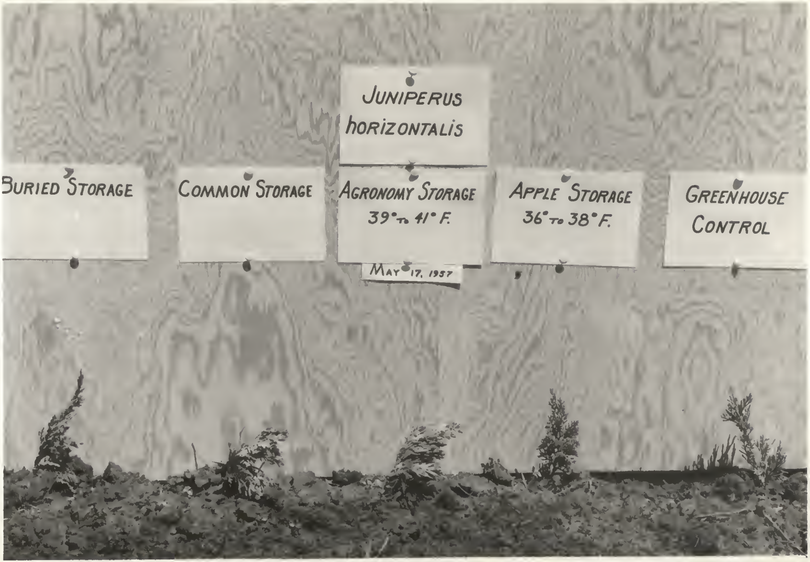
Azalea hinodegiri rooted cuttings were stored for 102 days (Table 1). Rooted cuttings in all storage conditions were partially or completely defoliated. It was considered to be due to inadequate light as explained by Kiplinger (4). Even under nursery conditions, too much shade during winter months will often cause defoliation of over-wintering plants. Defoliations possibly were aided in the apple storage groups by their exposure to ethylene gas.

Cuttings of all stored groups appeared about the same. The control plants on the other hand were far superior in size, vigor, and survival (Plate VI).

EXPLANATION OF PLATE V

Cuttings and control plants of *Juniperus horizontalis* one week after planting. Shows similarity in size.

PLATE V


Juniperus horizontalis
Buried Storage
Common Storage
Agronomy Storage
39° to 41° F.
May 17, 1957
Apple Storage
36° to 38° F.
Greenhouse Control

EXPLANATION OF PLATE VI

Cuttings and control plant of *Azalea hinodegiri* one week after planting in the lath house. Note larger and more vigorous greenhouse control plant.

PLATE VI


GREENHOUSE CONTROL
APPLE STORAGE 36° to 38°F
GRAIN STORAGE 39° to 41°F
COMMON STORAGE

Observations showed rather low survival in all stored groups (Table 6). After 50 days all stored cuttings planted in the lath house had leafed out, but had not made any increase in size and appeared to lack vigor.

Table 6. Survival of _Azalea hinodegiri_ after 50 days in the lath house.

Storage	Treatment	No. treated	No. survived	Total survival	Per cent survival
Control plot in greenhouse	None None	50	50	50	100
Apple storage 36-38° F	Captan Non-Captan	25 25	11 10	21	42
Agronomy cooler 39-41° F	Captan Non-Captan	25 25	21 18	39	78
Common storage 36-54° F	Captan Non-Captan	25 25	15 18	33	66

It appears that with the relatively low per cent survival, it would not be feasible to store azalea cuttings under the storage conditions used. Control plants held in the greenhouse maintained their larger size and vigor. As most azaleas are sold in the spring as liners, it is necessary for them to make as much growth as possible. They continue to grow when planted out in the spring. It would, in most instances, be impossible to sell them unless grown in the greenhouse over the winter as the top growth of the stored plants would be nearly the same size as when they were inserted. Storage of azaleas may retard the plants as much as the loss of a full growing season.

Taxus media clon _Hicks_, stored for 63 days, _Taxus cuspidata_, stored for 93 days, and _Ilex convexa_ clon _bullata_, stored for 127 days, did quite well under all storage conditions (Tables 7, 8, and 9). None of these varieties were defoliated (Plates VII, VIII, IX). The Hicks Yew and Ilex control plants made slight top and root growth. The Taxus cuspidata control plants appeared greener but new growth was not observed. All of the stored cuttings in both varieties survived; however, one Taxus cuspidata control plant died. Ilex mortality was very low, only a few plants died in storage.

