MOISTURE-STRESS-PLOT EVALUATION CF NURSERY STOCK SURVIVAL AND GROWTH POTENTIAL

by

Raymond J. Boyd, David A. Gibney, Lee L. Mason, and Steve McDonald-

INTRODUCTION

One of the prime functions of nurserymen and scientists engaged in nursery work is to improve the field performance of nursery-grown stock. Any change in nursery culture or stock handling practice must, regardless of early indications based upon general stock appearances or cost, face the ultimate test of what this change does to the ability of the stock to survive and grow under the rigors

1/Respectively, Associate Silviculturist, U.S.D.A. Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah 84401, stationed at Moscow, Idaho, at Forestry Sciences Laboratory, maintained in cooperation with the University of Idaho; Resource Assistant, Sullivan Lake Ranger Station, Metaline Falls, Washington (formerly Supervisory Forester, Forest Service, Northern Region, Coeur d'Alene Nursery, Coeur d'Alene, Idaho); Supervisory Forester, Coeur d'Alene National Forest Nurseries Unit; and Supervisory Forester, Coeur d'Alene Nursery.

of field planting. Accurate and efficient evaluation of stock survival and growth potential is, then, an important function for those engaged in the production of forest planting stock.

This evaluation of stock performance takes on many different forms ranging from direct observation in the field to indirect evaluation based upon real or imagined correlations, and from the crude ocular estimates to the scientifically sophisticated determinations. All of the various methods have their advantages and disadvantages. We all have probably used most of the methods at one time or another.

One of the most perplexing problems facing the nurseryman or researcher is choosing a stock performance testing technique that gives an accurate estimate of performance quickly and inexpensively. The ultimate device for this is probably a well-designed field test, adequately replicated on sites representative of the planting area, repeated over a period of from 3 to 5 years to iron out the vagaries of weather, and stringently controlled to minimize the confounding effects of extraneous variables. If all of these criteria are satisfied, excellent information should be obtained; however, the cost is high and results are slow in coming.

Several years ago it became clear to those of us associated with the Coeur d'Alene and Savenac Nurseries that a good substitute for, or supplement to, field testing was needed. At least one major study effort was largely invalidated by a year of weather that was extremely favorable for survival. Results of other studies were badly weakened owing to our inability to devote the time and money required for good field testing. Our attempts at long-range field testing indicated that such testing, for the time being, was prohibitively expensive in time and money.

We therefore concluded that expensive field testing of stock performance would have to be limited to studies involving especially important questions and decisions. Another technique was needed for the bulk of our testing program either as a substitute for, or as a supplement to, field testing. We reasoned that since moisture stress was the greatest single cause of field mortality our test procedure should feature the relative ability of different types of stock to survive under significant moisture stress. In addition, since moisture stress is the climatic variable that most often confounds a single year's field testing, it seemed advisable to test under a range of moisture stress levels in order to assure detection of stock performance differences. Consequently, we named the technique "Variable-Moisture-Stress Testing." In addition to providing a semicontrolled variable-moisture-stress condition, we sought to establish a system that minimized extraneous variables such as animal damage, stock handling variables, and planting differences that permitted a large number of treatments to be replicated without the expense of individual tree marking, and that required a minimum of travel expense.

METHODS

We designed our variable-moisture-stress plots with the desired features in mind, and have operated them for 3 years. The plots and associated equipment are at the U.S.D.A. Forest Service Coeur d'Alene Nursery and are planted and tended by nursery personnel. Test trees are planted in the plots in April or May and their survival and growth are followed in detail throughout the first growing season and, depending upon the circumstances, into the second or third season. Seedlings from a given nursery treatment are planted approximately

1 foot apart in rows 18 inches apart. Rows extend through a series of three to four plots on which various soil-moisture-stress levels are achieved through combinations of irrigation, weeding, no care, and shielding from natural rainfall. For any given seedling row, 2• trees are planted in each stress level. In order to standardize planting and reduce planting variability, seedlings are threaded into an 8-tree Yale Board under shelter, positioned in a plowed trench with one vertical side, and promptly backfilled and packed into place. The soil is at or near field capacity when the seedlings are planted and is sprinkled to bring it to field capacity and facilitate settling after a day's planting.

