than on cuttings taken from older plants.

WESTERN NORTH CAROLINA HEMLOCK SEEDLING PRODUCTION

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INTRODUCTION

To understand why we grow hemlock seedlings the way we do in Western North Carolina (WNC), you need to know something about us. Although we are nearly as far south as Los Angeles, WNC has nursery production areas in hardiness zones 5, 6, 7 and 8. Such dramatic differences in climate in a relatively small area are due to elevation and slope. Most of our hemlock seedling production is in the Blue Ridge and Smokey Mountains at elevations between 1500 and 3500 feet. Most hemlock field production is in Zone 7 while most seedlings and transplants are grown in Zone 6.

The mountains contribute to regular rainfall, abundant high quality irrigation water and morning fog, almost daily during mid-summer and early fall, in the coves and valleys where we grow hemlock seedlings. Our southern latitudes give us a frost-free growing season from about May 10 to October 10. This very closely parallels the period of active growth for above ground portions of hemlock seedlings. The southern mountains have not been glaciated or inundated so we often are faced with old, weathered clay soils.

Bed Preparation. The standard WNC hemlock seedling production unit is the 400 sq ft (4 × 100 ft) raised bed. Soil samples are taken in mid to late summer. If the production area is in sod or perennial weeds, the area is sprayed with Round-up.

When soil test results return, about a month later, needed fertilizer is broadcast. WNC soils are usually very low in phosphorus, calcium, magnesium, and pH. We like to lime with dolomite to a pH of 5.5 to 6.0 and achieve a calcium to magnesium ratio of about 3 to 1. Occasionally, we are unable to achieve the desired levels by liming. When this happens, we use sulfur to lower the pH, gypsum to raise calcium without raising pH and either magnesium sulfate or olivine to raise magnesium levels. Treble superphosphate (0-44-0) is most often used to raise soil phosphorus levels to the high reading we

seek. Where soils are too heavy, i.e., they have poor internal drainage, soil amendments such as pine bark are added.

After amendments, fertilizer and lime have been added, soils are subsoiled, plowed and disced, or subsoiled and rotavated to provide the required seedbed. Bed forming equipment is then used to throw a bed about 8 in. high in the center and sloping to a height of 6 in. at the sides. The center of the bed will settle so that beds are nearly level by the end of the first year. Drainage ditches to carry excess irrigation and rainfall are formed at this time. Distance between beds is determined by topography and equipment needs.

Within 2 weeks of bedding, plastic is pulled over the beds and they are fumigated. Most growers use methyl bromide at the rate of 2 lb per 100 sq ft in October or November when it's easiest to obtain the required soil moisture and temperature conditions for effective fumigation. The plastic remains in place until shortly before seed sowing. During the winter, locust stakes are driven along the sides of the bed to support shade in the spring.

Planting. Both northern and southern provenance seed are sown. Northern seeds require at least 60 days stratification while local seeds require 90 days. Few seeds, however, are artificially stratified. During the late January or early February thaw, plastic is removed from beds and seeds are sown by broadcasting at a rate sufficient to achieve a seedling density of 35 to 50 plants per sq ft. Seeds are immediately covered with about ½ in. of Canadian spaghnum peat and beds are compacted using a lawn roller. Black polypropylene shade cloth is next laid on the beds and secured to prevent wind erosion of the peat.

The First Year. In mid-April, about dogwood flowering time, shade cloths are raised to 2 to 4 in. above the bed surface but secured at the soil surface along the edges to prevent bird damage to emerging seedlings. At this time, irrigation begins, with regular light irrigation employed to keep the seeds and peat from drying out. Once seeds have germinated, irrigation time is increased with the days between waterings increased so that seedlings gradually harden off. Adequate rainfall usually occurs so that regular irrigation is not needed until June.

The percent shade employed depends upon elevation and slope. Above 2000 ft, 30% shade is used while below 2000 ft 47 to 55% shade is best. Growers located at near 2000 ft use 30% shade on north or east facing slopes with 47 to 55% shade on south or west facing slopes. Once germination has finished, 10 to 14 days after the first seedlings emerge, the shade cloth is raised to about 2 ft and secured with as little sag as possible.

Supports need to be adjusted during the season as shadecloth stretches.

Four to 6 weeks after germination, the initial nitrogen fertilizer is applied. If the high phosphorus and moderate potash levels sought are already present in the soil, only nitrogen is needed. Our research has shown equivalent response to sulfur-coated fertilizers, ammonium nitrate, and fertilizer solutions. Sulfur-coated, 3-month release complete fertilizers are broadcast at the rate of ½ lb actual nitrogen per 400 sq ft bed, e.g., 21-6-12 is applied at the rate of 2⅜ lb per 400 sq ft. Growers using ammonium nitrate apply it every two weeks at the rate of 0.1 lb actual nitrogen (4.8 oz. of 33.5-0-0) per 400 sq ft for a total of 5 applications.

Granular fertilizers should only be applied to dry foliage. Granules are then swept off foliage with a broom and at least ¼ in. of irrigation water is applied.

Growers using fertilizer solutions feed weekly through their irrigation system. The first application is approximately 50 ppm nitrogen which is gradually increased to 200 ppm by mid-July. Urea (45-0-0) is the most common nitrogen source but many soluble fertilizers are used. Fertigators always irrigate a little first, fertilize, then irrigate long enough to flush the lines and wash any fertilizer solution into the soil.