Table 7. Survival of Ilex convexa clon bullata after 52 days in lath house.

Storage	Treatment	No. treated	No. survived	Total survival	Per cent survival
Control plot in Greenhouse	None None	50	50	50	100
Apple storage 36-38° F	Captan Non-Captan	25 25	25 24	49	98
Agronomy cooler 39-41° F	Captan Non-Captan	25 25	25 25	50	100
Common storage 36-54° F	Captan Non-Captan	25 25	25 22	47	94
Buried storage	Captan Non-Captan	25 25	24 25	49	98

After being planted in the lath house for 52 days, the Hicks Yew and the Holly plants were observed. Taxus cuspidata were observed after 47 days. It was impossible to determine differences in the stored and control plants of these three varieties.

From the range of storage conditions, the per cent survival, and the comparable quality of the stored rooted cuttings to the control plants, it appears that these varieties may be stored satisfactorily on a commercial basis

(Plates VIII and IX). Snyder and Hess (12) found that rooted cuttings stored at 39° F made growth in the field comparable to those rooted cuttings potted and maintained at low temperatures in the greenhouse prior to planting. As there were no differences noted, at least in the first season's growth, time and effort may be saved by handling plants in this manner if adequate storage facilities are available.

Table 8. Survival of Taxus media clon Hicks after 50 days in the lath house.

Storage	Treatment	No. treated	No. survived	Total survival	Per cent survival
Control plot in greenhouse	None None	50	50	50	100
Apple storage 36-38° F	Captan Non-Captan	25 25	25 25	50	100
Agronomy cooler 39-41° F	Captan Non-Captan	25 25	25 25	50	100
Common storage 36-54° F	Captan Non-Captan	25 25	25 25	50	100

Table 9. Survival of *Taxus cuspidata* after 47 days in the lath house.

Storage	Treatment	No. treated	No. survived	Total survival	Per cent survival
Control plot in greenhouse	None None	50	49	49	98
Apple storage 36-38° F	Captan Non-Captan	25 25	25 25	50	100
Agronomy cooler 39-41° F	Captan Non-Captan	25 25	25 25	50	100
Common storage 36-54° F	Captan Non-Captan	25 25	25 25	50	100
Buried storage	Captan Non-Captan	25 25	25 25	50	100

EXPLANATION OF PLATE VII

Rooted cuttings and control plant of *Taxus cuspidata* one week after planting. Note uniform size of all plants.

PLATE VII


GREENHOUSE CONTROL
APPLE STORAGE 36° to 38°F
GRAIN STORAGE 39° to 41°F
COMMON STORAGE
BURIED STORAGE

EXPLANATION OF PLATE VIII

Cuttings and control plant of *Taxus media* clon *Hicks* one week after planting in the lath house. Greater size in the greenhouse control was due to the larger sized cutting, as well as about ½ inch growth.

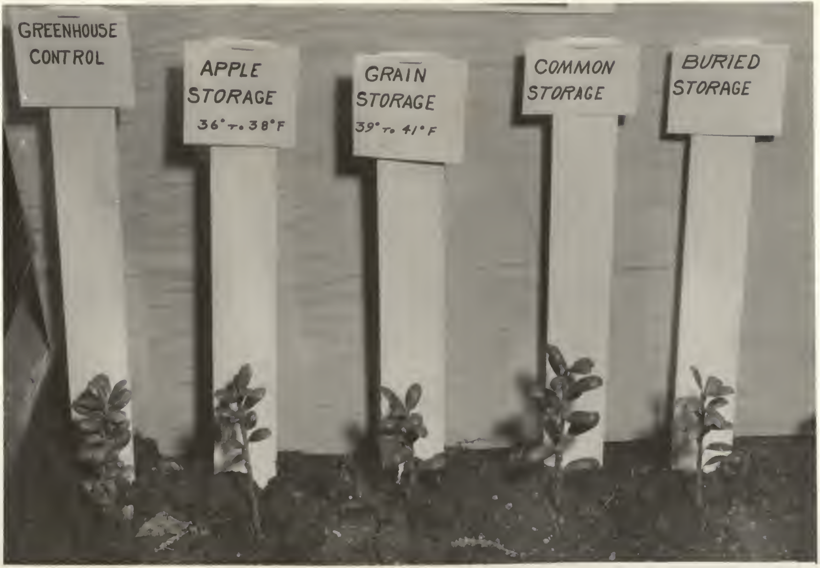
PLATE VIII


GREENHOUSE
CONTROL
APPLE
STORAGE
36° TO 38°F
GRAIN
STORAGE
39° TO 41°F
COMMON
STORAGE

EXPLANATION OF PLATE IX

Cuttings and control plant of *Ilex convexa* clon *bullata* one week after planting in the lath house. Note similar size.

