Interactions Between Vegetation Management and Fertilizer Applications

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Abstract

There has been little published research on early seedling fertilization in regeneration settings in the Pacific Northwest. Ongoing research by the Vegetation Management Research Co-op and published results from other investigators suggest three basic operational guidelines for seedling fertilization and weed control: (i) Fertilization in the absence of weed control on most sites will not result in a growth response. (ii) Where adequate soil moisture is available response to fertilization will be additive to that of vegetation management. (iii) How fertilizers are applied influences the success of a fertilization program.

Introduction

Seedling response to fertilization is often variable and can range from an increase in height and caliper growth to an increase in seedling mortality. Many factors influence conifer response to fertilization including soil fertility, stock quality, seedling nutrient status, and how well the seedlings are planted. Vegetation management is as important or more important than any of these other factors because without it seedlings are often incapable of taking advantage of increased nutrient availability.

Surprisingly there has been a limited amount of published work on the effects of fertilization on newly planted conifers and even less on the interaction of vegetation management. Most published research has centered on older stands in the 10 to 50 year old range. Of the studies looking at early seedling fertilization most have been done using conifer species other than Douglas-fir.

My goal in writing this paper is to briefly describe an ongoing research project of the Vegetation Management Research Cooperative (VMRC) and discuss the results of this study in relation to results from other investigators. A review of current early fertilization and vegetation management literature suggests three basic operational guidelines. I will discuss each guideline individually and relate it to current scientific research.

Operational guidelines for early forest fertilization and vegetation management:

1. Fertilization in the absence of good weed control results in no gain or can be a detriment to seedling growth.

2. Once a site induced weed control threshold has been reached benefits of fertilization appear to be additive to those from vegetation management.

3. Fertilizer application technique is important in producing a positive seedling growth response.

VMRC Herb II Research Project

The VMRC is currently conducting a study in which we have systematically manipulated the area of vegetation control around seedlings. Half of these seedlings have been fertilized and half have not. The fertilization treatment consisted of 2 fertilizer briquettes placed in the bottom of the planting hole. The combined briquettes are considered an 11-6-4 formulation delivering 4 grams of N, 2 grams of P, and 1.2 grams of K. The briquettes are complete slow release fertilizers delivering nutrients over a period of 2 to 3 years. A layer of dirt was scattered over the briquettes before the seedlings were planted to prevent root burn.

Vegetation control treatments consisted of a no control check treatment, a 2 ft radius treatment, and a 3 ft radius treatment. The radius treatments were maintained for two years and initiated the spring of planting. We currently have 5 replications of this experiment on 5 different sites with 4 conifer species. Two of the sites were planted in spring of 95 and the other three in spring of 96. Each site is a stand alone study consisting of 4 replications of 6 treatments (24 treatment plots in total per site) applied in a fully randomized design. Each treatment plot consists of 36 seedlings planted at 10 ft X 10 ft spacing and surrounded by a buffer row of seedlings between plots. At the time of writing this paper we have only second year data for the Vernonia and Klickitat sites and first year data for the other three. I am only going to discuss results from the Vernonia and Klickitat sites. The other 3 sites are still too young to have fully integrated the treatments into seedling growth responses.

The Vernonia site is a moist coast range site located in the far northwestern part of Oregon and was planted with 1+1 Douglas-fir. It is fairly typical of a regeneration setting in western Oregon. The Klickitat site is an and site located east of Mount Adams in Washington state and is planted with p+1 ponderosa pine. Forests in this area are typically mixtures of ponderosa pine and Douglas-fir.

Survivorship, height and caliper have been measured each fall since planting. Additionally, vegetation cover has been measured during late July in the first and second years. Stem volume was calculated from height and caliper measurements and is considered our best measure to illustrate treatment differences. All seedling measurements were analyzed by ANCOVA using initial stem volume at the time of planting as a covariate. Means reported are adjusted for the covariate. To meet assumptions of equal variance stem volume was natural log transformed and reported means are backtransformed.