After planting, all plots are kept moist until late June or early July, when stressing is started. At the start of the stressing period, special irrigation equipment2/ is installed on the low-stress plot. Low-stress plots are kept weedfree to reduce the need for irrigation as much as possible. Soil-moisture-metering devices, either electrical resistance units or tensiometers, have been used to indicate soil-moisture content and to provide information for irrigation control, The soils on the low-stress plots are kept roughly above 50 percent of available moisture at the 8-inch level. Stress levels on the other plots are controlled by the degree to which weed competition is removed and are varied according to the species planted. For ponderosa pine and Douglas-fir we aim for a wide range of soil moisture from the irrigated weedfree plots to a nonirrigated plot with a full component of weeds. With species that demand more moisture, such as white pine, Engelmann spruce, and grand fir, the stress range is kept narrower and shifted to the moist side by partial weeding of the severe-stress plot and complete weeding of the moderate-stress plot.

The end result for which we aim is a range of survival from near 100 percent in the low-stress plot to 40 percent or less in the severe-stress regime. Theoretically, if we use enough stress levels, we should be able to find the level at which differences in survival and growth among the stock being tested are the greatest. In our initial planning we were aiming for six stress levels but settled for four, the severe-stress level being a plot covered to shield it from natural precipitation. The extra precaution of a covered plot was subsequently abandoned in favor of the three-stress level approach.

RESULTS

The variable-moisture-stress-plot technique has been used to estimate the value for field survival and growth promotion of a number of nursery practices and stock treatments. Although the details of these individual tests are beyond the scope of this paper, certain highlights will be presented to illustrate the effectiveness of the method.

Ponderosa pine seedbed density study (1965)

Methods, -- Thirty random samples of 100 field-run trees were selected from broadcast-sown nursery beds that had been artificially thinned in July of their first growing season to densities ranging from 10 to over 100 per square foot. Subsamples of 24 seedlings were planted in each of four moisture stress plots designated as "low," "moderate," "high," and "severe" (covered). Their

---

2/ Schultz, LeRoy, and Roland Stoleson. A precision sprinkler for soil moisture studies. Tree Planters' Notes 18(1):15-17, illus. 1967 survival was checked by monthly examinations, and the final tally was made on October 20, 1965.

Results.-- Although the survival rates for stock grown at the various densities were quite variable at any stress level, there was a definite trend of better survival for seedlings grown at low densities (Fig. 1).

Douglas-fir antitranspirant study

Methods.--Douglas-fir 2-1 stock was treated with decenyl succinic acid, a physiological antitranspirant developed by workers at the Connecticut Agricultural Experimental Station. Three replications of treated and untreated seedlings were planted in six rows of the four stress plots described above.

Results.--Survival of both treated and untreated stock was greater than 85 percent under conditions of low to moderate stress, with no detectable differences attributable to the treatments (Fig. 2). However, under high stress only 32 percent of the treated stock survived the first growing season, while an average of 66 percent of the untreated stock survived the first growing season. On the severe-stress plot only 13 percent of the treated stock survived compared to 44 percent for untreated stock.

Engelmann spruce 2-1 vs. 9-0 stock (1965)

Methods.--Two age classes of spruce were tested in a six-row, three-replication experiment with four stress levels. For this, 2-1 and 3-0 stock were selected from lots with similar seed sources.

Results.--On August 20, survival on low-and moderate-stress plots was 95 percent or better for both age classes (Fig. 3). Survival under high- and severe-stress conditions for both age classes was less than 3 percent. These results are very uninformative as to the relative ability of the two age classes to survive under moisture stress. This limited information is typical of many field-test results, when conditions are such as to bring about either uniformly good survival or complete failure.

However, if we examine survival on July 15, when the lack of soil moisture had not yet caused such great mortality in the high- and severe-stress plots, differences in the survival of the two age classes are apparent. At this time survival of 2-1 stock on the severe-stress plot averaged 87 percent, whereas survival of the 3-0 stock was 65 percent. Fifteen days later both classes of stock had declined to an average survival of about 5 percent. Thus, under the particular range of moisture stress used in this test procedure, it appears that differences in survival potential could be detected by frequent examinations to find the point in time when the differences seem to be demonstrated. Unfortunately, the results of these intermediate examinations can be highly subjective because of the difficulty of classifying seedlings as alive or dead during periods of rapid attrition.

