MIST PROPAGATION OF EVERGREENS IN THE GREENHOUSE DURING WINTER*

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Horticultural forms of most evergreens have been relatively difficult to propagate and slow to root. Because of the relatively long period of time cuttings must remain in the propagation bench, greenhouse production costs have been very high. With the introduction of mist propagation equipment, however, much of the labour cost could be removed and the time element diminished if this technique could be applied to the winter propagation of evergreens.

Accordingly, experiments were initiated in the greenhouse in 1956 with cuttings being stuck in late December or early January. Over the four year period the effects of bottom heat, type of cutting, size of cutting, wounding, interval of mist and shade were studied with the variables being adjusted on the basis of current results.

In addition to the intermittent mist bench, cheesecloth, and in some instances, polyethylene covered propagation beds were used for purposes of comparison These propagation benches were installed on the standard bench used for regular greenhouse production. Thus, since humidity was a problem with the larger air volume, this was a more difficult test than would have occurred in a low air volume propagation house. Humidity was supplied by syringing the cheesecloth three or four times daily while the polyethylene tents were watered weekly.

The numbers within treatments (10 to 25 cuttings) and the number of treatments for a given variety was dependent upon the availability of cuttings on specimen plants in the ornamental plantings.

A medium of two-thirds sand and one-third peat moss was used in all propagation benches. The hormone powders used were Hormodin #1, Hormodin #2 and Hormodin #3, which contain 0.1, 0.3 and 0.8 per cent indolebutyric acid, respectively. Chloromone, a liquid extract of alfalfa with unknown active ingredient, was also tested.

ROOTING OF SPECIES OF JUNIPERUS

The only reference to mist propagation of *Juniperus* in winter has been by Snyder (6), who reported excellent success with *Juniperus chinensis pfitzeriana* under intermittent mist. Snyder (5) also summarized some 20 references related to the propagation of junipers.

Experiments with *Juniperus* spp. were initiated at Ottawa in 1956 and over the four-year period fifteen species and varieties were tested. Junipers, in general, showed a considerable difference in their reaction to the variables applied in the experiments. These responses and trends permitted us to draw a few generalizations.

Effects of Shade. Second only to the inherent ability of a species

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to root, light was the most important single factor in the successful rooting of juniper cuttings under intermittent mist during the winter months in the Ottawa area. Two years of poor results, following a very successful operation in the initial year coincided with the installation of lath shades on the propagation house. After this shade was removed in the fourth year, the rot problem practically disappeared and the best results were obtained without lath or shading compound in the winter months when light conditions were otherwise poor. For example, with *J. chinensis pfitzeriana aurea* and *J. sabina tamariscifolia*, 90 and 100 per cent rooting was easily obtained in a number of treatments before the shade was used. After it was removed, but during the two years where lath was used, practically all treatments yielded below 50 per cent rooting The rot usually started at or near the base of the cutting and affected the cambium, causing the bark to deteriorate and slough off.

During the second year of shading, regular Fermate sprays were applied as a rot preventative measure, but the results were inconsistent, and, in general, no control was obtained As shown in Table I, there was a considerable varietal difference in the occurrence of rot.

Table 1.—Susceptibility of **Juniperus spp.** to rot under intermittent mist in the greenhouse during winter

Highly Susceptible	Medium	Low
J chinensis blaauwi	*J chinensis* "Ramlosa #5"	*J chinensis hetzi*
J chinensis "Obelisk"	*J chinensis* "Ramlosa #6"	*J sabina tamariscifolia*
J chinensis pfitzeriana aurea	*J. chinensis "Skeena #10"*	
J horizontalis plumosa	*J horizontalis douglasi*	
J sabina		
J scopulorum		
J squamata meyeri		
J. virginiana (canaerti)		

Effects of Type of Cutting. As reported in the review by Snyder (5), no over-all trend was established where comparisons in types of cuttings were made. Apparently from the results at Ottawa, lateral and terminal cuttings, with and without a heel, rooted quite similarly under mist. Lateral cuttings with heels are commonly used, since a small heel forms naturally as the cuttings are pulled from the parent branch.

Effects of Size of Cutting. With most junipers larger cuttings that were not treated with hormones rooted in higher percentages and more rapidly than smaller ones similarly treated. However, since larger cuttings (10 to 18 inches) present a greater problem in maintaining stock plants and in shaping the subsequent tree after the cutting has rooted, small cuttings (5 to 8 inches) should be used in most instances. Satisfactory rooting with small cuttings could be obtained provided the proper hormone treatment was applied.

