In-Bed Herbaceous Windbarrier Produced More Ponderosa Pine Seedlings[1]

Richard W. Tinus[2]

Abstract.--There are currently no windbreaks at the Albuquerque Tree Nursery, but experience at other nurseries indicates windbreaks can be highly beneficial. To test the concept quickly without erecting or growing anything permanent, one drill row of oats was sown per bed when the rest of the bed was sown to ponderosa pine. The oats, which were maintained at 30 cm height by mowing, reduced wind velocity at ground level by 79%. In spite of a 25% loss of seedbed space (row 8 to planted oats and row 7 to competition from the oats), there were 55% more seedlings per running meter of bed with the windbarrier (6 rows) than without the windbarrier (8 rows). With the windbarrier, increases in seedling fresh weight and epicotyl height, and greener color were observed, but variability was too great for the differences to be significant. Windbarriers in adjacent beds across a section had no significant cumulative effect.

INTRODUCTION

Strong winds can be highly damaging to young seedlings. Since most nurseries experience strong winds at least occasionally, some form of wind protection is usually needed (Tinus 1978). Agronomic studies have also shown improved crop growth behind windbreaks even in situations where the wind is not strong enough to cause direct damage (Tinus 1976). However, the effects of windbreaks are not all beneficial, and careful planning is needed to maximize benefits while minimizing unwanted side effects (Read 1964, Stoeckler 1962).

Any windbreak has three primary characteristics: height, density, and orientation. The primary effect is reduction of wind velocity on the lee side. The pattern of wind velocity reduction is independent of barrier height, but the protected area is proportional to the height; therefore, the effect of a windbreak at any distance from it can be measured in terms of multiples of barrier height (H) (Read 1964). For complete protection, the array of barriers should be spaced about 10 H apart. That means a row of trees 15 m tall will protect an area out to 150 m from the trees, whereas a 1.3-m snow fence will protect only 13 m.

Trees and snow fences have been the main windbreaks used in nurseries. Trees have the disadvantage that they take years to grow to a useful size, and they may harbor pests that attack the crop trees. To be effective, snow fences must be erected in the middle of each section, where they tend to get in the way of farming operations and are a nuisance to put up and take down.

The Albuquerque Tree Nursery is currently devoid of windbreaks, but some small-scale experiments and observations indicate that windbreaks might be useful. In a recent nursery study, Douglas-fir, white fir, and Engelmann spruce seedbeds that were covered with snow fence on sideboards produced more and larger seedlings, but there was no apparent response by ponderosa pine. However, for protection from rabbits, the whole experiment was surrounded by 1-m-high, 6-mm hardware cloth, which is also an effective windbreak; and the growth of ponderosa pine within and close to the enclosure was clearly better than at distance beyond the windbreak influences.

From the apparent benefit of wind protection without significant shade, without interfering with cultural operations and at low cost, came the idea for an herbaceous windbarrier to be planted in one drill row of each bed of ponderosa pine. Oats were selected, because it is a coolseason grass that would reach an effective height quickly in the 1-0 season and die overwinter. If mowed to prevent heading out, it would not become a weed problem.

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[2]The author is principal plant physiologist, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Flagstaff, AZ.

Figure 1.--Ponderosa pine at Alburquerque Tree Nursery in July of the first season with an oat windbarrier, just before mowing to 30 cm.

MATERIALS AND METHODS

At Albuquerque Tree Nursery, the beds are oriented north to south, almost perpendicular to the strongest winds during the growing season. In May 1983, the seven beds of one nursery section were sown to ponderosa pine in seven drill rows. The eighth (westernmost) drill row in each bed was sown to Cimmaron oats, a tall-stemmed variety of Texas origin (fig. 1). The oats were sown fairly thick (about 65 seeds per running meter) to insure a windbarrier of adequate density. Another nursery section sown entirely to ponderosa pine with no oats served as the control. Windbreak and control sections were separated from each other and to the sides by fallow sections. Windbreak and control sections were replicated twice, all on about 2 ha of the nursery that were reasonably uniform in soil texture. In the middle of each windbreak and control section, a totalizing cup anemometer was installed, recessed into the ground so that the cups were just above ground level at the expected seedling crown height.

