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EVALUATING SEEDLING QUALITY: IMPORTANCE TO REFORESTATION

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ABSTRACT--High-quality seedlings are those that meet defined levels of performance (survival and growth) on a particular forest site. Improved evaluation of seedling quality will permit better predictions of performance and also improve production and handling practices. Such evaluations can be divided into two categories: tests of material attributes (morphological and physiological traits that are directly measurable) and of performance attributes (performance of whole seedlings when subjected to specified tests). The principles, procedures, and predictive abilities of 10 tests of such attributes will be reviewed in these proceedings. Nurseries and reforestation specialists use the various tests of seedling quality for different purposes. Seedling evaluations need to be refined so that they predict not only growth as well as survival but also performance of specific seedling lots on particular sites.

1.1 INTRODUCTION

High--quality seedlings are those that meet defined levels of survival and growth on a particular planting site. If seedlings fail to meet these defined standards, replanting or interplanting with additional seedlings may be necessary. People involved in reforestation are familiar with sites that have been planted repeatedly because of failures. This delay not only causes a doubling or tripling of regeneration costs but also increases the time required for the forest stand to reach merchantable size.

Improved seedling quality allows better interaction of planted seedlings with the planting site and, therefore, fuller expression of site potential (Fry and Poole 1980). For this reason, there is a trend toward better evaluation of those seedling attributes that determine the quality of planting stock. Such evaluation will result in better predictions of performance and improved practices of seedling production and handling.

It was the importance of such predictions and practices that prompted the formulation of these proceedings on Evaluating Seedling Quality. The present chapter sets the stage for the later ones by (1) summarizing the rationale for various types of seedling evaluation, (2) reviewing why these evaluations are important, and (3) discussing the need for their

refinement. Along the way, the format and objectives of the proceedings are highlighted.

1.2 SEEDLING EVALUATION

The importance and increasing interest in seedling quality and its evaluation are illustrated by the recent publication of several reviews. Sutton (1979) noted a trend toward closer and more complete characterization of planting stock. He emphasized that although seedling morphology is important, especially in relation to handling at the time of lifting, grading, and planting, the crucial thing is not what the tree looks like but how it performs in the field. And although a morphological grade can be determined quickly and remains unchanged through outplanting, stresses that occur between lifting and planting can alter the seedling's physiological condition so that its assigned morphological grade is irrelevant to field performance. Bunting (1980) also emphasized the importance of both morphological and physiological criteria when describing stock quality. A special issue of the New Zealand Journal of Forestry Science [Vol. 10. No. 1, 1980) includes original research and reviews on various physiological techniques for assessing quality of planting stock. Ritchie's (1984) comprehensive chapter. "Assessing Seedling Quality." in the Forest Nursery Manual reviews the state-of-the-art in technology in this field. The interest expressed in Ritchie's chapter by practicing reforestation and nursery personnel, as well as researchers, spurred the expansion of this topic into the present proceedings.

Ritchie organized evaluation of seedling quality into the measurement of two kinds of attributes: material and performance (Fig. 1). Material attributes can be either morphological or physiological and are directly measurable. Examples are mineral nutrition. carbohydrate status, and morphology. Performance attributes, on the other hand, are measures of the performance of whole seedlings when subjected to specified test conditions. Examples are frost hardiness and vigor.

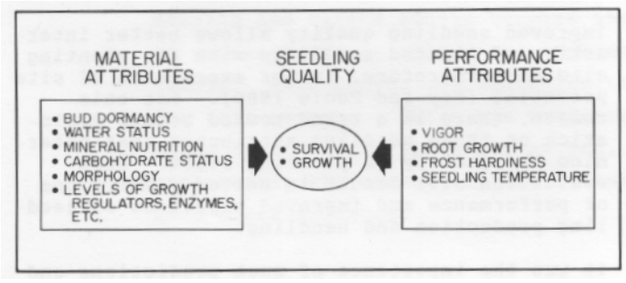

FIGURE 1. SEEDLING QUALITY CAN BE EVALUATED BY DIRECTLY MEASURING MATERIAL ATTRIBUTES OR BY A MEASURE OF PERFORMANCE ATTRIBUTES. THE OBJECTIVE OF SEEDLING QUALITY EVALUATION IS TO PREDICT POTENTIAL SURVIVAL AND GROWTH. [ADAPTED FROM RITCHIE (1984).]