The last fertilizer application for fertigators and those using ammonium nitrate will be about 6 weeks before the average first frost date to help induce hardening. Depending on elevation, the last application is between July 21 and Labor Day.

Beginning about a month before first frost, both irrigation frequency and duration are reduced in an attempt to slow growth and harden plants. Shade cloth is removed by mid-September in most nurseries but nurseries in warmer areas may wait until as late as October 1. Shade cloth is not removed from the field however. If an early frost threatens, shade is pulled over the bed and irrigation turned on from the time frost starts to form until well after sunrise.

The 1-0 seedlings should go dormant naturally. Even though hemlocks are supposed to withstand −35° F, these small seedlings cannot survive the freeze-thaw cycles of a WNC winter. The regular occurrence of frost heaves make mulching essential to prevent heaving of seedlings and the subsequent desiccation and death of roots. Standard practice has been to apply an organic mulch in late November to early December. The organic mulch is held in place by shade cloth, pea netting, or conifer boughs. Mulch is carefully removed before temperatures warm consistently in the spring, generally

mid-March to early April, depending upon elevation.

We estimate the cost of organic mulch per bed is about $16.00. Organic mulches have many problems, among which are poor moisture control, harboring pests (weed seeds, insects, rodents, and disease), poor light penetration, and labor costs. Research with spun-bonded polymers last winter left us the hope that Reemay, a spun-bonded polyester manufactured by DuPont, may solve some of these problems at a cost of $11.50 per bed. We lost no plants with any of our mulch treatments; however, hemlocks exhibited a yellow frost-burn when uncovered from Reemay mulching. This color change occurred the last week before uncovering. The plants "greened-up" shortly after spring fertilization but were significantly shorter in June. By the end of the season, the stunted plants had caught up (Table 1). We're continuing this work to see if we can manage Reemay to avoid the early season yellowing and growth reduction.

Table 1. Effects of mulch materials on growth of one year old hemlock seedlings.

Mulch material	Height (in.)	
	6/20	10/1
Organic mulch	5.8	13.5
Reemay - 1 layer	4.9	12.8
Reemay - 2 layers	5.0	13.1

The Second Year. When mulch is removed, about half the growers shade their 2-0's. The others leave them unshaded. Shade-grown plants will be a more attractive, darker green color but show no difference in performance otherwise. Growers using shade will keep shade in place until the fall hardening period.

Most growers apply a granular fertilizer at the rate of one pound of actual nitrogen per 400 sq ft before bud break in the spring. Although sulfur-coated fertilizers and ammonium nitrate are still favorites, many growers are using diammonium phosphate (DAP, 18-46-0) at the rate of 5½ lb per 400 sq ft because they feel they get better cool season growth with DAP. Since bud break occurs from late April to mid-May, growers have ample time to fertilize after uncovering before bud break.

Eight to 10 weeks after bud break in lower elevations, 2-0 seedlings are fertigated weekly, or ammonium nitrate is applied every 2 weeks until 6 weeks before first frost.

Pest Management.

Insects. The only consistent insect problem we see is white grubs. Land preparation and fumigation takes care of them with 1-0's. We have had good results with Oftanol and Proxol with fall and spring applications. Diazinon has provided variable results depending on the species of grub and time of application.

Diseases. Second year seedlings, 2-0's, have more disease problems than 1-0's, probably due to the fact that a vigorous bed of 2-0 hemlock seedlings shades itself so that the base of the plants may not dry out for days at a time. Hemlock rust generally shows up as flagging and "rat-tailing" of twigs with the first flush of growth in spring. Ferbam or carbamate sprayed at 10 to 14 day intervals is an effective control.

Aerial *Rhizoctonia* symptoms will usually first show as a roughly circular group of plants turning yellow and appearing to wilt. The circle widens rapidly under warm moist conditions with plants on the interior turning light golden brown and dying. Benlate sprayed at 7 to 10 day intervals with enough pressure to penetrate to the base of the plants and thoroughly coat the surfaces has worked best for us.

Weeds. Weeds are the number one pest of hemlock seedlings. We have done extensive tests to screen herbicides for efficacy and phytotoxicity. We have had damage from Roundup, Surflan 75W, Simazine 80W (Princep) and Goal 2E. We've safely used Devrinol 5G and 50W, Enide 90W, Goal 1.6E, Fusilade, Kerb, OH-II, Poast, and Ronstar 2G.

In WNC, most growers use no herbicide beyond fumigation on 1-0 hemlock. Where weed seed contamination exists prior to seed germination, 1 pint of Goal 1.6E per acre may be used safely until the first seedling hemlock emerges. If weed seed contamination shows after germination, hand weeding followed by Devrinol 50W at 4 to 6 lb active ingredient per acre is used.

On 2-0's Goal 1.6E is used before bud swelling. Any application after mid-April may result in phytotoxicity below 3000 ft. rates vary from 5 pints to 5 quarts per acre with 1 gallon per acre being most common. One gallon per acre gives 10 to 12 weeks of good control. By then a healthy crop of 2-0 hemlocks at 35 to 40 plants per sq ft will out-compete most weeds.