Effects of Wounding. Admittedly, as reported in Snyder's review (5), wounding of the basal portions in many instances also increased the number of roots per cutting and gave higher rooting percentages at Ottawa. However, equal results can be more easily obtained by using strong hormones and the unilateral rooting caused by wounding is avoided.

Effects of Hormone Treatment. From our results at Ottawa, it was obvious that Chloromone is a beneficial aid for the rooting of junipers. Both the rapidity and percentage of rooting were increased by Chloromone, but the variability in results with Hormodin powders suggested that these preparations were not strong enough for junipers (Table 2).

Table 2.—Effects of hormone on the rooting of juniper cuttings under intermittent mist

Plant Material	Size in Inches	Bottom Heat	Check	Hormone Treatment H#1	H#2	H#3	Chloromone
Juniperus chinensis	6-8	None	70	80	50	50	100
pfitzeriana aurea	-	65° F	60	40	70	50	100
	8-10	None	50	70	90	70	100
	-	65° F	90	50	80	80	100
Juniperus sabina	6-8	None	30	40	60	40	100
tamariscifolia	-	65° F	70	80	80	100	100

These results were obtained with one and one-half seconds of mist per minute during the daylight hours. Although not shown in tabular form, dilutions of Chloromone down to one-quarter strength with water did not reduce its influence on rooting. A further survey of the most concentrated Hormodin powder was made in 1959 to ascertain its effects on rooting. However, the increased rooting of the check treatments under the conditions existing in 1959 minimized the effects of hormone and beneficial results were obtained in only a few instances as shown in Table 3.

Effects of Bottom Heat Under the less favourable propagating condition, the effects of bottom heat were variable, but, as shown in Table 3, bottom heat was beneficial in 1959. The relative response varied with the plant material used.

Effects of Mist Interval. As shown in Table 3, six intervals of eight seconds per 30-minute cycle gave increased rooting as compared to three intervals with most materials. Thus a change from the one- and one-half seconds of mist per minute used previous to 1959 to six intervals of eight seconds of mist per 30-minute cycle increased rooting. Even though the amount of water was approximately equal, the longer intervals of mist in the latter allowed more runoff and the five minute inter-

Table 3.—Percentage rooting of **Juniperus spp.** in 1959

Plant Material	Lateral or Terminal	Size	Hormone	IMI BH MIA	IMI BH MIB	IMI NBH MIA	CTI BH	CTI NBH
Juniperus chinensis blauwi	T	6-8	H #3	60	30	50	—	—
			Check	0	30	30	—	—
	L	6-8	H #3	20	—	—	—	—
			Check	0	—	—	—	—
	L	3-5	H #3	10	10	0	0	0
			Check	0	10	0	0	0
Juniperus chinensis hetzi	L	5-8	H #3	84	98	55	10	0
			Check	86	100	80	25	0
Juniperus chinensis pfitzeriana aurea	T	5-8	H #3	20	100	0	—	—
			Check	10	90	0	—	—
	L	5-8	H #3	10	100	—	—	—
			Check	0	80	—	—	—
	L	3-5	H #3	25	100	25	15	0
			Check	50	100	25	20	5
Juniperus horizontalis douglasi	L	6-8	H #3	95	90	70	5	5
			Check	85	95	80	10	5
Juniperus horizontalis plumosa	T	5-7	H #3	40	70	10	20	20
			Check	20	30	20	10	0
	L	5-7	H #3	65	80	—	—	—
Juniperus sabina	L	3-6	H #3	64	58	35	10	5
			Check	44	28	20	10	0
Juniperus sabina tamariscifolia	L	5-8	H #3	80	90	45	0	0
			Check	55	90	40	5	0
Juniperus scopulorum	T	5-7	H #3	0	10	0	0	0
			Check	10	0	0	0	0
Juniperus squamata meyeri	T	6-8	H #3	75	90	55	55	15
			Check	75	95	70	—	—
	L	4-5	H #3	60	50	—	—	—
			Check	90	100	—	—	—
Juniperus virginiana canaerti	T	5-8	H #3	0	0	—	—	—
			Check	10	10	—	—	—
	L	5-8	H #3	0	0	0	—	—
			Check	0	0	0	—	—
	L	3-4	H #3	0	0	—	—	—

IMI—Intermittent mist indoors; CTI—Cheesecloth tent indoors; BH—Bottom heat; NBH—No bottom heat; MIA—Mist interval "A" = 3 periods of 8 seconds per 30 min. cycle, MIB—Mist interval "B" = 6 periods of 8 seconds per 30 min. cycle.

val between mistings allowed the foliage to become drier than when mist was applied for a shorter period every minute

With the more difficult to root material such as *J. chinensis blauwi* and *J. sabina* a further reduction in moisture to three intervals of eight seconds per 30-minute cycle was apparently beneficial. Whether this was a real effect of mist or whether it is confused by the poor and slow rooting potential was difficult to ascertain from these results. Of course, the results with *J. scopulorum* and *J. canaerti* are governed by a poor rooting potential under winter conditions.

