

EFFECT OF STORAGE ON SUBSEQUENT GROWTH AND REPELLENCY OF DOUGLAS-FIR SEEDLINGS SPRAYED WITH TMTD

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Successful spraying of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seedlings with TMTD rabbit repellent is partly dependent on favorable weather conditions. Spraying should be done when relative humidity is low, seedlings are dry, and air temperature is close to 70°F. (Duffield and Eide 1962). Under these conditions, the adhesive in the TMTD formulation now in use binds the repellent to the seedlings best.

Since these conditions are uncommon during the cool, moist, spraying season in the Pacific Northwest, TMTD applications are made whenever the weather is favorable. It often becomes necessary, therefore, to hold treated seedlings for a few weeks when outplanting is delayed by adverse weather or other conditions. During this time, treated seedlings are either left in the nursery beds or lifted and cold stored until needed.

¹ Active ingredient: tetramethylthiuram disulfide (Thiram).

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Storage of treated seedlings in nursery beds causes significant weathering losses of the repellent (Radwan 1965), but effect of cold storage on treated seedlings has not been investigated. Such an investigation is necessary in order to determine the best storage method for TMTD-treated seedlings.

The purpose of this study was to determine the effect of storage on subsequent growth and repellency of TMTD-sprayed and unsprayed 2-0 Douglas-fir seedlings. Repellency was evaluated both in the laboratory, - by determining amounts of repellent on the seedlings, and in a pen against snowshoe hare (*Lepus americanus washingtonii*). Survival, date of bud burst, needle appearance, and height growth were studied in the nursery after seedlings were outplanted. In order to compare fall and spring TMTD-spray applications, the study was run twice-first in October and again in April.

Procedure

Spraying.-Selected were 2-year-old Douglas-fir seedlings grown from the same low-elevation seed source in six 4- by 330-foot nursery beds at y L. T. "Mike" Webster Forest Nursery near Olym-

pia, Wash. Stocking within the beds was as uniform as possible, with an average of about 45 seedlings per square foot. Three beds were assigned at random to the fall treatments in October, and the other three were used for the spring treatments in April. Each bed was divided into three 4- by 110-foot units. For both the fall and spring trials, the spray treatments, with three replications each and assigned to the nine bed units at random, were: (a) unsprayed, no TMTD; (b) sprayed, 9.0 gallons TMTD repellent per 1,000 square feet applied at the start of each trial (October for fall applications and April for spring applications) ; and (c) the same spray for formulation as in (b) but applied 19 days later. The repellent, in a 10-percent formulation containing 10 percent Rhoplex AC-33³ adhesive, was applied to the seedlings with an agricultural-type sprayer mounted on a tractor as previously described (Radwan and Dodge 1965).

Storage.-Two days following spraying, 3 samples of 25 seedlings each were taken at random from each replication of treatments (a) and (b). Roots seedlings were wrapped in moist peat moss and tective paper. The resulting 18 bundles were cold stored for 21 days at 35°C. and about 90-percent relative humidity. At the end of the coldstorage period, all bundles from replications of (a) and (b) were taken for outplanting in the hare pen. Similarly, samples were collected from sprayed and unsprayed seedlings which were "stored" in the beds for 21 days and from "unstored," freshly sprayed seedlings which were sprayed in the (c) treatment 2 days earlier. Thus, for each of the three evaluations (nursery, laboratory, and pen) , seedlings with the following treatment combinations, replicated three times, were available for testing:

1. Unsprayed (no TMTD) and unstored (stored in beds for 21 days).
2. Unsprayed (no TMTD) and in cold storage for 21 days.
3. Sprayed (9.0 gallons TMTD per 1,000 square feet) and unstored (freshly sprayed) .
4. Sprayed (9.0 gallons TMTD per 1,000 square feet) and stored in the beds for 21 days.
5. Sprayed (9.0 gallons TMTD per 1,000 square feet) and in cold storage for 21 days.

³An acrylic resin used as adhesive. Manufactured by Rohm Haas Co., Philadelphia, Pa.

Seedlings for the nursery test were outplanted in 15 rows at the nursery. Treatments were assigned to the rows at random. Following outplanting, the height of

each seedling was measured to the nearest half inch. Height of surviving seedlings was also measured at the end of the experiment in order to determine height growth. Other data collected were date of bud burst, survival, and appearance of needles on surviving seedlings.

In the hare pen, seedlings were planted as in the nursery experiment using the random-row design. Incidence of damage to the seedlings was recorded binomially as plus or minus and reported as percent of the total number of seedlings available. The hare enclosure covered an area of 1 acre and had two to five hares during the test period. This represents an animal pressure somewhat higher than is generally encountered under natural conditions.

In the laboratory, seedlings were processed and amounts of TMTD were determined in duplicate according to Keppel's method (1959) as outlined earlier (Radwan and Dodge 1965).

Results

Growth and survival.-Table 1 shows that in both fall and spring treatments, survival, height growth, needle appearance, and date of bud burst of 2-0 Douglas-fir seedlings were not affected by TMTD or storage of seedlings in nursery beds for 21 days after spraying. However, cold storage of seedlings with and without TMTD greatly reduced survival and height growth in the fall treatments. Survival of seedlings without repellent was lowest. On the other hand, in the spring treatments, coldstored seedlings both with and without TMTD grew and survived somewhat better than bed- and unstored seedlings.

