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Reforestation Systems

Response of Coastal Douglas-fir to Fertilization at Planting: Some Screening Trial Results from Eastern Vancouver Island

WHY FERTILIZE

Silviculturalists are often faced with the problem of reforesting sites that are nutritionally impoverished. Fertilization at planting represents an expensive, but potentially feasible means of ameliorating the nutrient status of such sites. Correction of phosphorous deficiency by fertilization at planting has been successful in New Zealand, Australia, Great Britain, and the southeastern United States. With the recent development and commercial availability of slow-release fertilizers there has been increased interest in nitrogen fertilization in areas, such as British Columbia, where nitrogen availability is usually the nutrient most limiting to growth.

In practice, response to fertilization at planting has been unpredictable and ambiguous. In British Columbia, height growth responses have been small, or non-existent. Variability in response to fertilization has been attributed to a variety of site, climatic, stocktype, and fertilizer factors including soil fertility, microbial activity, stocktype, species, weather (temperature and moisture), site preparation, fertilizer source, nitrogen form, placement method, application rate, and presence of other mineral nutrients.

Slow Release Fertilizers

Slow-release fertilizers are commonly used in horticulture, but their application in silviculture is largely untested. Silvicultural conditions and species are considerably different from the conditions and crops for which these fertilizers were developed. Although slow release fertilizers are more expensive than conventional soluble fertilizers, they offer several advantages:

1. their pelletized form simplifies application,
2. their low-solubility minimizes salt stress,
3. under the correct conditions, a single application can continue to provide nutrients for several growing seasons.

The use of conventional soluble fertilizers requires particular care in application placement and rate. Over-application of soluble fertilizer can lead to osmotic stresses due to increased levels of salt in the soil. Under droughty conditions, this high salt concentration can make it difficult for plants to obtain adequate supplies of water. Slow release fertilizers add salts slowly to the soil solution and thus pose less of a risk of fertilizer burn.

OBJECTIVES

Three experiments starting in 1981, investigated the response of coastal Douglas-fir seedlings to fertilization at the time of planting (van den Driessche 1988). These studies were conducted in plantations on the east coast of Vancouver Island where the initial growth of Douglas-fir may be very slow for several years following planting due to soil infertility or drought-induced nutrient deficiencies. On these sites, fertilization at planting may be one method of minimizing planting shock. The work focused on nitrogen fertilization and included the effects of fertilizer source, application rate, and stocktype.

Sites, Seedlings, Treatments

The studies were located on eastern Vancouver Island on a site near Campbell River and two sites in the Koksilah Valley (Table 1). All seedlings were planted and fertilized at the time

TABLE 1. Sites, seedlings, and fertilizers

1. Campbell River - 110 mASL; CDFb
Seedlings: Br 2+0 Fdc 952
Planted: 1981
Slow release fertilizer:
- Agriform®
- Osmocote®
Application rates: 0, 4.2, 8.4, 16.8, 33.6g N/ seedling.
2. Koksilah Valley - 540 mASL; CWHa1
Seedlings: Br 2+0 Fdc 2751
Planted: 1983
Slow release fertilizer:
- Agriform®
- sulphur coated urea
Soluble fertilizer:
- diamonium phosphate
- ammonium sulphate
- triple super phosphate
Application rates: 0, 8.4, 16.8, 25.2 g N/ seedling. 0, 9.2, 19.4, 28.6 g P/ seedling.
3. Koksilah Valley - 540 mASL; CWHa1
Seedlings: Br 2+0 Fdc 1294, PSB 313 1+0 Fdc 1294
Planted: 1984
Slow release fertilizer:
- Agriform®
- sulphur-coated urea
Application rates: 0, 8.4, 16.8 g N/ seedling.

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of planting, in mid-March. Comparisons of fertilizer source, solubility, and application rate were made. The responses of two stocktypes of Douglas-fir were also investigated.

Site and soil characteristics

Site characteristics, soil physical and chemical properties should be considered when making decisions concerning fertilization at the time of planting. Soil characteristics will influence the existing reserves of nutrients and their availability as well as the fate of any added nutrients. In particular, soil depth, texture, organic matter content, and mineral nutrient levels are important site factors to be considered. The Campbell River site, site 1 was on deep, coarse sand with relatively low organic matter and nitrogen content. Site 2 and 3 in the Koksilah Valley were on stony soil with the fine fraction a relatively nutrient-rich silt loam. Site 3 had a lower soil fertility than site 2 (Table 2).

Fertilizer Source

Fertilizer source is an important consideration as different fertilizers may have different:

1. solubilities and release rates,
2. proportions, constituents, and availability of mineral nutrients other than nitrogen, phosphorous, and potassium,
3. nitrogen forms (Table 3).

