EARLY SEEDLING FERTILIZATION

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Abstract

Seedling fertilization at the time of planting has gained increased interest over the last 5 years. The responses to fertilization both in operational settings and from controlled experiments has been mixed. There are a variety of operational and environmental factors that influence the success of any fertilization program. This paper details some of those factors and presents preliminary results from a fertilization experiment carried out by the Vegetation Management Research Cooperative.

Introduction

Seedling fertilization has been a hot and cold silvicultural topic over the past several decades. One of the principal reasons for this is the large variability in response observed with seedling fertilization in the field. Fertilization in the nursery setting is a routine and closely regulated practice and usually results in a positive response. Fertilization in agricultural settings has increased the yield and quality of nearly every type of agricultural crop for decades. Thus, fertilization of outplanted conifer seedlings would be expected to enhance growth. However, responses to fertilization in plantations are often inconsistent.

The Vegetation Management Research Cooperative (VMRC) and the Nursery Technology Cooperative (NTC) in the Department of Forest Science at Oregon State

University have both been experimenting with seedling fertilization for the past several years. As a result, several key factors critical to fertilization success have been identified. These include: weed control, timing of fertilization, application technique, type and formulation of fertilizer used, amount of fertilizer used, and site conditions (moisture availability, soil type, etc.).

Soil Moisture and Response to Fertilization

Part of the reason for inconsistent responses to fertilizers are the drier soil conditions in the field versus the nursery or agricultural environment. Most nutrients absorbed by conifer seedlings are in solution with moisture drawn from the soil. As soils dry less moisture and nutrients are taken up by seedlings. Additionally, when soil moisture drops, access to nutrients outside the immediate rooting zone decrease due to less mass flow and diffusion of nutrients and a decrease in the seedling's ability to produce new roots and exploit increasing volumes of soil. Thus, moisture is the key to eliciting a positive fertilizer response. In the agricultural or nursery setting, plants are seldom allowed to experience the extended periods of drought common to most PNW reforestation environments. One of the most deleterious impacts of drying soil conditions is the build up of fertilizer salts, which can reach toxic concentrations in the rooting zone of outplanted conifers by early to mid-summer.

Good weed control, especially herbaceous weed control, is likely the most important factor in generating a positive fertilizer response. Weed control provides greater soil moisture availability through the growing season. On most sites, fertilization will be ineffective without adequate weed control. On others, because of increased fertilizer salt concentration as soils dry, fertilization may even damage or kill seedlings. Timing of application is also very important. Although root growth can occur nearly all winter long, the best root growth occurs in soil temperatures of 40º F or higher. Fertilization in late winter to early spring ensures that trees can take full advantage of nutrients when soils warm. If using temperature dependent slow-release fertilizers, late-fall applications can be made such that release of nutrients coincides with the onset of root growth in the spring. Applying fertilizer late in the spring can be less effective because seedlings have less time to take advantage of nutrients before summer drought decreases nutrient availability and toxic salt concentrations are more likely to occur.

Where, and How Much?

The methodology of fertilizer application can also be important. The VMRC and NTC have had excellent results with putting slow-release fertilizer right in the planting hole. Dibbling fertilizer adjacent to the seedling, is also a popular method. However, our results have been less consistent with this method. Surface application around the base of the seedling is another popular method. With this method it is especially important to apply the fertilizer early to allow time for the nutrients to leach into the rooting zone; this may take especially long if using slow-release fertilizers. Another less traditional method is to mix slow-release fertilizer in the media of container stock. This has gained increasing attention over the past few years and shows excellent promise. However, fertilized container stock is currently difficult to find and can be expensive.

There are two types of fertilizers used in forestry, soluble fertilizer (such as urea) or coated prill slow-release technology such as Osomocote, Forestcote, and Simplot blends. Other slow-release technologies such as IBDU and Urea-formaldehyde have been tried with poor success. The coated prill fertilizers are temperature-dependent and are designed to release nutrients during warm periods when root growth is greatest. Their labeled release rates are generally based on 70º F temperatures, but few forest soils reach this temperature so the release rate can be expected to be longer than label estimates. Toxic salt buildups are less likely using slow-release fertilizers and we recommend them over most soluble forms.

Fertilizer rate is another factor but is not well understood. For example, excellent results have been achieved by the NTC with 18 grams of slow-release fertilizer in the container media. In contrast, the VMRC has had equally encouraging results using 70 grams in the planting hole. On dry sites it is probably wise to err on the side of caution and use less fertilizer on drier sites because the potential of elevated salt concentrations are highest on these sites. The size of stock being fertilized may also influence the rate to use. As a rule of thumb, larger stock will endure greater levels of fertilizer than small stock.

Probably one of the most confusing issues with seedling fertilization is which formulation of fertilizer to use. That is, what ratio of nitrogen, phosphorus and potassium to use. There is little available data on this question and results from both the VMRC and NTC suggest that most measurable responses are more correlated with nitrogen content than with other nutrients. However, a complete blend fertilizer with all the macros and micros is recommended.

What are the Gains?