Soil fumigation study (1966)

Methods.--Ponderosa pine, Douglas-fir, western white pine, and Engelmann spruce 2-0 stock grown in fumigated and unfumigated soils at Coeur d'Alene or

Savenac nurseries, or both, was planted in a three-stress-level design with three replications per treatment in the spring of 1966. Degree of stress varied according to species, as explained earlier.

Results. --Douglas-fir stock grown in fumigated soil survived and grew better in the moisture-stress plots than stock grown in unfumigated soil (Fig.4). Actual differences in survival averaged about 8 percent regardless of the stress level, but the differences were significant only under moderate and severe stress. As stress increased, survival decreased from a high of 82 percent to a low of 23 percent. These seedlings have been left in the moisture-stress plots for two and a half growing seasons, the last one and a half without variable stressing. During this time seedlings grown in fumigated nursery soil have maintained a height superiority over seedlings grown in unfumigated soil.

The survival of ponderosa pine stock grown in fumigated soil, unlike that of Douglas-fir, was either equal or inferior to that of stock from unfumigated nursery beds when planted in the stress plots. Under low stress, survival was uniformly good (95 percent). Moderate stress produced an average survival of 81 percent for fumigated stock vs. 88 percent for stock grown in unfumigated soil, a significant difference. The greatest average difference occurred in the severe-stress plot, again in favor of the stock from unfumigated beds, but high variability caused this difference to be nonsignificant. The average height of stock from fumigated beds was significantly greater in the low-stress plot only.

Ponderosa pine and Douglas-fir age class comparisons (1967)

Methods.--By the summer of 1965 it was apparent that improved nursery practices at the Coeur d'Alene nursery might make it possible to reduce the time required to grow suitable stock by 1 year. Ponderosa pine and some Douglas-fir 1-0 stock seemed large enough for field planting. Consequently, in 1966 the moisture-stress plots were devoted to testing the survival and growth potential of 1-0 and 2-0 ponderosa pine and Douglas-fir stock. For each species, 20 lots of 1-0 stock and 20 lots of 2-0 stock were selected for testing and paired as closely as possible according to seed lot and nursery conditions. Random samples wore planted in a three-stress-level version of the stress plots; severe-stress plots were not irrigated or weeded. All roots were pruned to 8 inches before planting.

Results.--Survival of 2-0 ponderosa pine stock averaged slightly, but not significantly, better than 1-0 survival under moderate and severe stress. Under low stress there were no survival differences. Douglas-fir survival was favored by planting 2-0 stock at all stress levels, with differences ranging from 10 to 13 percent. Results from the stress plots have led to the installation of a large field test to compare the performance of 1-0 and 2-0 stock under natural conditions this summer.

DISCUSSION AND CONCLUSIONS

While moisture-stress-plot evaluation of nursery stock performance has been a valuable and relatively efficient tool for us at Coeur d'Alene, there are weaknesses in the mechanics of the operation and questions concerning the validity of results. The irrigation equipment, although designed for semiautomatic operation, has several shortcomings which need to be corrected for trouble-free