Each of the 10 material and performance attributes listed in Figure 1 can be tested, and it is these 10 tests or test areas that are to be covered in the following chapters. Each chapter reviews the principles, procedures, and predictive abilities of one of the test areas. Each is designed (1) to help nursery managers and foresters understand the detailed principles and procedures of an area of testing; (2) to help them determine which tests are best at predicting field performance and, therefore, most useful; and (3) to predict the direction for future work in this area.

It will be immediately obvious to the reader that areas such as root-growth potential. morphology, and frost hardiness have received much more attention than have areas such as carbohydrate status and mineral nutrition. In these less-investigated areas, the authors have speculated about tests that might be used in evaluating seedling quality. For example. carbohydrate tests may help determine the storability of seedlings, and pressure-volume curves may help reveal drought resistance. Having a wide array of tests to choose from may soon enable us to predict a seedling's suitability for particular planting sites with specified conditions of weed competition. drought, or nutrient deficiency.

1.2.1 Why Evaluate Seedling Quality?

At present, the most commonly used tests of seedling quality are for bud dormancy (the dormancy-release index), morphology, vigor (stress), root-growth potential, and frost hardiness. Nurseries and foresters test seedling quality for very different reasons. Nurseries do so to:

- Show the customer that their stock is of high quality when it leaves the nursery.
- Determine when to employ certain practices such as lifting and storing.
- Assess how cultural practices in the nursery alter seedling quality so that the best practices for long-term use can be determined.
- Cull seedlings that probably will not perform well in the field.

Foresters evaluate seedling quality to:

- Match seedlings having specific character-istics to specific sites.
- Determine when quality changes occur during handling and planting and then correct practices that reduce quality.
- Avoid regeneration delay of a forest site by discarding seedlings with low potential and substituting those with higher potential,
- Determine how to handle or plant specific lots of seedlings (for example, seedlings

that are breaking bud would not be stored for long).

- Determine whether regeneration success or failure was a result of stock quality or other factors,

- Identify which seedling characteristics are most important for optimal performance on specific sites (for example, which seedlings do best on droughty sites).

1.2.2 When to Evaluate Seedling Quality

Although nurseries sometimes track seedling quality throughout the various stages of culturing, in these proceedings we concentrate on evaluating stock quality during the stages from lifting through planting (Fig. 2). For example, tests at the time of lifting might include those for (a) nutrition, (b) carbohydrate status, and (c) frost hardiness. From the results, specialists might conclude that a specific seedling lot (a) needs nitrogen and so should be fertilized at the time of planting, (b) has adequate carbohydrates for storage up to 4 months, and (c) is frost hardy to -10^{0}C. Later tests during grading and packing might include those for (a) plant moisture stress and (b) morphology. From the results a nursery or seedling user might conclude that (a) the seedling lot is not being stressed during grading and packing and (b) the seedlings are larger in stem diameter and height than expected and would be appropriate for a site with heavy vegetative competition. Tests immediately before planting might include those for vigor (stress) and root-growth potential. From these tests one might conclude that seedlings are of poor quality and should be discarded or at least not planted on a stressful site.

Test results may be used immediately to alter practices or discard seedlings from a specific lot, or they may be used to improve future cultural and handling practices. For immediate use, of course, results must be reported quickly so that decisions can be made. For long-term improvement of practices, fast turnaround may not be as important. Most often, however, we will need quick, reliable tests so that operational decisions can be made immediately.

One additional point about test results--communication of these results between nurseries and foresters is of paramount importance if seedling evaluations are to be useful and improve seedling quality in the long run.