Effects of Mist as Compared to Other Propagation Frames. Although better results than those shown in Table 3 were obtained in the cheesecloth covered beds in other years, the percentage rooting never approached the results obtained under mist in 1959.

The use of the polyethylene covered propagation beds was practically a complete failure. Unbleached cheesecloth bandage was used as a liner to provide shade and conserve moisture. However, the cheesecloth proved to be an excellent substrate for mould growth. This mould finally spread to the cutting, although most of the loss was due to scorching. The cuttings treated with hormones were the most severely affected.

In summary, the inherent ability of a given species or variety to root was the most important factor in rooting junipers under intermittent mist in the winter months. *J. chinensis hetzi, J. chinensis pfitzeriana aurea, J. horizontalis douglassi, J. sabina* "Arcadia," *J. sabina* "Scandia," *J. sabina tamariscifolia* and *J. squamata meyeri* could be classed as easily rooted, while *J. chinensis blauwi, J. horizontalis plumosa,* and *J. sabina* exhibited a medium rooting potential. *J. scopulorum* and *J. virginiana canaerti* were very difficult to root during the winter. *J. chinensis* "Ramlosa #5," *J. chinensis* "Ramlosa #6" and *J. chinensis* "Skeena #10" gave medium rooting under conditions where rot was prevalent and it was felt that increased rooting would be obtained under more favourable conditons.

It was clearly demonstrated that no shade should be used with mist propagation under the poor light conditions existing during the winter months. Rot was a severe problem with most varieties when shade was used.

In general, lateral and terminal cuttings rooted equally well. Although heel cuttings were normally used, they were seldom superior to those without heels.

Large cuttings rooted faster and more abundantly but this practice was of questionable application since there was a problem of maintaining stock plants and training the plant after rooting had occurred. With suitable hormones, smaller (5 to 8 inch) cuttings were quite successful.

Wounding was beneficial, although similar results could be obtained more easily by the use of strong hormones. This latter treatment circumvents unilateral rooting caused by wounding.

Although not all species and varieties needed hormones to give good rooting percentages, in general, quicker rooting and better root systems occurred with concentrated hormones. Chloromone yielded the greatest rooting response, while Hormodin #3 was strong enough for some junipers and not for others.

The relatively high rooting and the superior results under intermittent mist compared to those obtained in other propagation beds established the feasibility of mist propagation. Bottom heat and six intervals of eight seconds of mist per 30-minute cycle generally gave the best results.

ROOTING OF THUJA OCCIDENTALIS VARIETIES

The rooting of *Thuja* commercially is generally not considered difficult. Chadwick (2) reported that the cuttings could be taken in early winter (December and January) and handled in the greenhouse, or taken in March, April or August and rooted in frames. De Groot (3) reported on the beneficial effects of a strong hormone such as Chloromone on the rooting of *Thuja* stuck in frames.

There is little information in the literature on the mist propagation of *Thuja*. Snyder (6) reported that intermittent mist was superior to the open bench type propagation and hormones increased rooting to 71 per cent as compared to 41 per cent for the untreated check. Although not exactly a mist propagation bed, Bailey (1) reported an overall 80 per cent rooting with a number of varieties in a greenhouse where a high humidity was maintained with a Binks nozzle system.

Experiments with *Thuja* were initiated in 1957 at Ottawa. However, with the lath shade and one- and one-half seconds of mist per minute the results were not indicative of the potential and were further confused by the occurrence of rot. The rot affected the tops of cuttings instead of the bases as with the junipers. Under the poor light conditions the tops were soon reduced to a slimy gelatinous mass and regular Fermate sprays in 1958 did not control this rot. Essentially the only results obtained in these two years was an index of varietal susceptibility to rot as shown in Table 4

Table 4.—Varietal differences in susceptibility of **Thuja** to rot under intermittent mist

Highly Susceptible	Intermediate	Low
T o. globosa	*T o fastigata*	*T o. hoveyi*
T o "Patmore"	*T o lutea (elegantissima)*	*T o* "Rheingold"
T o. robusta	*T o lutea douglasi*	*T o spiralis*
T o rosenthali	*T o. lutescens*	
T. o saundersi	*T. o pyramidalis*	
T. o. verveaneana		

Under the poor propagating conditions there was practically no hormone effect and wounding did not increase the rapidity of rooting to overcome the onset of rot However, even under these conditions, it was apparent that poorer rooting and more rot occurred when the cuttings were taken from older, less active trees.

