The Effects of Fertilization on the Early Growth of Planted Seedlings: A Problem Analysis - FRDA Project 3.30

Rapid early growth of planted seedlings is an important factor in successful plantation establishment. Early growth performance can be greatly improved by using physiologically superior seedlings and appropriate site preparation techniques. In addition, under certain conditions, growth can be further enhanced by fertilizing seedlings at the time of planting.

The concept of fertilizing planted seedlings to stimulate growth during their establishment phase is not new. Research elsewhere has shown that improved seedling growth from fertilizing can result in permanent production gains. Fertilization at or near the time of planting is standard practice on many forest sites in Australia, Great Britain, and the southeastern United States. Although a substantial amount of seedling fertilization research has been undertaken in western North America, the approach to the subject has been fragmented. Results have been inconsistent and the relative benefits of various treatments and treatment combinations are still unclear. Moreover, much of the work has not been reported. Rob Brockley, Research Silviculturist for the Ministry of Forests, Research Branch, has conducted a FRDA project to review and summarize available seedling fertilization information. His problem analysis has the following objectives:

1. to discuss some of the factors that may affect seedling response to fertilization;
2. to give some estimate of the response expected from fertilization at planting;
3. to describe some effects of combining fertilization with other treatments; and
4. to make specific recommendations regarding future operational seedling fertilization projects and research trials in British Columbia.

Throughout the study, special reference was made to interior spruce because of its preeminent position within the provincial reforestation program and its problems with "planting check". The following discussion summarizes the information contained in Brockley's 16 page FRDA Report No. 011 - The Effects of Fertilization on the Early Growth of Planted Seedlings: A Problem Analysis.

FERTILIZER SOURCE

Redly soluble inorganic sources of nitrogen (i.e., urea, ammonium nitrate) generally increase mortality and have not consistently improved the early growth of northern temperate conifer seedlings. Drastic changes in the chemical and microbial activity of the rhizosphere, such as those brought about by some fertilizers, may be detrimental to the health and vigor of the planted seedlings. Also, non-target vegetation may successfully compete for the readily-available nitrogen, thereby stimulating vegetation competition. Placement method is critical when using readily-soluble nitrogen fertilizers. In-hole placement will almost certainly cause substantial seedling mortality.

Most recent seedling fertilization studies in western North America have used various types of slow-release fertilizers. Some are resin-coated soluble, inorganic NPK fertilizers (e.g., Osmocote, Nutricote) while others are uncoated, compressed, slowly-soluble fertilizers (e.g., Agriform, Woodace). All of these fertilizers have relatively low nitrogen analysis (15 - 24% N) and release their nutrients over a 1- to 2-year period under normal field conditions. None of these slow-release products were developed specifically for use with conifer seedlings. Results from seedling fertilization research trials generally indicate that the majority of the growth response is due to nitrogen. With conventional fertilization application methods, the amount of P and K incorporated in slow-release products is probably too small to benefit planted seedlings.

Direct comparison of slow-release fertilizers is difficult for two reasons: 1) there have been very few comparative trials, and 2) optimum placement method and application rates are probably different for the various products. However, given appropriate placement and application rate, there may not be much difference in response to the various products.

PLACEMENT METHOD

There are basically three ways in which fertilizer can be applied to seedlings at the time of planting: 1) in-hole placement (i.e., in the planting hole), 2) adjacent placement (i.e., placed in a hole or slit beside the seedling), and 3) broadcast placement (i.e., sprinkled on the ground in a 15- to 25-cm radius around the seedling). In-hole placement has the advantage of positioning fertilizer where seedling roots have ready access to it but, as mentioned earlier, may increase seedling mortality (especially with soluble N sources). Also, in-hole placement may not be effective once the roots have expanded beyond the planting-hole zone. Adjacent placement requires more labour, but probably reduces the risk of mortality. To be effective, the fertilizer should be placed relatively close to the seedling. Broadcast application, although successful on some sites, is probably the method most likely to stimulate vegetation competition.
APPLICATION RATE

The nutrient requirements of newly planted seedlings are small, and there is little evidence that seedlings benefit from large doses of fertilizer. In fact, nutrients exceeding the seedlings utilization capacity will, in all likelihood, be: 1) leached below the rooting zone, 2) immobilized in microbial biomass, or 3) used by competing vegetation, possibly to the detriment of the planted seedlings. Research results indicate that incremental growth responses are generally small for application rates in excess of 10 g N per seedling, and likely do not justify the added costs.