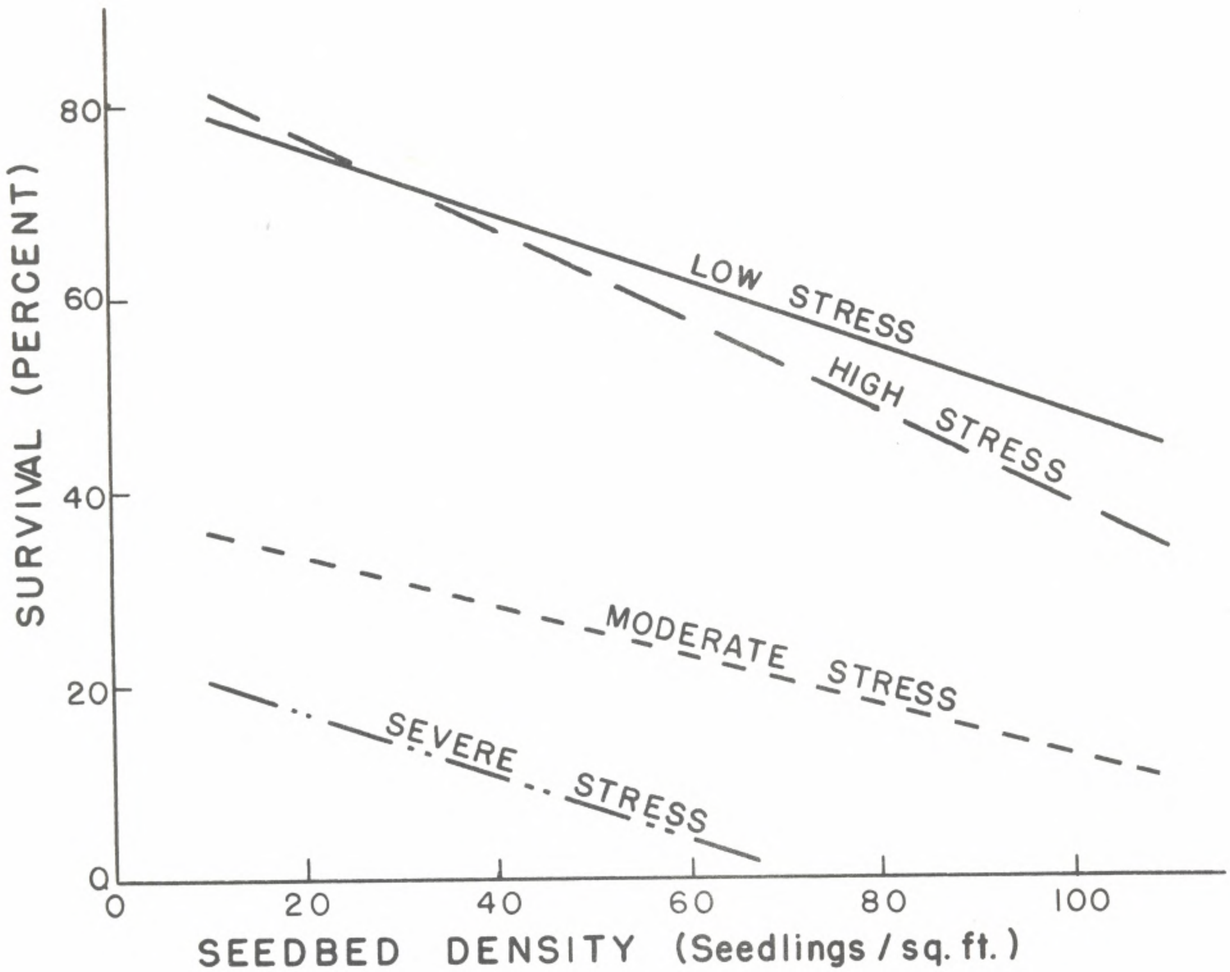

Fig. 1

The effect of seedbed density on survival of 2-0 ponderosa pine at various soil-moisture-stress levels (survival as of August 20).