All application rates in these screening trials were calculated on the basis of the total amount of nitrogen. Other elements would also have been affected by adjustments in the application rate. Nutrient analysis obtained from manufacturer's guaranteed analysis. P% calculated from P_2O_5 and K% calculated from K_2O .

Fertilizer Rate

Fertilizers were applied at rates calculated to supply nitrogen at a range of 0 to 33.6 g per seedling. Along with this range in nitrogen concentration is a range of other mineral nutrients. The range of fertilization rates used is high by horticultural standards but is similar to the rates used in plantation establishment in Australia and New Zealand.

RESPONSES

Survival

Survival on all sites was less than the operationally acceptable level of 80% survival (Figure 1). Survival of fertilized trees was equal to or, in some cases, worse than controls.

Fertilizer rate

At concentrations below 8.4g N/seedling, survival was not influenced by fertilizer application. At high levels or with soluble fertilizers, survival may have been depressed.

Fertilizer source

Generally there were only slight differences between fertilizer sources on survival. The TSP treatment was the only treatment to show a survival gain of 10%. There was a tendency for treatments with soluble fertilizers to have poorer survival than slow release fertilizers, particularly at higher application rates.

Fertilizer placement

Fertilizer placement (broadcast vs. dibble) was investigated as part of Campbell River study. There were only slight differences and these interacted with the fertilizer source. For operational purposes, dibble placement a short distance from the tree (15cm) is probably the most reliable.

TABLE 2. Soil fertility. Values are averages for four separate samples pooled over the depth of 0 to 30 cm.

Site	Texture			pH	CEC (meq/100g)	Organic matter (%)	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
	sand	silt	clay								
1	79.5	14.4	6.1	5.5	8.4	2.6	400	82.0	.13	.41	.32
2	38.8	49.1	4.7	4.7	25.5	12.2	1300	26.5	.35	3.33	1.15
3	46.1	42.4	11.6	5.0	15.2	3.6	500	19.0	.30	.25	.25

TABLE 3. Fertilizer nutrient analysis

	Nitrogen source	N%	P%	K%	Ca%	S%	Fe%
Slow-release fertilizers:							
Agriform® (AGR) 20-10-5	Urea formaldehyde soluble 7 insoluble 13	4.4	5	2.6	1.6	.35	
Osmocote® (OSM) 17-7-12	Ammonia nitrate 7.9	9.1	3.1	12	2.3	4.2	.05
Sulphur coated urea (SCU) 35-0-0	Urea	35	0	0	0	16	0
Soluble fertilizers:							
Ammonium sulphate (AMS) 21-0-0	Ammonia	21	0	0	0	24	0
Diamonium phosphate (DAP) 21-55-0	Ammonia	21	24	0	0	0	0
Triple super phosphate (TSP) 0-45-0	None	0	19.6	0	20	1.4	0