Results

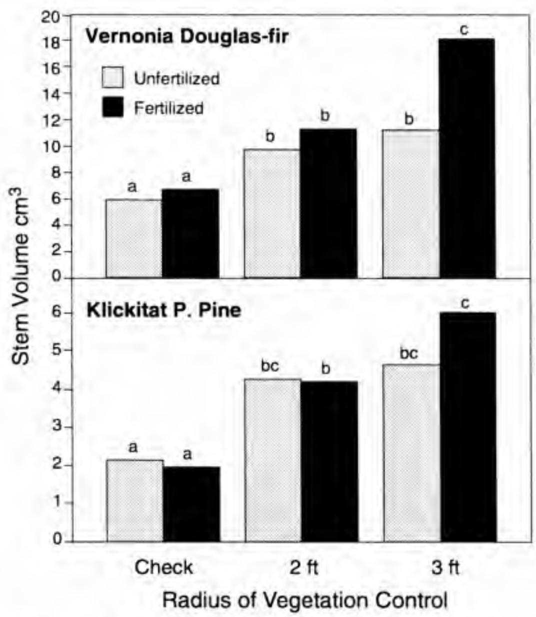

Figure 1. Second year means for stem volume at the VMRC Vernonia and Klickitat study sites. Within each site, bars with the same letter are not significantly different ($p \leq .05$).

Second year stem volume increased with increased vegetation control at both Vernonia and Klickitat (Figure 1). No significant increases in stem volume were observed between fertilized and unfertilized treatments at Klickitat. Conversely, at the greatest level of vegetation control, 3 ft, fertilization resulted in a significant increase in Douglas-fir stem volume at Vernonia. Differences in survivorship by treatment were evaluated but confounding from localized swamping at Vernonia and pocket gopher damage at Klickitat made it impossible to determine if fertilization and weed control interacted to result in differences in seedling survivorship.

Discussion

Vegetation Management a Must

Our results suggest that if seedlings are to respond positively to fertilization good vegetation control is a must. Seedlings absorb many nutrients in solution with soil moisture and this moisture is often the most limiting factor in regeneration environments in the Pacific Northwest. This suggests that when faced with high moisture stress seedlings also face limited nutrient

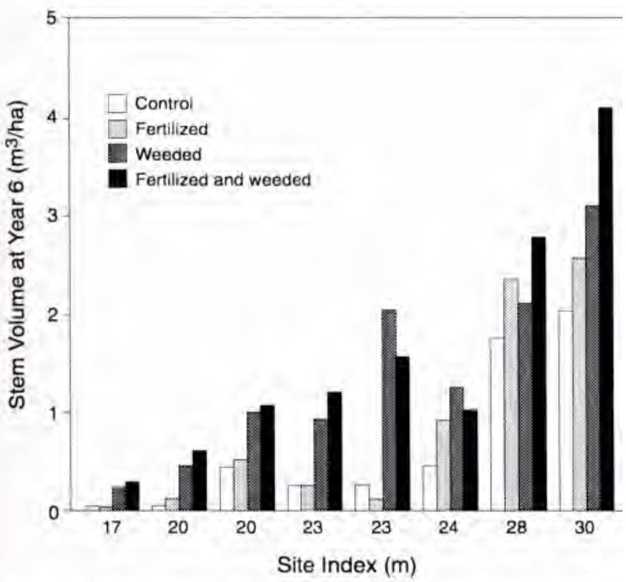

Figure 2. Stem volume of six year old ponderosa pine in control, fertilized, weeded, and fertilized+weeded plots across 8 sites (adapted from Powers and Ferrel 1996).

