RED PINE NEEDLE LENGTH IN RELATION TO FIELD PERFORMANCE

by

John M. Paterson'

Abstract. Nursery needle lengths, which can be influenced by nursery cultural practices, are discussed in relation to survival and height increment after outplanting. Outplanting effects on root, needle and bud development are also discussed showing their relationship to eighth year field performance.

To understand the relationship of red pine (*Pinus resinosa* At.) needle length to subsequent field performance, various growth processes such as stem elongation, needle elongation, bud formation and root development should be considered with respect to the time of year in which they occur and their interaction (Fayle and Pierpoint 1978). The potential length of the shoot that will elongate in the spring is, in part, predetermined by the size of the terminal bud formed in the previous summer. Moisture supply during bud formation can influence the number of stem units that will be formed, while the elongation of these stem units will be influenced by moisture supply during stem elongation the following year. Thus, field performance, express(by stem elongation, is influenced by moisture supply during bud formation in July-August of the current year and moisture supply in May-June of the following year.

Needle elongation, which is sensitive to moisture stress (Strothmann 1967, Glerum and Pierpoint 1968, Clements 1970) is most rapid when stem elongation is largely completed and reaches a maximum rate of elongation at the time of bud initiation. Thus, the time periods for needle elongation and bud formation overlap during July and August so moisture stress affecting needle elongation will also have an effect on bud formation. Under conditions of limited moisture supply causing moisture stress short needles and small buds form, whereas when moisture supply is not restricted long needles and large buds can develop.

Root development affects all processes due to their control over moisture absorption. Thus, any treatment which affects root growth causing moisture stress, will be reflected in the development of the shoot (stem elongation, needle elongation, bud development).

Roots and terminal buds are good indicators of how well a tree is establishi after outplanting but assessing their condition can only be determined throu destructive sampling. Needle length, in comparison, is a non-destructive indicator of moisture supply from the developing roots and also indicates bu development, and in addition it can be easily classified during field surviv assessments.

'Research Assistant, Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ontario, LOJ 1E0.

In previous field studies (Patterson and Fayle 1984), needle length classes at the end of the first and second years after outplanting were shown to be good predictors of subsequent growth and survival. In this study I investigated whether nursery needle lengths, which could be altered through nursery cultural practices, would also indicate potential outplanting performance.

In the spring of 1980, the field performance of two 3+0 red pine compartments from the Kemptville Tree Nursery (lat. 45°01' long. 75°38') were compared in which seedlings from one compartment had "normal" needle development and seedlings in the other exhibited shorter than normal needle development. Shorter needles developed as a result of root-wrenching in mid-summer with no follow-up irrigation or rainfall. Since root-soil contact had been broken, the normal moisture uptake in the seedling had been altered resulting in shorter needle growth. Total height accumulation, however, was unaffected since elongation had been completed prior to wrenching.

Two bags of red pine (containing 250 trees each), one from the normal-needled compartment, and one from the short-needled compartment, were taken for outplanting at the Ganaraska Forest (lat. 44°06' long.78°38'). Trees had previously undergone normal grading procedures for weight, diameter, root area and height (Reese and Sadreika 1979).

Five replications of 50 trees per treatment were planted by hand in a randomized block design. The site was an abandoned farm field of well-drained fine to very fine sand, previously site-prepared with a shallow scalper. No herbicides were necessary for competition control prior to or after planting.

In the fall of 1980, the length of the previous year's shoot formed in the nursery, first year increment, and total height were measured. In addition, needle length on the previous years shoot formed in the nursery, and in the first year after outplanting were measured by selecting one pair of needles from the mid-point of the terminal leader. Previous tests showed this to be representative of the average needle length of the terminal leader (unpublished data). At the end of the second, third, fourth and fifth field seasons annual height increment, total heights and needle lengths were measured. At the end of the eighth year after planting total heights were measured. Survival data was collected for all assessment years.

Trends established at five years were still evident after the eighth year assessments, therefore, only nursery attributes, first year increments after outplanting, first and second year needle lengths after outplanting and eighth year survival and total heights are presented. Eighth year survival data, after arc sine transformation, nursery attributes and eighth year total heights were tested using an analysis of variance and the results are presented at the 957 confidence interval.

Results and Discussion

Survival and total height eight years after planting are shown relative to initial characterization of seedlings at time of planting (Table 1). Height at planting was significantly greater on the short-needled trees,

Table 1. Eight year total height and survival with some initial nursery stock characterization parameters for two needle length classes.