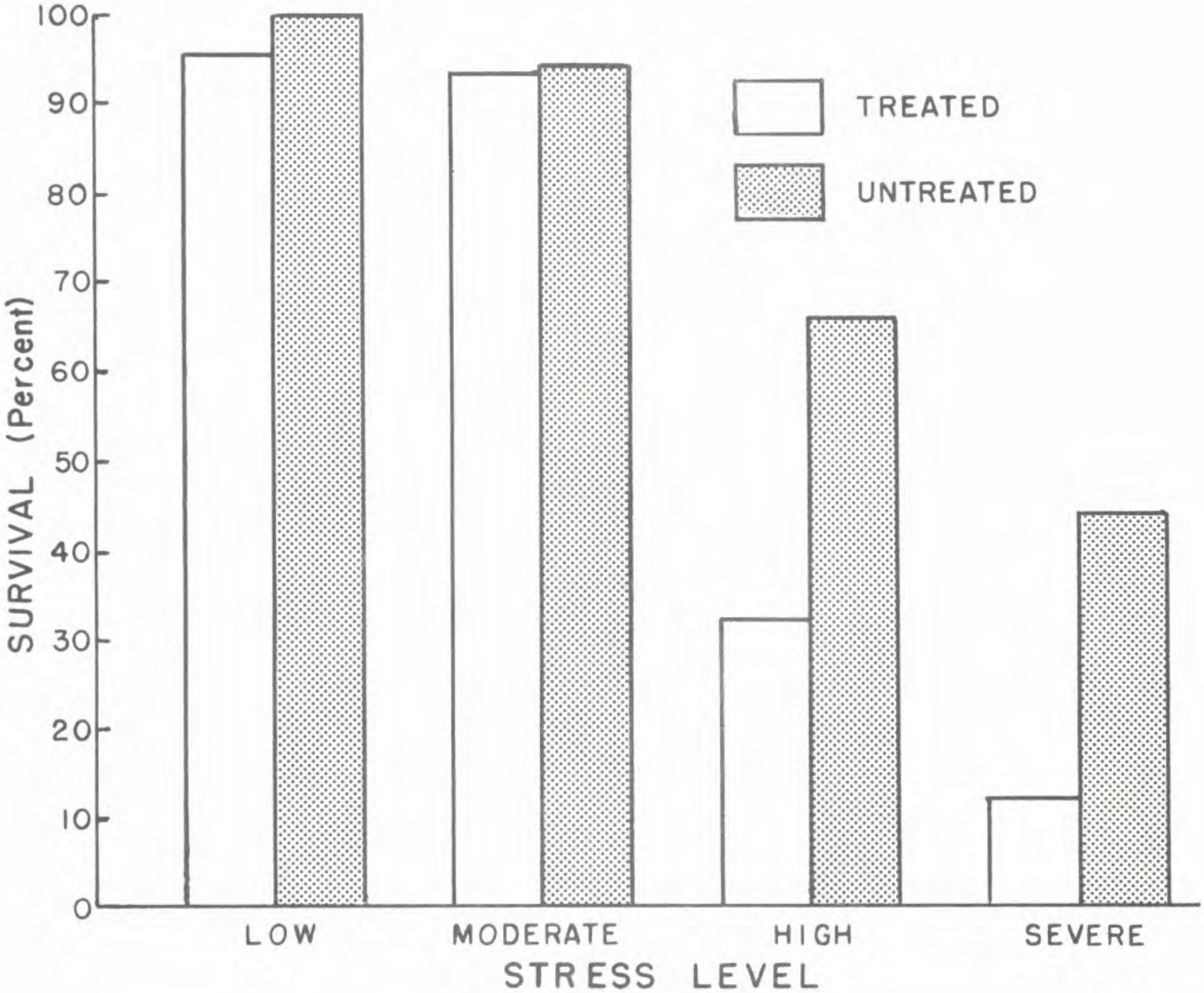

Fig. 2

The effect of antitranspirant treatment on the August 20 survival of 2-1 Douglas-fir growing at various moisture-stress levels.