PLATE IX


GREENHOUSE
CONTROL
APPLE
STORAGE
36° TO 38°F
GRAIN
STORAGE
39° TO 41°F
COMMON
STORAGE
BURIED
STORAGE

SUMMARY AND CONCLUSIONS

These tests were conducted to determine if certain species of plants would survive at low temperatures as rooted cuttings; further, would the stored plants be of comparable quality as those held under glass.

Seven species of plants were tested. Cuttings of Taxus media clon Hicks, Euonymus kiautchovicus, Ilex convexa clon bullata, Azalea hinodegiri, Pyracantha coccinea lalandi, and Juniperus horizontalis were obtained and inserted into a rooting medium. The Taxus cuspidata cuttings were purchased rooted.

As the cuttings rooted or were received, they were packaged in non-perforated polyethylene bags, sealed, and put into storage. Storage conditions included (1) apple storage room held at 36-38° F, (2) agronomy storage held at 39-41° F, (3) common storage in a cellar held at 36-54° F (Table 1), and (4) buried storage at a 12 inch depth in a lath house at varying soil temperatures (Table 1). A control group of each species was potted and held in the greenhouse.

The euonymus and pyracantha (stored for 133 days) and the juniperus cuttings (stored for 91 days) were planted to field conditions. The plants were spaced eight inches apart in rows 40 inches apart. The ilex (stored for 127 days), Taxus cuspidata (stored for 93 days), Taxus media clon Hicks (stored for 63 days) and the azaleas (stored for 102 days) were planted in a lath house. The cuttings were planted on a six-inch by six-inch spacing.

The euonymus, junipers, and pyracantha plants were observed after being in the field for 62 days. Survival counts were made as well as observations regarding comparable quality between the stored cutting of each species and control plants from the greenhouse. The Hicks Yew and Holly plants were observed after 52 days, the azaleas after 50 days and the Japanese Yew after 47 days in the same manner as the euonymus, pyracantha and juniper plants.

Taxus cuspidata, *Taxus media* clon *Hicks*, and *Ilex convexa* clon *bullata* stored cuttings made favorable growth comparable to the control plants. The Hicks Yew (Plates VII, VIII, and IX) had 100 per cent survival, while the *Taxus cuspidata* lost one control plant. Ilex plants had quite good survival, ranging from 94 per cent to 100 per cent (Tables 7, 8, and 9). The per cent survival and the comparable quality of these three species under all storage conditions used indicates these varieties may be satisfactorily stored on a commercial basis.

The stored juniper cuttings ranged from 74 to 82 per cent in survival, while the controls had 98 per cent survival (Table 5). Quality of the controls was superior to the plants from the four storages. Juniper rooted cuttings seem to be a borderline case. With careful handling, it may be possible to store juniper rooted cuttings. Juniper rooted cuttings held at 39-41° F had the highest survival per cent of the plants in storage.

Azaleas had rather low survival (Table 6). Plants held in the apple storage at 36-38° F had a 42 per cent survival. This may have been due to the ethylene gas given off by the apples which were stored with the azaleas. Survival was 78 per cent in the agronomy grain storage. The control plants held over in the greenhouse were a great deal larger in size, had many side branches, and were generally far superior to the stored rooted cuttings from all storage conditions (Plate VI). Stored cuttings after 50 days in the lath house had leafed out, but made little growth. It would not be feasible to handle azaleas at these storage conditions.

Euonymus plants were observed after 62 days under field conditions. Survival percentages were high for all stored groups (Table 3). The cuttings held in the common and buried storages made the greatest amount of growth. It seems the ethylene gas may have affected the survival and vigor possibly due in part to the defoliation of those plants held in the apple and agronomy storages. The plants from all storages compared favorably with the control plants. Storage of euonymus rooted cuttings may be feasible under all the storage temperatures used.

Pyracantha rooted cuttings had low survival in the apple and agronomy storages in which plants had been exposed to ethylene gas. Plants held in common and burried storage had good survival (Table 4). Due to the superior quality of the control plants which were held in the greenhouse, it would not be feasible to handle pyracantha by storage, at least under these storage conditions (Plate IV).

