Sample Size for Evaluating Treatment Effects on Red Pine Seedlings

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Basal diameter and total height measurements of 990 3-0 red pine seedlings provided the variance data to compute sample sizes for various probabilities and allowable errors. A precision level ± 5 percent of the mean would require approximately 20 to 100 seedlings, depending upon the probability level chosen.

Many studies involving the effects of various treatments on growth of tree seedlings rely on measurements of stem diameter and seedling height as variables (2, 4). A common question that occurs in the planning of such studies centers around the appropriate sampling size or the number of seedlings to include in each study replicate. The number of seedlings depends upon the variability associated with diameter and height, the degree of precision desired, and the appropriate probability level.

The objectives of this study were to determine the variation associated with diameter and height of red pine seedlings and to compute the sample sizes required for varying probabilities and levels of precision.

Methods

In April 1983, 990 3-0 red pine seedlings were obtained from the Griffith State Nursery in Wisconsin Rapids, Wis. On each seedling, basal stem diameter (mm) and total height (cm) were measured. Means, standard deviations, and coefficients of variation were computed, and the iterative procedure of Avery and Burkhart (11) was used to determine sample sizes. The following formula was used:

$$n = \left[\frac{(t)\ (cv)^2}{A}\right]$$

n = sample size
t = Student's t
cv = coefficient of variation (%)
A = allowable error expressed as a percentage of the mean

Results and Discussion

Sample statistics are presented in table 1, and calculated sample sizes for diameter and height for various probabilities and allowable errors are presented in tables 2 and 3.

Table 1—*Sample statistics based on measurement of 990 3-0 red pine seedlings*

Statistic	Basal diameter	Total height
	Mm	*Cm*
Mean	4.36	26.3
Standard deviation	.88	4.3
Range	2.18-8.82	14.0-43.5
Coefficient of variation (%)	20.2	16.2

Table 2—*Number of seedlings to sample for various probabilities and allowable errors for basal diameter*

	Allowable error as a percentage of the mean				
Probability	1%	5%	10%	15%	20%
80	699	28	8	4	2
90	1,102	46	13	6	4
95	1,564	65	18	9	6
99	2,702	112	31	16	9

Table 3—*Number of seedlings to sample for various probabilities and allowable errors for total height*

	Allowable error as a percentage of the mean				
Probability	1%	5%	10%	15%	20%
80	433	19	5	2	1
90	714	30	9	5	2
95	1,013	43	13	7	3
99	1,750	75	21	11	4

Coefficients of variation for diameter and height were fairly close, 20.2 percent for diameter and 16.2 percent for height. Thus, for those studies where both seedling diameter and height are to be measured, approximately the same number of seedlings would provide the desired precision for both variables.

For both diameter and height, an allowable error of ±1 percent of the mean results in an inordinately high sample size, regardless of the probability level chosen. Most investigators would probably prefer to operate in the +/- 5-percent range, where the sample size varies from about 20 seedlings to slightly over 100, depending upon the probability level chosen.

Sample sizes for other probability levels can be computed using the data in table 1 and the sample size formula.

Conclusion

If appropriate phenotypic variation data is available, numbers of seedlings that should be used in various studies need not be based on guesswork or perceived convenience. As shown by this study, there is a great deal of variation in sample size based upon the desired level of precision alone. According to Freese (3), "the aim in planning a survey should be to take enough observations to obtain the desired precision-no more, no less." The information presented here should aid those workers faced with setting up studies that involve the measurement of seedling diameter and height.

Literature Cited

1. Avery, T. E.; Burkhart, H. E. Forest Measurements. New York: McGrawHill; 1983. 331 p.
2. Carlson, W. C.; Presig, C. L. Effects of controlled-release fertilizers on the shoot and root development of Douglas-fir seedlings. Can. J. For. Res. 11: 230-242; 1981.
3. Freese, F. Elementary statistical methods for foresters. Agric. Handb. 317. Washington, DC: U.S. Department of Agriculture; 1967. 87 p.
4. Yawney, W. J.; Schultz, R. C.; Kormanik, P. P. Soil phosphorus and pH influence the growth of mycorrhizal sweetgum. Soil Sci. Soc. Am. J. 46:1315-1320; 1982.