As with *Juniperus*, there was a marked improvement in rooting, when the shade was removed. The 1959 data are presented in Table 5.

It was felt that the recorded rooting percentages in 1959 were more indicative of the rooting potential of *Thuja Species*. Of more importance, however, was the elimination of rot even with the mist usage of

Table 5.—Percentage rooting of Thuja spp. in 1959

Plant Material	Terminal or Lateral	Size	Hormone	IMI BH MIA	IMI BH MIB	IMI NBH MIB	CTI BH	CTI BH
Thuja occidentalis ellwangeriana	L	4-6	H #3	100	100	100	70	60
			Check	100	100	100	30	30
Thuja occidentalis filiformis	L Single	4-6	H #3	60	20	40	0	10
			Check	60	10	40	0	0
	L Branched	4-6	H #3	80	60	60	0	10
			Check	100	100	90	30	0
Thuja occidentalis globosa	L	3-5	H #3	90	100	100	70	10
			Check	80	100	100	80	30
Thuja occidentalis boveyi	L	3-5	H #3	75	95	90	70	30
			Check	85	95	60	60	60
Thuja occidentalis "Little Gem"	L	3-5	H #3	92	95	100	80	45
			Check	100	94	100	55	25
Thuja occidentalis lutea	L	3-5	H #3	75	70	60	50	10
			Check	95	55	50	20	10
Thuja occidentalis lutea (elegantissima)	L	3-5	H #3	95	100	70	10	0
			Check	75	100	70	10	0
Thuja occidentalis "Patmore"	L	3-5	H #3	90	100	95	50	25
			Check	100	95	100	35	15
	T	5-7	H #3	100	100	—	—	—
Thuja occidentalis pyramidalis	L	3-5	H #3	100	60	100	40	20
			Check	95	85	100	40	40
Thuja occidentalis robusta	L	4-6	H #3	95	75	80	60	20
			Check	95	80	60	50	40
Thuja occidentalis saundersi	L	4-6	H #3	100	100	100	50	10
			Check	100	100	100	0	0

IMI—Intermittent mist indoors; CTI—Cheesecloth tent indoors; BH—Bottom heat; NBH—No bottom heat; MIA—Mist interval "A" = 3 periods of 8 seconds per 30 min. cycle, MIB—Mist interval "B" = 6 periods of 8 seconds per 30 min. cycle.

six intervals of eight seconds per 30-minute cycle when all shade was removed.

Taking the varieties as a whole, hormones were not beneficial and the differences in mist interval had little effect. Bottom heat was apparently beneficial to only a few varieties.

In the cheesecloth covered propagation beds, there was a greater varietal difference in response to bottom heat and hormone; both being beneficial. In general, combinations of Chloromone and bottom heat, yielded reduced rooting in previous years. It should be noted that the results, in most cases, were far below those obtained with intermittent mist.

The results in the polyethylene tent were a complete failure for reasons previously explained for junipers

In summary, *Thuja occidentalis* is easily propagated under intermittent mist in the greenhouse during winter if all shade is eliminated. Hormones are, in general, not needed and bottom heat unnecessary. Only a few varieties showed a preference to a certain interval of mist, but, for the most part, the two intervals, namely, three and six seconds per 30-minute cycle did not influence rooting. The use of mist was superior to open frames covered with cheesecloth which was kept moist.

ROOTING OF TAXUS SPECIES

Considerable work has been carried out with *Taxus* over the years. One of the better reviews on *Taxus* propagation was made by Keen (4), in which he cited numerous references. Subjects such as rooting medium, date of sticking, type of cutting, size of cutting, bottom heat and hormone treatments were discussed. De Groot (3) also reported upon the beneficial effects of Chloromone when the cuttings were rooted in frames outdoors. These subjects will not be elaborated on at present, but items pertinent to mist propagation in winter will be discussed.

No specific reference to the mist propagation of *Taxus* was found. The experiments which were begun in 1956 and carried through to 1959, illustrated clearly that *Taxus* was not subjected to reduced rooting when lath shade was used. This is contrary to the general results with *Chamaecyparis, Juniperus* and *Thuja*.

Effects of Age and Size of Cuttings. This is one of the more important factors in the propagation of *Taxus* As shown in Table 6 the terminals, usually unbranched, rooted far faster and in greater percentages than the older cuttings. Generally, the rooting dropped off with two-year-old cuttings but then increased with increasing age of the basal portion of the cutting which was usually accompanied by increased size of cutting.