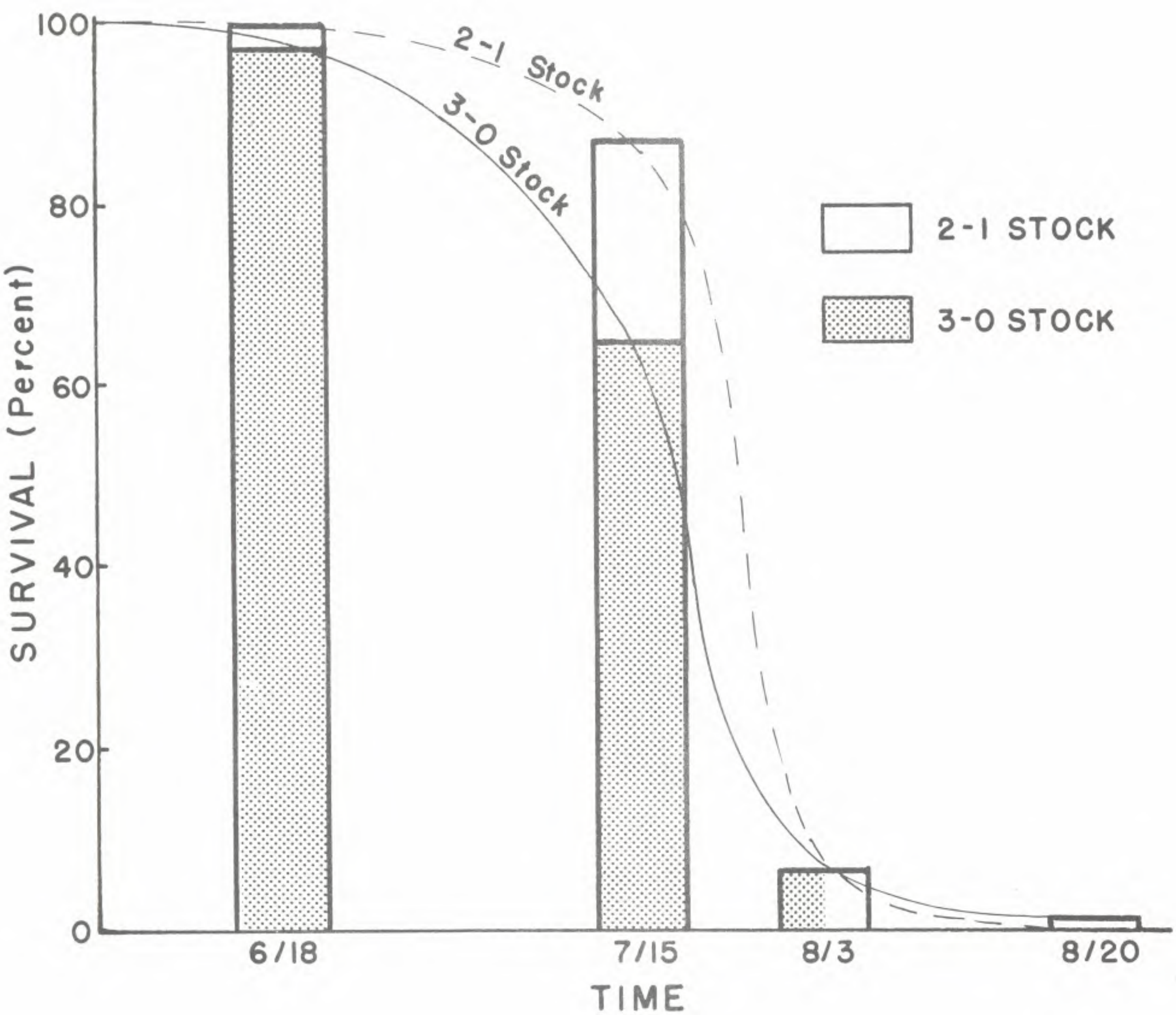

Fig. 3

First-year survival trends of 2-1 and 3-0

Engelmann spruce under severe soil-moisture stress.