Nursery needle class	Mean nursery total height (cm)	Mean nursery needle length (cm)	Mean eight year total height (cm)	Eight year % survival
Short	22.1*	5.9	200.5	80.4
Normal	20.3	9.8*	217.4*	97.6*

*Significance tested at the 95% level.

however, nursery needle length, eight year total height and eight year percent survival are all significantly greater on the normal-needled trees. Basing future success on original nursery height is misleading unless other attributes are taken into account which can indicate success. Top length, stem diameter, top volume and root volume are attributes which have been shown to indicate potential growth performance (Racey et al. 1983). When this study was initiated, stem diameter, top and root volumes were not assessed. Stem length, however, was assessed in this study but needle length at time of planting appeared to be a better indicator of subsequent field performance. Needle length can be used as an indicator of root and terminal bud development and hence the trees ability to become established once outplanted.

Since some normal-needled trees did exist in the short-needled treatment and vice versa, both treatments have been combined into one data set to look at the correlations of nursery and field attributes (needle length, total height). Survival was correlated to nursery needle length. Seedlings which died after planting had mean nursery needle lengths of 6.4 cm and a mean nursery total height of 21.0 cm as compared to mean nursery needled lengths of 8 cm and mean total heights of 21.1 cm on the surviving trees. Of the 55 trees that died, only two trees had needles greater than 9 cm. Greatest mortality (25) occurred to seedlings whose nursery needle lengths were from 5 to 6.9 cm.

As previously stated this year's needle length indicates bud development in the current year, with the realization of this potential being expressed in the following year. The first year increment after outplanting should therefore reflect the nursery terminal buds potential as indicated by the length of the nursery needles. Using last year's height increment in the nursery to indicated plant size, the data have been divided into two groups; short and tall, and further subdivided, based on nursery needle length into two needle groups; short and long. Dividing the data into these four groups now made it possible to examine the relationship of the last year's nursery increment and nursery needle length to height increment at the end of the first year after outplanting. The results of this relationship are presented in Table 2.

Nursery needle length was a better indicator of outplanting performance than was nursery height increment. The short trees with short needles only grew 2.8 cm of height increment in the first year after planting as compared to 8.5 cm of height increment on the short trees with long needles. The short trees with long needles (8.5 cm) actually put on more height increment than the tall trees with short needles (6.8 cm) by the end of the first field season.

Table 2. Mean first year increment (cm) after outplanting by nursery increment group (cm) and nursery needle group (cm).

Nursery needle group (cm)	Nursery increment group: Short mean 9.5 (cm)	Nursery increment group: Tall mean 23.5 (cm)
	First year mean height increment (cm)	
Short mean 5.5	2.8	6.8
Long mean 12.5	8.5	11.1

The relationship of nursery needle length to eight year total height is illustrated in Figure 1. The data were subdivided into five nursery needle groups; <50, 50-69, 70-89, 90-109 and >109 mm, and mean eight year total heights, with confidence intervals at the 957. level, plus mean nursery total heights were plotted for each group.

No significant differences in original nursery heights were found between the groups selected but trees with nursery needles greater than 90 mm were significantly taller at eight years than those with needles less than 70 mm.

So far, my discussion has focused on nursery needle lengths related to field performance, but the length of needles formed during the first two years after outplanting also help to indicate how well the tree is establishing in its new environment. The rate of root establishment after planting will be reflected in the length of needles and bud size formed on the new terminal leader, i.e. slow establishment - short needles, small bud; fast establishment - long needles, large buds. Future growth will be influenced by this rate of root establishment. By adding nursery, first and second year needle lengths together on an individual tree basis, the effects from the outplanting shock on long term performance can be examined. This point is illustrated in figure 2. Total three-year needle lengths were sorted into six needle groups (Fig 2) and mean nursery total heights plus mean eight year total heights, with 95% confidence limits were calculated for each group. Greater eight year total height separation than that shown in Figure 1, is now possible when field establishment indicated by field needle length, is incorporated with nursery needle lengths. There is a significant difference of 91 cm mean total height at eight years between the group of trees with total three year needle lengths <251 mm when compared with the group >350 mm. As total needle length accumulation increases, total tree height also increases.

Conclusions

Nursery needle length has been shown to indicate red pine seedlings growth potential prior to planting. Trees with nursery needles greater than 8 cm in length, performed significantly better after planting than seedlings with nursery needles less than 8 cm. Total seedling height at time of planting was a less sensitive indicator of growth potential.