Seedling cultural treatments, such as irrigation, fertilization, and weed and pest control, were the same as elsewhere on the nursery. When the oats began to head out at 50 cm in height at the end of June (fig. 1), they were mowed to 30-cm height.

The four anemometers were read weekly throughout the first and second growing seasons. At the end of each growing season, two randomly located but widely spaced transects were laid out perpendicular to the sections. The two transects across two field replications were treated as four block replicates for statistical purposes. All of the seedlings in a 30-cm strip were lifted by hand and kept separate by drill row.

The seedlings in each sample plot (30-cm strip of drill row) were counted and bed density computed. On a random subsample of 10 seedlings (or fewer, if there were not 10), fresh weight, epicotyl height, and foliage color were measured. Foliage color varied from dark green to yellow and was measured by an index keyed to the following Munsell standard colors (Anon. 1977):

Index	Color	Munsell code	
4	dark green	7.5 G	4/4 to 2/4
3	light green	7.5 GY	5/6 to 5/8
2	yellow green	5.0 GY	6/6
1	yellow	2.5 GY	7/6 to 7/8

The color index was treated as a continuous variable, as were the other measurements, and analyzed as a randomized block design with beds within treatment and rows within beds treated as split plot and split-split plot factors, respectively. Only six rows per bed were analyzed to balance sample size between treated and control blocks.

RESULTS AND DISCUSSION

Reduction of Wind

After the oats had reached about 50 cm in height by the beginning of July (fig. 1), and for the remainder of the first growing season after the oats had been mowed, the oat windbarrier reduced surface wind by 74%, or to only 26% of what it was with no windbreak. This result was as expected for a moderately dense windbreak at a distance of about 2.5 H (Tinus 1976). The oats remained standing overwinter and throughout the second growing season, during which they reduced surface wind to 21% of total wind with no protection. Therefore, for at least 16 months, the oats were a highly effective windbreak within about 10-15 cm of the soil surface.

Main Effects of Windbreak

Seedling numbers were strikingly affected by the oat windbarrier. Competition and shading from the oats (in row 8) was so strong that seedlings grew poorly in row 7. Therefore, for the following comparisons, it was assumed that no usable trees would be produced in rows 7 and 8 with the windbarrier. To simplify analysis, rows 1 through 6 with a windbarrier are compared with rows 1 through 6 without the windbarrier.

At the end of the first season, the differences in seedling number and size, with or without a windbarrier, were not significant. However, by the end of the second season, bed density without a windbarrier was 104 seedlings per square meter, but 215 per square meter with a windbarrier (106% greater); and seedlings per lineal meter of bed (which includes rows 7 and 8 where there was no windbarrier) was 127 and 197, respectively, or 55% greater. Fresh weight and epicotyl height were greater and foliage color greener with a windbarrier than without in some, but not all, of the replications. Variability was too great for these differences to be significant.

Cumulative Effect

If linear multiple windbreaks are spaced closely enough so that the effect of one is not completely dissipated before the next one is encountered, there may be a cumulative effect up to as many as four windbreaks (Read 1964, Tinus 1976). In this experiment, such an effect was sought by comparing beds within treatments; however, no significant differences were found, except that at the end of the first year, foliage color tended to be yellower in the eastern beds than in the western, and the difference in color was greater in beds without a windbarrier than with one. Thus, there is little evidence of any cumulative effect.

Within-Bed Effects

At the end of both the first and second seasons, there were distinct differences in seedling number, size, and color by row within bed (fig. 2). Number of seedlings followed no pattern