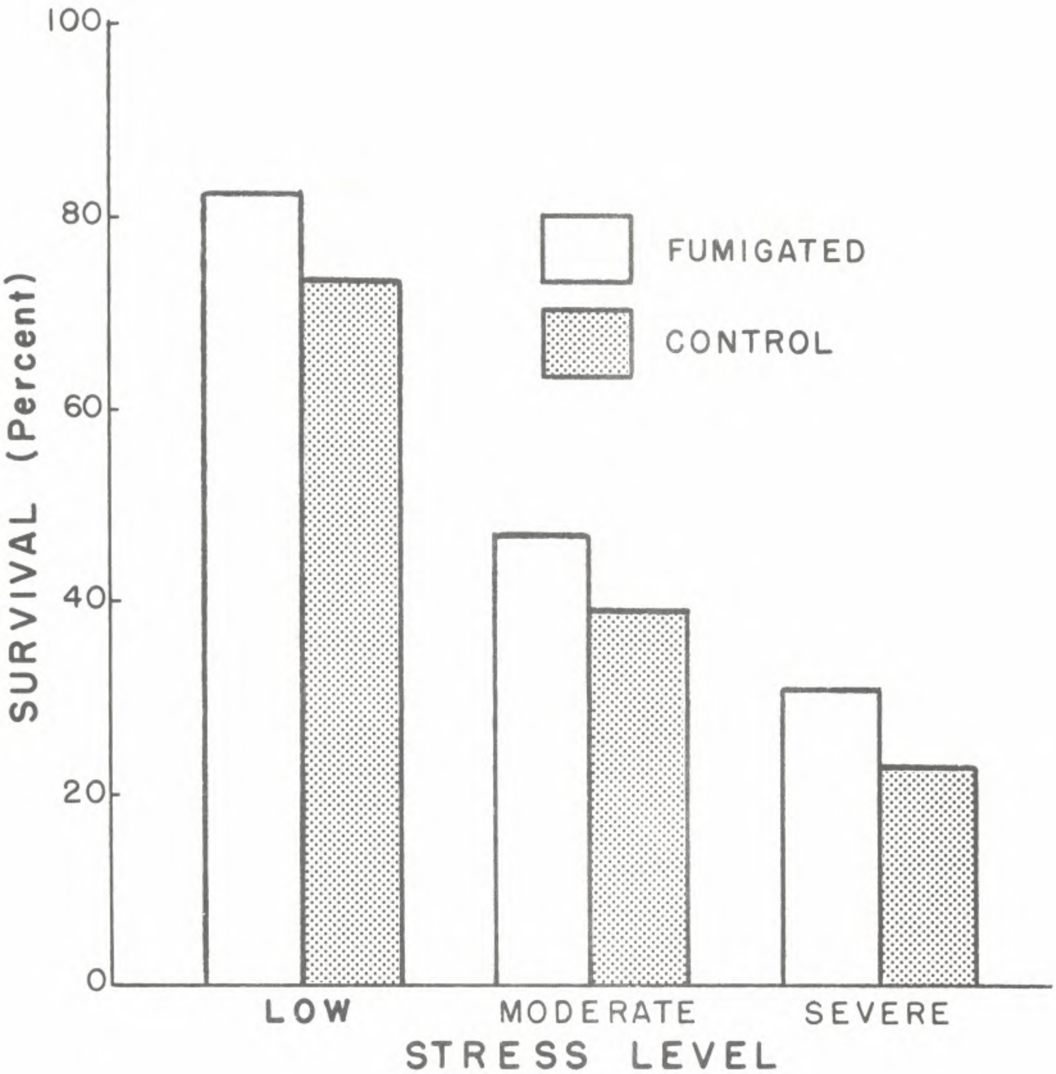

Fig. 4

Moisture-stress-plot survival of 2-0 Douglas-fir stock grown in fumigated and unfumigated seedbeds (survival as of September).

operation with a minimum of attention. These problems, of course, can be solved mechanically and have nothing to do with the validity of test results except when they cause undesirable variation in stress or when trees are mechanically damaged by the wheels of the irrigator.

We have experienced a greater degree of variation in our test results than we had anticipated. This variation is probably the result of stress variation caused either by (1) variations in irrigation during the month or two preceding the start of the stress cycle or (2) stress variations caused by soil and competition differences within a given stress-level plot. Greater care during the prestress period and better control of competition might help to reduce this variability and make the technique more sensitive from the statistical standpoint. If not, more replications of test comparisons can be incorporated into the design.

Perhaps the greatest criticism that could be made about our work so far is that we have not checked the survival and growth of stock planted in the stress plots against equivalent field-planted stock. However, if we look at the objectives of moisture-stress testing more closely, the omission of field-test comparison may not seem too serious. Our objective has been to test the relative survival- and growth-promoting value of nursery and stock-handling practices under a range of moisture-stress conditions. Other highly variable factors of the field environment such as animal damage, smothering, soil, and planting variations are virtually eliminated. So, for our objectives, testing the validity of moisture-stress-plot results with field-test results might be likened to checking the accuracy of Naval Observatory time with an hourglass. We have recognized that the primary cause of field mortality is moisture stress and are testing only the ability of stock to avoid or to endure this one factor.

We have been somewhat concerned about the possibility that soil and competition differences between the field-planting site and the stress plots might cause important differences in moisture-stress development patterns. A soil-moisture-depletion rate at the stress plots that is greater or less than that on planting sites could result in a total plant moisture-stress pattern that is not typical of field sites. We feel that this is a rather remote and perhaps unimportant possibility, but we hope to investigate the matter soon.

In conclusion, we feel that the variable-moisture-stress-plot technique of stock performance evaluation is a rather happy combination of many of the best features of other systems. It is a relatively direct approach similar to field testing, but it is quick. It has many of the control features of the more scientific indirect techniques, but is suitable for mass testing and broader inferences. The scheme is not perfect by any means. Refinements are being developed. Other techniques have been proposed, and we plan to spend considerable effort on exploring them. But until a better technique is developed, the stress plot will be used as a valuable part of our continuing effort to improve planting success in the Northern Rockies.