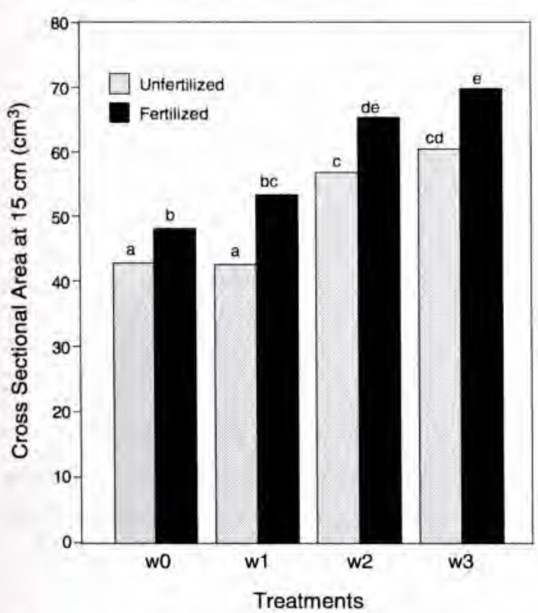

Figure 3. Average cross sectional area at 15 cm above the ground for 3 year old radiata pine either fertilized or unfertilized and receiving differing vegetation control treatments (w0=no vegetation control after year two, w1=1 meter strip of tree centered vegetation control in year three, w2=2 meter strip of tree centered vegetation control in year three, w3=3 meter strip of tree centered vegetation control in year three. Fertilization treatments were broadcast over entire treatment area. Bars with the same letter are not significantly different (p≤.05). Figure adapted from Woods et al. (1990).

availability. It should not be surprising that with increased vegetation control (greater soil moisture availability) increases in foliar nutrients are commonly observed (Woods et al. 1992, Powers 1996).

It is difficult to separate the relative influence of competition for moisture and nutrients. Nambiar and Sands (1993) argue that it is impossible to have water stress through competition without nutrient stress, but you can have nutrient stress without having water stress. Consequently, where water is limiting it is difficult to impossible to determine the relative importance of competition for nutrients because soil moisture influences nutrient availability. This suggests that on dry sites responses to fertilization in the absence of good weed control would be minimal which is often the case in published research (White and Newton 1990, Roth and Newton 1996, Powers and Ferrel 1996). On the poorest 5 of 8 sites Powers and Ferrel (1996) found that fertilization in the absence of weed control had little to no effect on ponderosa pine growth (Figure 2). On their best three sites fertilizer improved growth rates and even more so in the presence of good weed control. In contrast, Woods et al. (1992) found fertilization resulted in measurable increases in seedling growth even in plots receiving no vegetation control after year 2 (Figure 3). In treatments receiving additional vegetation control in year 3 even greater growth responses occurred as a result of fertilization. These results disagree with Powers and Ferrel (1996) and the VMRC findings. However, Woods et al. (1992) did not apply fertilizer until year 3 which followed two years of previous vegetation control. Likely, this early vegetation control had allowed the planted radiata pine to capture a sufficient soil volume to take advantage of additional nutrients from fertilization regardless of weed control in year three.

Both Woods et al. (1992) and Powers and Ferrel (1996) used fertilizers that were readily available i.e. not slow release fertilizers. Slow release fertilizers complicate the interaction between soil vegetation management and fertilizer response. Available moisture is mandatory for the release of many of the slow release fertilizers currently on the market. Two of the more common procedures by which fertilizers slowly release nutrients, microorganism degradation and water hydrolysis, require soil moisture at reasonably high levels for nutrients to be released. Without adequate soil moisture these products do not release nutrients or release at slower rates. Using these types of fertilizers it would be unlikely to have a seedling growth response under low soil moisture conditions because little or no nutrients would be released and nutrient uptake is tied to soil moisture availability. In the VMRC study a slow release rate as well as low soil moisture availability in treatments receiving poor vegetation control are suspected in limiting the response measured. This may also explain why a significant fertilizer response was measured at the moister Vernonia site and not at the drier Klickitat site with a 3 ft radius of vegetation control. At Klickitat soil moisture may have been high enough to create a growth response but not enough to release nutrients at rates needed for a measurable response.

Additive versus Synergistic Response

Results from the VMRC study and others (Woods et al. 1992, Powers and Ferrel 1996) suggest that responses from vegetation control are additive once a threshold level of weed control is reached. The required weed control threshold must be high enough for seedlings to take advantage of additional soil nutrition. For example, with no vegetation control (check treatment) or with poor vegetation control (2 ft treatment) no added benefit from fertilization is observed (Figure 1). With the greatest level of vegetation control (3 ft) a strong and significant response occurs at Vernonia. A similar pattern is evident at Klickitat but is not statistically significant. I suspect that if there had been ample soil moisture at both sites we would have measured a fertilizer response with lower levels of vegetation control.