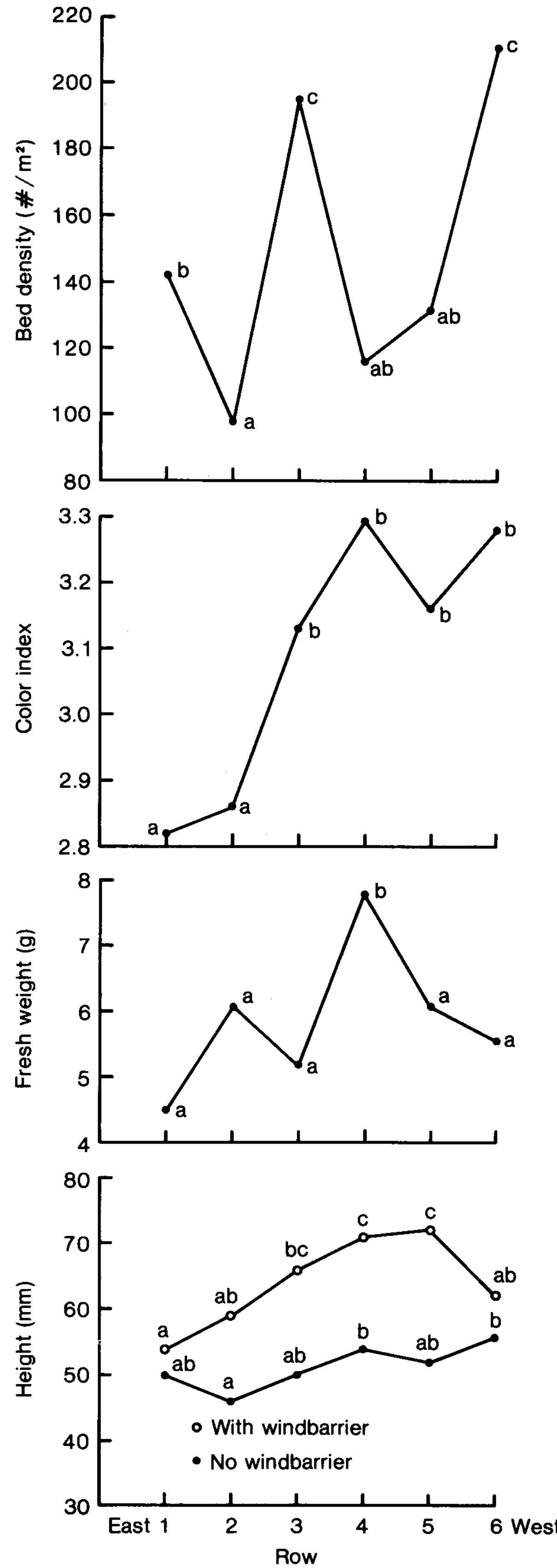

Figure 2.--Number, size, and color of 2-0 ponderosa pine seedlings as a function of row within bed. Bed density, color, and fresh weight showed similar patterns with or without a windbarrier. Points on a given line with the same letter are not significantly different at p=0.05 by an F-protected LSD test.

that could be related to the experiment; but the pattern was the same with or without the windbarrier, in both first and second seasons. It may have been caused by nonuniform sowing or seed covering.

With the windbarrier, epicotyl height and fresh weight were largest in the middle rows and declined on either side creating a distinct "breadloaf" effect. This is evidence of the competition from the oats and was expected. Growth and tree numbers were so strongly depressed in row 7 (adjacent the oats in row 8) that this row was deleted from calculations of size and number of seedlings produced with the windbreak.

Although there were some significant differences in beds without a windbarrier, there was not a clear pattern. Sometimes a breadloaf pattern is observed in beds of not only tree seedlings, but of horticultural and agronomic crops (Tinus 1976). As the seedlings gain height and foliage density, they become a windbarrier in themselves and protect their neighbors to the lee side.

Seedling color tended to be greener in the *middle* and western rows and more chlorotic in the easternmost rows, with or without a windbarrier. In the first season, the effect was more pronounced without a windbarrier than with one. Sometimes growth in the outermost rows of a bed is poorer because of exposure, wheel compaction of the alley between beds, or sloughing of the edge of the bed. However, there was no evidence for any such conditions in this experiment. A second possible explanation is that the most detrimental winds come from the east. If so, local weather records could indicate the time of year and circumstances under which windbarriers would be most useful.

CONCLUSIONS

More ponderosa pine seedlings were *produced* in six rows per bed with an oat windbarrier than were *produced* in eight rows without it. The effectiveness of the windbreak was due in part to seedbed orientation, because the beds are laid out perpendicular to the prevailing strong winds. This technique shows promise as a means for a nursery to obtain wind protection for the seedbeds quickly with little capital expenditure. As with all innovations, however, it should be treated on a small scale on an area typical of the nursery as a whole to determine if the benefits warrant the costs, before being applied to the whole nursery.

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