1.3 REFINING EVALUATION OF SEEDLING QUALITY

Several gaps exist in our present understanding and approach to evaluating seedling quality:

- Although the importance of good physiological condition to high seedling quality is widely acknowledged, there is still a need for better understanding of the physiological processes that are critical to seedling performance. For instance, what happens to carbohydrate reserves in seedlings that are stored, and how are these reserves important to seedling growth and survival?

- Because no single material or performance attribute is critical to all seedlings and all planting sites (e.g.. frost hardiness may not be critical on a mild site), we need a battery of tests that can be customized for specific lots of seedlings.

- If we are ever to predict actual rather than potential performance, we must define the critical environmental factors that limit survival and growth on a specific outplanting site. Then we need to apply tests that will determine how seedlings will respond to those factors.

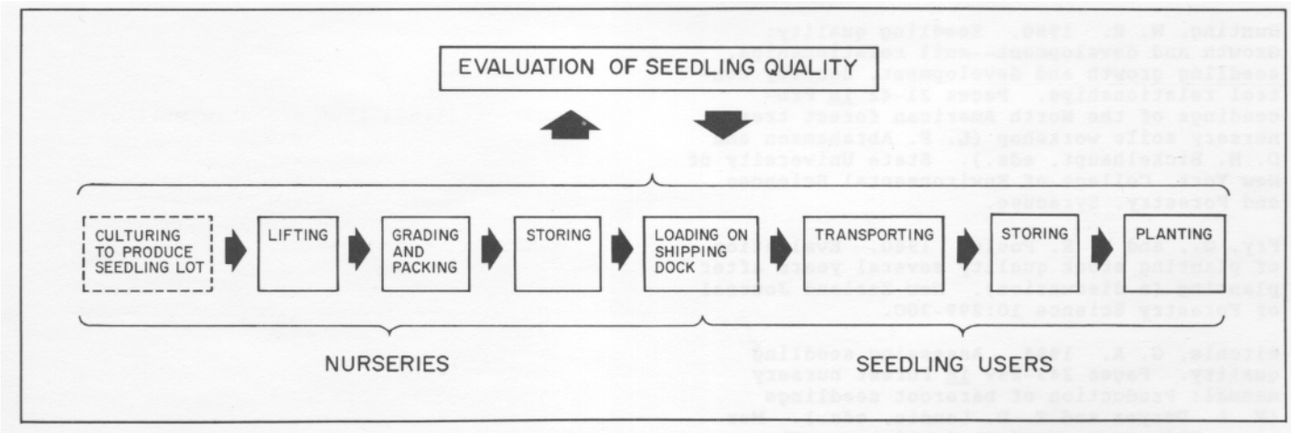

FIGURE 2. SEEDLING QUALITY CAN BE EVALUATED AT EACH STAGE FROM CULTURING THROUGH PLANTING. TEST RESULTS AT EACH STAGE CAN BE USED TO ALTER CULTURAL AND HANDLING PRACTICES FOR THE SPECIFIC SEEDLING LOT OR FOR FUTURE LOTS.

- For tests of material attributes, we must define critical thresholds for optimal performance under specific site conditions. Their use as indices of seedling quality is most likely to be important when critical levels are not achieved. For example, if 2% N is necessary for optimal seedling performance and tested seedlings show only 1.5% N. poor performance is likely.

  We need to be able to predict growth and not just survival. Everyone in reforestation is familiar with sites where seedlings survived adequately but grew unacceptably for a number of years. We should be able to alleviate this problem of lowered productivity and value by not planting such seedlings in the first place.

1.4 FUTURE RESEARCH

Achieving better evaluation of seedling quality will require steps such as those in the following four-part research plan:

1. Launch basic research on seedling physiology and the importance to survival and growth of such attributes as mineral nutrition, bud dormancy, and carbohydrate levels.

2. Identify the environmental factors that are critical to successful seedling performance on the majority of sites.

3. Compare the effectiveness of various tests for predicting survival and growth of major tree species on the major kinds of sites (for example. droughty or cool and moist).

4. Develop a computer model of seedling quality that predicts survival and growth of various species on particular sites from test results.

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