STOCK TYPE

The largest and most consistent responses to fertilization have generally been obtained with container seedlings. This is probably due to their high root growth capacity (RGC) relative to that generally measured in bare root stock. Seedlings that exhibit vigorous root growth shortly after planting are in a much better position to use the added fertilizer.

The physiological condition of the seedling is more important than initial size in determining seedling response to fertilization. Therefore, a small, vigorous seedling will likely be more responsive than a larger but less vigorous seedling.

MAGNITUDE AND DURATION OF RESPONSE

A combination of many factors (e.g., site type, site preparation, weather, fertilizer source, application rate, placement method, and seedling physiology) affect the response of seedling to fertilization. The permutations are innumerable and, not surprisingly, responses to fertilization of planted seedlings have been highly variable.

In other parts of the world, spectacular gains have been achieved by applying fertilizer at the time of plantation establishment. In fact, on some severely nutrient-deficient sites, fertilization can make the difference between plantation success and failure. On these sites, the beneficial effects of nutrient additions often carry over into the next rotation. In British Columbia, demonstrated growth responses have been far less spectacular. Height growth responses directly attributable to fertilization are relatively small (e.g., 15 to 30 cm) and short-lived and, therefore, will not have a significant direct impact on crop yield or rotation length. However, seedling stem caliper, foliage biomass, and root biomass are also positively influenced by fertilization, and the indirect effects may be substantial if fertilized seedlings are able to avoid the competitive influence of non-crop vegetation and thus achieve free-growing status earlier. Recent research indicates that gains may be improved by combining fertilization with other silvicultural treatments such as site preparation and vegetation control.

SITE PREPARATION AND VEGETATION CONTROL

The positive effect of fertilizer may be negated by competing herbaceous or woody vegetation, which commonly respond better than newly planted seedlings to added nutrients. In Australia, and the southeastern United States, efficient vegetation control is the key to securing positive growth responses to seedling fertilization. On some sites, synergistic growth responses have been obtained by combining fertilization at planting with vegetation control. Similar results have recently been documented in British Columbia.

Site preparation may also have a major impact on seedling response to fertilization. For example, the removal of organic matter and/or disturbance of soil by various mechanical site preparation practices (e.g., windrowing, ploughing, mounding) may increase seedling fertilization response potential primarily as a result of nutrient depletion, soil warming, and destruction of competing vegetation. Conversely, the release of nutrients from many broadcast burns may be sufficient to satisfy the short-term nutrient requirements of newly planted seedlings. On these sites, seedlings may not respond positively to fertilization despite the possible long-term negative impact of burning on site productivity.

ALTERNATIVE METHODS OF FERTILIZING SEEDLINGS

Traditional methods of applying fertilizer to seedlings at the time of planting are expensive and inefficient. Total costs (i.e., fertilizer and application) probably average between 8 - 15¢ per seedling. Also, the fertilizer rates used with traditional application methods (e.g., 30 - 50 g of fertilizer per seedling) exceed the nutrient requirements for early seedling growth which may result in stimulation of competing vegetation. One way of reducing costs substantially is to incorporate slow-release fertilizer into the soil mix when container nursery stock is sown. The ideal fertilizer for this technique would exhibit minimal nutrient release in the greenhouse. Most of the incorporated nutrients would be released after outplanting to stimulate early seedling growth. Results from recent trials using this technique have been promising. Further research using different sources and rates of fertilizer combined with various nursery cultural regimes are warranted.

CONCLUSIONS:

Fertilization may be a useful silvicultural technique for stimulating the early growth of planted seedlings. However, the following points should be stressed:

1. Growth response expectations must be realistic.

2. Seedling fertilization has the greatest potential when combined with other silvicultural treatments.

3. Fertilizer should only be applied to high quality seedlings.

4. The need remains to:
   - develop more appropriate fertilizer sources;
   - develop alternative nutrient delivery systems to improve the efficiency and cost effectiveness of the technique; and
   - investigate the nature of fertilization x vegetation control x site preparation interactions.

Further information on the project is available from:

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