Table 6.—Effects of size and age on the rooting of **Taxus** cuttings under intermittent mist

Age	Size in Inches	Percentage Rooting	
		T cuspidata	T bacoata repandens
1	6-8″	100	100
2	6-8″	40	70
2	8-10″	70	—
3	8-12″	90	70
4	10-14″	—	80

Effects of Hormone Application. As shown in Table 7, hormones were not necessary with the current season's wood but were beneficial on cuttings of older material.

Table 7.—Effects of hormones on the percentage rooting of **Taxus baccata repandens**

Type of Cutting	Check	Hormone Treatment			Chloromone
		H#1	H#2	H#3	
Current terminals, no heel	90	100	80	100	100
3-year-old with heel	50	40	70	40	100

Effects of Wounding As would be expected, wounding was of slight benefit to the current season's tips, which rooted readily. With older cuttings, however, wounding did increase the number of roots per cutting and the percentage of rooting. For example, with *Taxus baccata repandens,* the unwounded material rooted 50 per cent, the cuttings with one and two wounds 90 per cent and those with three wounds 100 per cent. However, as with other plant material, it is felt that these results can be more easily obtained through the use of strong hormones.

Effects of Bottom Heat Although the effects were small, in general, cuttings rooted slightly better where bottom heat was supplied. This may not always have been exhibited as a greater percentage of rooting but rather an increase in the rapidity of rooting.

Effects of Mist Interval. With the recommended one-year-old tip cuttings, the three intervals, namely, one and one-half seconds per minute, three intervals of eight seconds per 30-minute cycle and six intervals of eight seconds per 30-minute cycle, yielded practically no differences.

Effects of Mist as Compared to Other Propagation Frames. *Taxus* was relatively easily rooted from current season's wood and this type of wood also rooted well under the cheesecloth covered beds whether at 48, 53 or 60 degrees F. Hormones and bottom heat were generally beneficial under these conditions

In summary, *Taxus* is very easily rooted from the current season's wood. This type of wood roots readily and responds less to hormones, wounding and bottom heat than older wood. Discounting the current season's wood, the larger and older cuttings gave increased rooting and response to hormone, bottom heat and wounding. Of the four genera, *Taxus* exhibited the smallest difference between mist and other forms of propagation.

ROOTING OF CHAMAECYPARIS SPECIES

Practically nothing was found in the literature concerning the propagation of *Chamaecyparis.* Snyder (6) reported that two species were tested but he failed to give the results.

Only a few tests have been conducted with this genus at Ottawa. In 1956, *C. pisifera plumosa aurea* rooted 85 per cent with Hormodin #2 and only 15 per cent with the check. Rot was not a problem when no shade was used and the interval of mist was one and one-half seconds per minute. *C. pisifera plumosa argentia* rooted 75 and 15 per cent with Hormodin #2 and check, respectively under the same conditions.

However, in 1958 top and stem rot was a severe problem with *C pisifera plumosa* "Golden Spangle" and practically no rooting occurred even though regular Fermate sprays were used As with the other genera lath shade was used in 1958.

Chamaecyparis pisifera filifera aurea and *C. p f. nana* yielded 100 and 80 per cent rooting, respectively, with bottom heat in 1959. The former doubled its performance from 1958 where lath was used while the latter remained the same In 1959, both yielded better results with six intervals of eight seconds of mist per 30-minute cycle than with three intervals and hormones were not beneficial. A test without bottom heat was used with *C. p. f. nana* and the rooting was slightly reduced.

Chamaecyparis pisifera squarrosa, tested for the first time in 1959, responded to Hormodin #3 and six intervals of eight seconds of mist per 30-minute cycle. A reduction in mist or the use of no hormone each reduced rooting by 30 per cent.

From the meager results, it is suggested that clear glass, bottom heat and a mist schedule approaching six intervals of eight seconds per 30-minute cycle be used. Hormones were beneficial to *C. pisifera plumosa* and *C. p. squarrosa* but not to *C. pisifera filifera.*

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MODERATOR FILLMORE: We thank Dr. Nelson for his discussion on the rooting of conifers under intermittent mist, and we shall now hear from two practical growers who are also very much interested in this problem. The first of these is Mr. Albert Ferguson, Linn County Nurseries, Center Point, Iowa. Mr. Ferguson!

Mr. Ferguson presented his discussion on the use of outdoor mist to propagate junipers, arborvitae, and yews. (Applause)