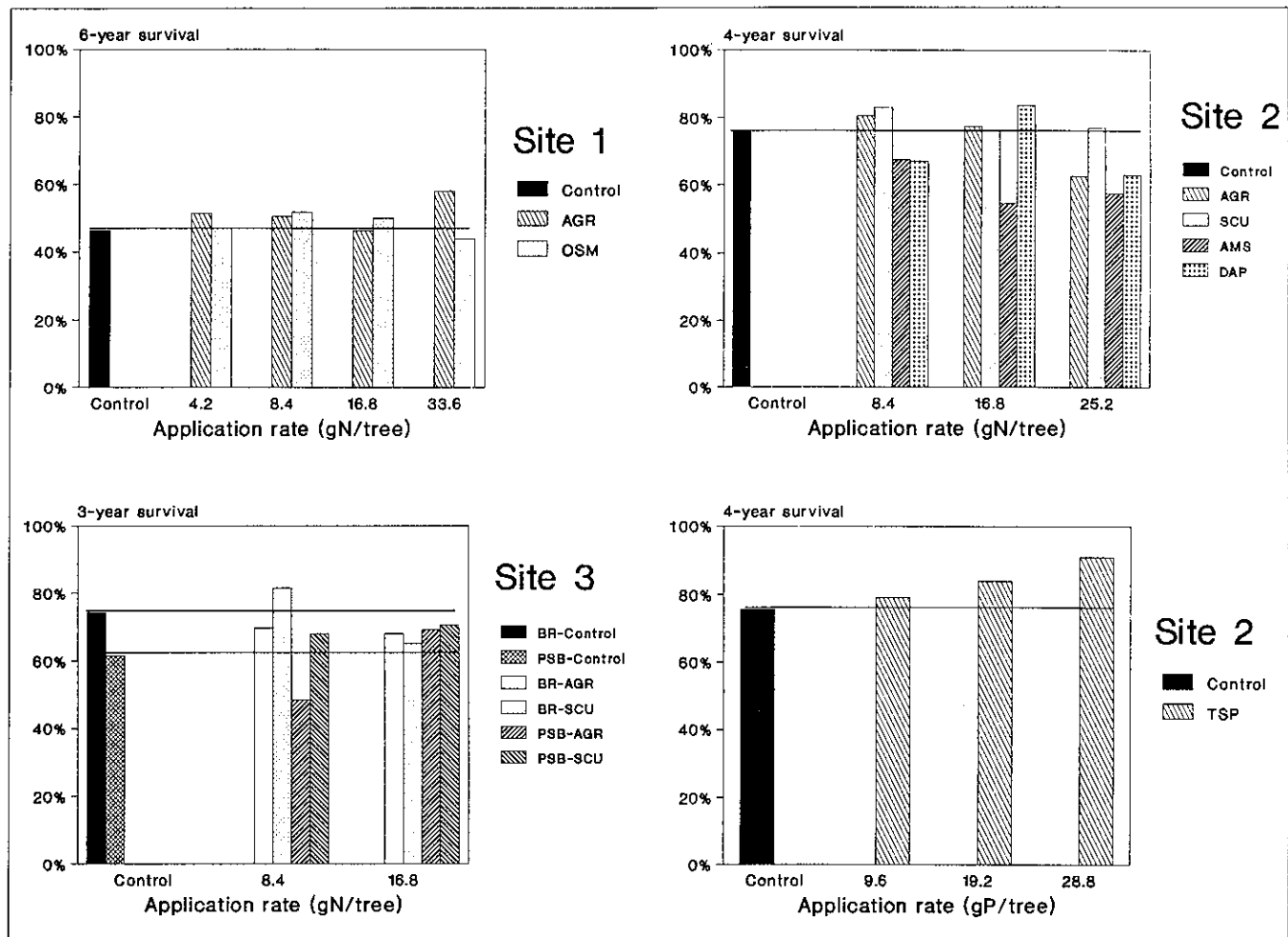


FIGURE 1. Survival results for different sites. Horizontal line represents the survival obtained by the experimental controls. Fertilizer abbreviations given in Table 3.

Stocktype

Generally, bareroot stock had a higher survival than the container-grown stock. But the survival of the bareroot stock declined slightly at highest application rates whereas the container-grown stock increased survival with application rate.

Growth

Fertilization did not have a large effect on the first year's height growth. However, three to four years after planting most fertilized trees were taller and had greater diameters than controls (Figure 2). In most cases, fertilization resulted in height growth gains of 20 to 30% over the unfertilized controls.

Fertilizer rate

Most height growth gain was achieved by 8.4g N/seedlings. Additional fertilization up to 33.6 g N/ seedling provided little or no additional gain.

Fertilizer source

In most cases, the fertilizers did not differ from each other in their effects on growth. The exception was the TSP treatment which showed significantly poorer growth than any of the other fertilizers.

Stocktype

Container-grown stock responded more strongly to fertilization than did bareroot stock. Three years after fertilization, seedlings treated with the higher rates of AGR or SCU were about 20% larger than unfertilized controls. Height growth gains of fertilized bareroot stock were only 4% (5 cm). After three years, the bareroot seedlings were still considerably larger than the container seedlings. This difference in response to stocktypes has been noticed by others and may be due to fertilizer placement method, stock quality, and seedling dormancy at planting.

CONCLUSIONS

Improving the nutrient status of seedlings is not simply a matter of adding nitrogen either in the nursery or plantation.

- Fertilization rate appeared to affect survival slightly at the highest application rates of soluble fertilizers.
- There was little response to fertilization in the first year, but responses accumulate to become significant after three years.
- Fertilization, regardless of source, produced height gains of 20 to 30%.