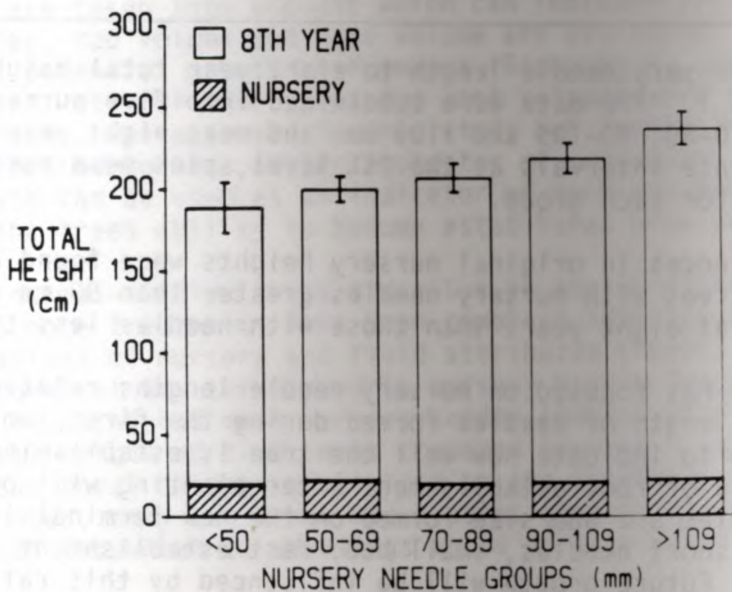

Figure 1 Mean nursery and eight year total heights by nursery needle groups. Confidence limits were calculated at the 95% level.

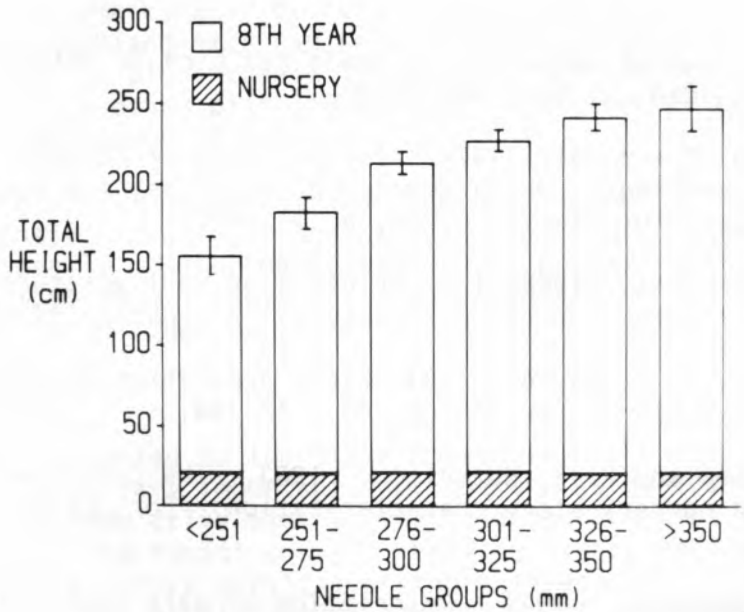

Figure 2 Mean nursery and eight year total heights by needle length groups. Needle groups were attained by adding nursery needle lengtn to first and second year needle lengths on an individual tree oasis. Confidence limits were calculated at the 95% level.

Needle length attained after planting helps to indicate the trees ability to establish in its new environment. Trees under stress due to the lack of new root development, will produce shorter needles, thus less photosynthetic area for carbohydrate production, and smaller buds which will result in less total height accumulation than trees which are not under stress.

Acknowledgements

I wish to thank Joan Schuppli for her assistance in the analysis of this data and the preparation of figures used in this paper.

References

Clements, J. R. 1970. Shoot responses of young red pine to watering applied over two seasons. Can. J. Bot. 48: 75-80.

Fayle, D. C. F. and G. Pierpoint. 1978. Interpreting performance of recently outplanted pine seedlings. White and red pine symposium proceedings. Dept. Environ., Can. For. Serv., O-P-6, p. 113-121.

Glerum, C. and G. Pierpoint. 1968. The influence of soil moisture deficits on seedling growth of three coniferous species. For. Chron. 44: 26-29.

Paterson, J. M. and D. C. F. Fayle. 1984. Early prediction of plantation performance for red pine. For. Chron. 60: 340-344.

Racey, G. D., C. Glerum and R. E. Hutchison. 1983. The practicality of top-root ratio in nursery stock characterization. For. Chron. 59: 240-243.

Reese, K. H. and V. Sadreika. 1979. Description of bare root shipping stock and cull stock. Ont. Min. Nat. Resource., Toronto. 39 p.

Strothmann, R. O. 1967. The influence of light and moisture on the growth of red pine seedlings in Minnesota. For. Sci. 13: 182-191.