Other investigators have illustrated that fertilizer responses are generally additive to those due to vegetation control (Woods et al. 1992, Powers and Ferrel 1996). Woods et al. (1992) illustrated that with increased weed control a subsequent increase in seedling growth was observed (Figure 3). Fertilization increased cross sectional area of seedlings roughly equally across all vegetation control treatments. Powers and Ferrel (1996) illustrated that on the best sites fertilization resulted in an additive increase in seedling growth to that of weed control (Figure 2). On poorer sites fertilization resulted in little added benefit and surmised that soil moisture was limiting fertilizer response. This supports the idea of a site induced threshold. That is, there is a threshold of moisture availability that must be met before fertilizer responses will occur. On the driest sites 100% weed control may never result in enough soil moisture for plants to take advantage of fertilization. On moister sites there is likely a threshold level of weed control necessary before benefits from fertilization are observed. Once the soil moisture threshold is reached growth responses from fertilization can be expected to be additive to those from weed control.

Application Technique

Insuring that fertilizer gets to the target conifer is extremely important. Placing the fertilizer in the planting hole at the time of planting or dibbling it close to the roots will insure the target seedling has the greatest potential to take advantage of the treatment while excluding other competitors. Broadcast applications often feed the weeds versus the target trees and can exacerbate existing competition for moisture between crop trees and weeds (Roth and Newton 1996, White and Newton 1990).

As a researcher, drawing direct correlation's from broadcast applications can be imprecise at best. It is difficult to determine exactly what dose of fertilizer each tree receives and dose will vary by site due to different soil and moisture conditions. From an operational perspective broadcast applications are appealing to foresters because large areas can be treated quickly and efficiently. Adding fertilizer to the planting hole or dibbling after planting requires individual attention to every tree and greater planning which increases the expense of the fertilization project. The reality of the situation is, newly planted seedlings only occupy a small percentage of the soil volume being treated limiting access to the total amount of fertilizer broadcast. The majority of broadcast applied fertilizer is likely to be lost either through leaching or taken up by competing plants. Not only will weeds limit nutrient availability by decreasing soil moisture but they will also absorb a large percentage of the fertilizer applied.

An example of this was reported by Roth and Newton (1996). They broadcast urea over Douglas-fir seedlings in weeded and unweeded plots. Broadcast nitrogen on unweeded plots resulted in increased conifer overtopping by weeds and greater soil moisture depletion. Consequently, seedling survival was less on fertilized versus unfertilized unweeded plots. Interestingly, on weeded plots urea fertilization did not result in a growth response. Roth and Newton (1996) explained the lack of response due to adequate soil nitrogen prior to fertilization and or a possible soil chemistry interaction in which soil pH was lowered which influenced the form of available soil nitrogen and reduced availability of other nutrients in the soil.

Woods et al. (1992) also used a broadcast application however, he showed a positive radiata pine response even in his no weeding plots. Additionally, he reported that 68% of N applied in unweeded areas was assimilated by plants other than the target conifers. Obviously, this suggests that broadcast applications can be wasteful if not damaging to crop trees in unweeded areas.

Care should be taken when dibbling or adding fertilizer to planting holes. If the product used is not a slow release fertilizer damage to the roots of the seedling may occur. This is especially the case with highly soluble salts such as urea under low soil moisture conditions. To avoid this problem do not add these types of fertilizers to the planting hole and avoid dibbling the product into direct contact with seedling roots.

Conclusion

To achieve success from early fertilization good vegetation control is a must. Without it only seedlings on the most moist sites can be expected to respond favorably to fertilization. With good weed control, benefits from fertilization will be additive to those of vegetation control. To insure that the target conifers are the plants being fertilized the extra effort should be made to apply fertilizer as a dibble next to the tree or in the planting hole using a slow release fertilizer formulation. More research is needed before we can reliably predict the response to fertilization on sites across the Pacific Northwest. In addition research is needed in matching fertilizer formulations to site conditions and determining minimum thresholds of weed control to obtain positive fertilizer responses.

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