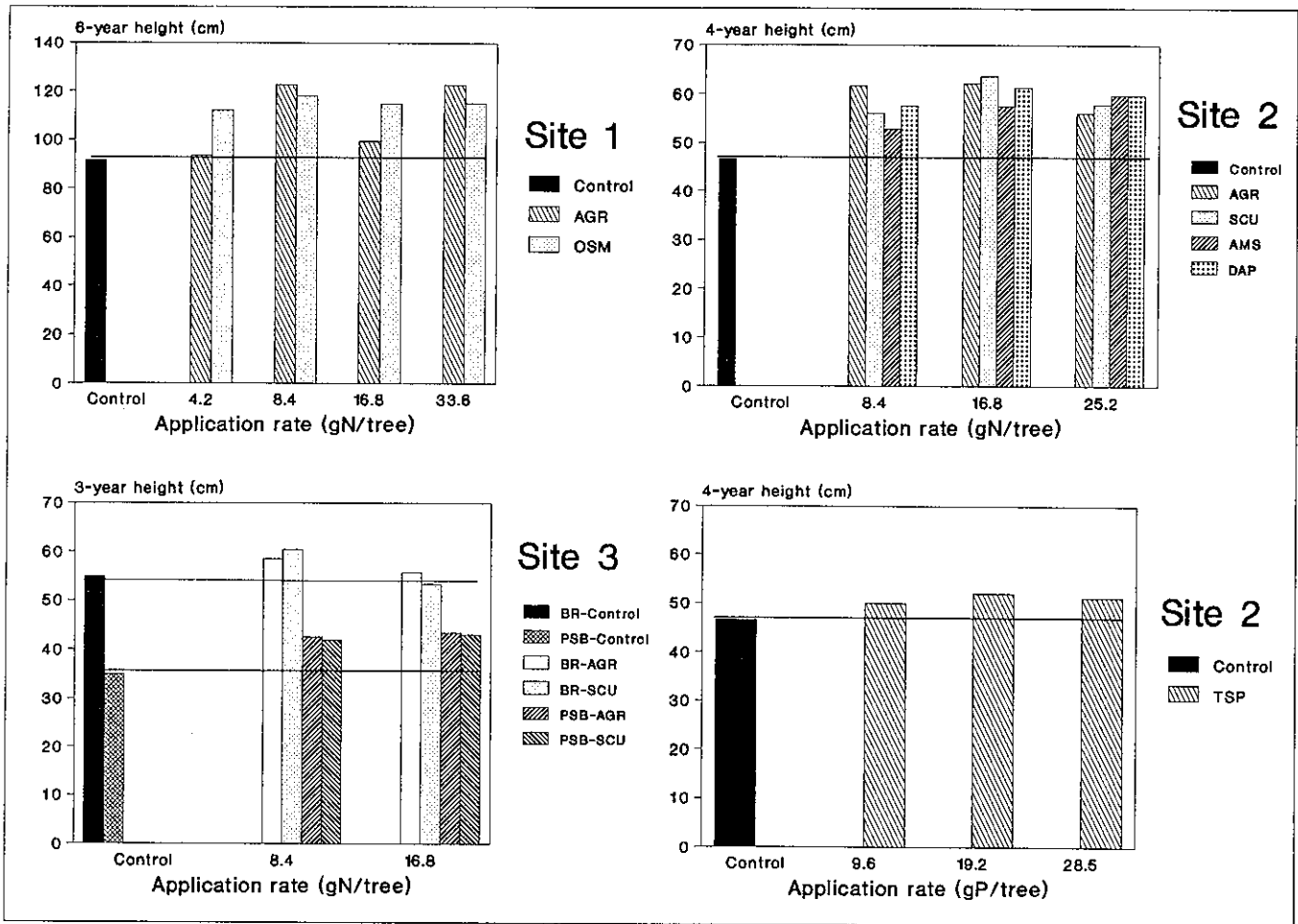


FIGURE 2. Height growth results for different sites. Horizontal line represents the height obtained by the experimental controls. Fertilizer abbreviations given in Table 3.

- Height gains did not depend on fertilizer source.
- There was little additional height gain observed with application rates above 8.4 gN/tree.

OPERATIONAL CONSIDERATIONS

Fertilization at establishment is expensive and economic analysis is necessary to determine whether it is justified. Operational fertilization at the time of planting is unpredictable at present due to the lack of experience. All fertilizers can cause mortality if misapplied. The appropriate rate, season, and method of application are influenced by species, stocktype, and site and, in practise, these factors can be expected to interact. Screening trials are necessary for determining the relative efficacy of different fertilizers and application rates.

Fertilizer Placement - Dibble

Do not broadcast fertilizer as this may create lush herbaceous competition or inadvertently damage seedlings. Do not place in the bottom of the planting hole where readily soluble fractions of fertilizers may dissolve and damage seedling roots.

Fertilizer Source – Slow Release Formulations

Slow-release fertilizers are preferred to minimize risk of fertilizer burn.

Fertilizer Application Rate – Over Application

Large amounts of nutrients have to be applied per tree to obtain a long term response. This strategy demands the least risky fertilizer placement. The amount of fertilizer applied should be accurately measured and accurately placed to avoid over fertilization. Pelletized or prepackaged fertilizers are particularly attractive as a means of simplifying accuracy of measurement and placement. Over-application is likely to be the most common fault at establishment.

Stocktype

Fertilization is an expensive proposition, it should only be applied to vigorous stocktypes on sites where maximum benefit is ensured.

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