The real issue in most foresters' minds is "how large a fertilizer response can I expect?". This is probably the least understood aspect of seedling fertilization and the long-term response to early fertilization is still unknown. Early results from a VMRC research project have started to shed some light on the potential gains fertilization might yield relative to other early silvicultural treatments. The VMRC "2 meters in 2 years" study was designed to evaluate the relative response of Douglas-fir and western hemlock to fertilization, different initial seedling size, and weed control. Three Douglas-fir sites were installed (Rainier, Belfair and Randle) and two western hemlock sites (Forks and Cathlamete) all in Washington State.

Treatments

Twelve treatments were tested resulting from a 2 x 2 x 3 factorial treatment design. Two stock sizes, 2 vegetation control treatments, and 3 fertilizer treatments were tested for a total of 12 different treatment combinations.

Stock size

Two 2-3 mm diameter groupings were identified (S and L) each separated from the other by at least 1 mm. At lifting the seedlings were sorted and separated into these different size groupings.

Vegetation control

The two vegetation management treatments were complete vegetation control for 2 years (2V) and complete vegetation control for 3 years (3V). The vegetation control was achieved by using pre-emergent herbicide applications (oust or velpar). The herbicide used varied by site. At sites where there were species resistant to the herbicide used, additional applications of either accord or garlon were used.

Fertilizer application

Three fertilizer treatments were applied: a no fertilizer treatment (NF), a one year fertilizer treatment (1F) and a two year fertilizer treatment (2F). The fertilizer treatments consisted of a 70g teabag of Scott's slow release fertilizer, 10-22-6 formulation. The one-year treatment consisted of placing a fertilizer teabag in the hole at planting. The two-year treatment was year one fertilizer teabag in the hole treatment and then a dibbling of the same fertilizer teabag formulation in the winter following the first year of growth. The fertilizer was formulated from Scott's Forestcote fertilizer with added coated MAP and uncoated triple super phosphate. Each tree will realize 7g N, 15.4g P_2O_5 and 4 g K_2O_4 from each year of fertilization. The fertilizer used has an eight month release period.

Preliminary results

Planting larger initial stock and first year fertilization have resulted in larger seedlings two and three years after planting at all of the sites examined regardless of species planted (Table 1). The second year dibble fertilization treatment did not result in added growth at any site. These results suggest either dibbling is an ineffective fertilizing technique for young conifer seedlings or the trees simply will not respond to additional fertilization in year two.

Because the study is entering its third year only at the Belfair and Rainer sites weed control can be examined only at these sites; all other sites are only in their second year. At both sites stem diameter was slightly increased by the third year weed control treatment but height was not. This increase in stem diameter also resulted in an increase in stem volume at Rainier but not at Belfair. Larger differences in competing vegetation cover were found at the Rainier site than the Belfair site which may explain the more pronounced effect at Rainier than Belfair. However, weed cover at both was higher than desired. In an early June visit to the sites, weed control appeared to be excellent

Table 1. Mean stem volume, stem caliper, and height for the tree size class, fertilizer treatments and vegetation control treatments.[1]

	Initial Sort		Fertilization Treatment			Weed Control	
	(L)	(S)	(NF)	(1F)	(2F)	(2V)	(3V)
Stem Volume							
Douglas-fir							
Rainier	343a	249b	256a	313b	318b	278a	314b*
Belfair	362a	250b	250a	314b	354b	290a	321a
Randle	99.6a	73.0b	74.3a	93.1b	93.1b	88a	84a
Western Hemlock							
Cathlamet	44.1a	25.97b	21.3a	40b	43.76b	35.4a	34.7a
Forks	122.01a	68.7b	58.6a	110.2b	117.2b	96.9a	93.8a
Mortality							
Douglas-fir							
Rainier	4a	7b*	3a	5b	9c	5a	5a
Belfair[2]							
Randle	14.2a	18.2b*	8a	18b	22b	15a	16a
Western Hemlock							
Cathlamet	12a	21b	17.4a	17a	17a	17a	16a
Forks	2a	3b	22a	27a	28a	25a	26a

[1]Means for the tree size treatments, fertilizer treatments or weed control treatments followed by the same letter (a or b) are not significantly different ($p < 0.05$).

[2]Mortality was less than 7% in all treatments at Belfair and no treatment differed from another.
*Different at ($P \leq 0.1$).

but by the time cover was measured in late July weed cover had noticeably increased suggesting the treatments were effective for only a short period early in the growing season.

After three growing seasons the treatment resulting in the greatest Douglas-fir seedling size gains has been planting larger caliper seedlings. Differences in basal caliper at the time of planting have continued to increase in each year of the study and at all sites except Randall where differences are the same after two growing seasons as at the time of planting. Western hemlock gains have been greater due to first year fertilization than from planting larger stock although both increased second year seedling size. Gains for Douglas-fir from fertilization only occurred in the first year and have remained fixed in years two and three. For western hemlock, growth was larger in fertilized plots in both years one and two suggesting the fertilization treatments are having a more prolonged impact at these sites. Whether this longer period of response is species specific or a result of different site conditions is unknown.

Conclusion

Fertilization should be done with forethought. Success depends on carefully choosing the type and rate of fertilizer, application technique, and timing to the site conditions. The interaction of all these factors is not fully understood and any forester entering into a seedling fertilizer regime should experiment on a small scale before committing to an intensive fertilization program. Initial VMRC results suggest that growth gains from fertilization can be achieved on most sites with both Douglas-fir and western hemlock. The long-term gains achieved from early fertilization are not yet known.