Repellency.-Repellency of seedlings from the different treatments was measured in the hare pen by determining percent damage, and in the laboratory by estimating amounts of TMTD retained by the seedlings following storage.

In the pen, no test was obtained with the spring treatments. Hares did not feed on any seedlings, apparently because other more desirable vegetation was abundant in April. Table 2 shows results from the pen test for fall treatments only. In this trial,

TABLE 1.—Effect of TMTD and seedling storage on growth and survival of 2-0 Douglas-fir seedlings.

Seedling treatment ¹	Fall treatments (October) ²				Spring treatments (April) ²			
	Survival	Height growth	Needle appearance	Date of bud burst	Survival	Height growth	Needle appearance	Date of bud burst
	Pct.	In.			Pct.	In.		
No TMTD, unstored -----	96	1.2	normal	4/1-20	100	1.8	normal	4/1-20
No TMTD, cold stored -----	67	0.3	normal	4/1-20	100	2.2	normal	4/1-20
TMTD, unstored -----	97	1.4	normal	4/1-20	100	1.5	normal	4/1-20
TMTD, bed stored -----	97	1.3	normal	4/1-20	100	1.4	normal	4/1-20
TMTD, cold stored -----	80	0.4	normal	4/1-20	100	2.1	normal	4/1-20

¹ Cold storage was for 21 days at 35° C. and about 90 percent relative humidity. Bed storage was in nursery beds under natural weather conditions. TMTD was applied at 9.0 gallons/1,000 square feet of bed.

² Averages of three replications. Needle appearance was determined for surviving seedlings only.

TABLE 2.—Effect of TMTD and seedling storage on clipping of 2-0 Douglas-fir seedlings by snowshoe hare under pen conditions.

Seedling treatment	Number of seedlings per replication	Average number of seedlings clipped per replication	Average percent damage
No TMTD, unstored -----	25	25	100
No TMTD, cold stored ¹ -----	25	25	100
TMTD, unstored -----	25	3	12
TMTD, bed stored ² -----	25	5	20
TMTD, cold stored -----	25	6	24

¹ Cold storage was for 21 days at 35° C. and about 90-percent relative humidity.

² Storage in nursery beds was under natural weather conditions.

unstored and stored TMTD-treated seedlings were much more repellent to hare than seedlings without TMTD, which sustained 100-percent damage. Storage, however, reduced the repellency of TMTD-treated seedlings. Although differences between bed-stored and cold-stored seedlings were small, un-stored seedlings sustained the least damage and were superior in their repellency.

Table 3 shows that unstored seedlings in both fall and spring trials retained the most repellent. In both trials, amounts of TMTD remaining on seedlings were moderate following storage in nursery beds, and low after cold storage. Storage in the cold, therefore, produced the least repellency in both the fall and spring trials.

TABLE 3.—Effect of seedling storage on retention of TMTD by 2-0 Douglas-fir seedlings

Storage category	TMTD per seedling in milligrams ¹							
	Fall treatments (October)				Spring treatments (April)			
	Replication			Average	Replication			Average
	1	2	3		1	2	3	
None -----	19.2	18.6	23.2	20	9.8	24.6	31.7	22
Nursery beds -----	17.4	10.2	18.5	15	6.3	15.4	25.7	16
Cold -----	12.5	8.7	16.0	12	1.7	9.7	4.6	5

¹ Average oven-dry weight per seedling was 2 to 3 grams. All TMTD values were adjusted to a 3-gram seedling to eliminate weight variations.

Discussion and Recommendations

Results show that growth, survival, and repellency of TMTD-treated seedlings were affected by storing the treated seedlings before outplanting.

When TMTD was applied early in the fall (October), cold storage reduced survival and growth of the seedlings. This reduction, however, was not due to the repellent, since a more pronounced reduction was obtained when seedlings without the repellent were stored in the cold. This effect was probably caused by low temperature when seedlings were not fully dormant.

Similarly, the small stimulating effect of cold storage on growth and survival of seedlings which were treated in April was not caused by TMTD, since the same effect was observed with cold-stored seedlings which received no TMTD treatment. Stimulation here was also the direct effect of the cold treatment.

The largest amounts of TMTD and the highest repellency were obtained when the seedlings were not stored. Storage in nursery beds caused moderate losses of TMTD. These losses were undoubtedly due to weathering (Radwan 1965). Loss of TMTD from seedlings during cold storage was much greater and was probably due to the effect of low temperature and high humidity on the repellent-adhesive film on the needles. Much repellent, therefore, separated from the needles and was lost during handling in the pen and the laboratory. Similar or even higher losses following cold storage

could be expected when seedlings are outplanted in the field.

To obtain the best repellency, growth, and survival, seedlings should be sprayed with TMTD just before outplanting. If conditions for outplanting become unfavorable or impractical after spraying, seedling should remain in nursery beds, especially if they were sprayed early in the season before they were completely dormant. When an agricultural-type sprayer is used, seedlings treated with the present TMTD formulation should not be put in cold storage. Better spraying equipment and/or a better adhesive than Rhoplex AC-33, currently in use, must be developed if cold storage of TMTD-treated seedlings is necessary.

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70 Percent of Reforestation was on Privately-owned Lands in 1966

Seventy percent of all reforestation in the United States was on privately-owned lands during fiscal year 1966, according to the annual report of forest and wind-barrier planting and seeding in the

United States, issued by the Forest Service. The total was 935,502 acres out of a total of 1,319,819. The balance was planted and seeded by Federal, State and local agencies.