For those plants where storage is feasible, there is a possibility for low cost, efficient handling until planting or shipping time. Further, greenhouse space may be made available for re-use. There is also a possibility that cuttings may be held in storage to facilitate propagation; that is, (1) holding of cuttings until adequate numbers are taken (2) benches may not be ready when cuttings are ready to be taken from stock plants, and (3) it may be advantageous to store plants for a time due to labor problems or other conflicts. Plants may be packaged and made ready for shipment during early winter months and be ready for spring delivery.

Careful consideration should be given to the storage facilities used. Determination of products held in the storage and the harmful gasses they may give off should be considered. Tests were conducted on rooted cuttings in the apple storage as it was one of the storage facilities available.

Even though buried storage showed excellent results in some instances, there is always the element of risk regarding weather conditions. It is possible under severe weather conditions, rodent damage, and so forth to lose a portion or the whole of the crop.

Captan treated rooted cuttings showed similar results to non-treated cuttings in storage with the exception of the pyracantha. It was observed that pyracantha cuttings stored in the apple and agronomy storages had approximately twice as many non-treated cuttings die as those that were treated with Captan.

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STORAGE OF ROOTED WOODY CUTTINGS

by

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of Agriculture and Applied Science, 1953

AN ABSTRACT OF A THESIS

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The purpose of the tests conducted was to determine if rooted cuttings stored at various low temperatures will survive, further will they be of comparable quality to those plants handled in the usual manner; that is, removal from the propagation bench, potted, and held under glass. If storage is feasible, there is the possibility of low cost, efficient handling of rooted cuttings. Since many plants require only a few weeks to root, greenhouse space may be made available for re-use.

Rooted cuttings of _Taxus media_ clon _Hicks_, _Taxus cuspidata_, _Ilex convexa_ clon _bullata_, _Juniperus horizontalis_, _Azalea hinodegiri_, _Pyracantha coccinea lalandi_, and _Euonymus kiautchovicus_ were used in the tests. Two hundred fifty cuttings of each variety were divided into five groups. Each group was then subdivided into equal lots of 25 plants each. Twenty-five plants were treated with a Captan solution at the rate of one tablespoon per gallon to prevent mold, the remaining 25 plants received no treatment. The lots of 25 plants were sealed in non-perforated polyethylene bags and put into storage. All varieties tested were stored "bare root," with the exception of the azaleas. Control groups of 50 plants of each variety were potted and held in the greenhouse.

Storage for the rooted cuttings included the (1) apple room held at 36-38° F, (2) agronomy grain storage held at 39-41° F, (3) common storage held at 36-54° F and (4) buried storage which fluctuated with soil temperatures.

Rooted cuttings of _Taxus media_ clon _Hicks_ (stored for 63 days), _Taxus_ cuspidata (stored for 93 days) and _Ilex convexa_ clon _bullata_ (stored for 127 days) were planted in the lath house and observed for survival and comparable quality to the control plants. Data were collected approximately 50 days after planting. Survival was high on these varieties ranging from 94 to 100 per cent under all storage conditions. Rooted cuttings compared favorably with the control plants. Results indicate that these varieties may be successfully stored under the above conditions.

Euonymus rooted cuttings stored for 133 days were planted to field conditions and observed after 62 days. Survival percentages were high for all stored rooted cuttings ranging from 86 to 96 per cent. Control plants had 96 per cent survival. Plants from storages compared favorably in most instances to the control plants. Euonymus cuttings appear to be a good prospect for storage.

Pyracantha rooted cuttings stored for 133 days were planted to field conditions and observed for survival and compared to control plants after 62 days in the field. Survival under storage ranged from 42 to 96 per cent. Control plants had 96 per cent survival. The control plants were far superior in size and vigor indicating storage of rooted cuttings under these conditions would not be feasible.

Juniperus rooted cuttings were stored for 91 days, planted to field conditions and observed for survival and compared to control plants 62 days later. Plants from all storages had survival percentages between 74 and 82 per cent. Controls had 98 per cent survival. Roots appeared brittle and many broke off during storage or handling. The control plants appeared more vigorous than those that had been stored. It may be feasible, with careful handling, to successfully store juniper rooted cuttings.

Azalea rooted cuttings were stored for 102 days, planted in the lath house, observed for survival and compared to the control plants after 50 days. The rooted cuttings from the four storages had rather low survival, between 42 and 78 per cent as compared to the control plants with 100 per cent survival. Control plants were much larger and more vigorous than the cuttings from storage. Azaleas are not a good prospect for storage.