COMPARATIVE STUDY OF CHARACTERISTICS OF SEEDLINGS AND CLONAL CUTTINGS

H. Roulund
The Royal Veterinary and Agriculture University Arboretum,
Horsholm, Denmark

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ABSTRACT

This paper is concerned with the nature of the improvement that can be obtained from using cuttings in forestry. Potentially, this improvement represents both gain in the characters under selection and greater uniformity in the tree crop.

One experiment involved both Sitka spruce and Norway spruce. In each species cuttings of eight clones and a population of seedlings were planted and studied during a three-year period. Each clone was highly uniform in date of flushing. With respect to height growth and stem form, however, the clones did not show consistently greater uniformity than the seedlings.

In the other experiment a 29-year-old clonal planting of Norway spruce was compared with seven 16-year-old seedling families for height, diameter, and branching habit. In this material the effects of competition, and of the duration of the competition, appear to have had an over-riding effect on variability between trees.

INTRODUCTION

The use of clones in forestry may be divided into three fields; viz research, seed orchards and forest planting. Clones are widely used in the first two of these fields and in this connection the method of propagation has mainly been grafting, Gradually, as the technique of rooting cuttings has been developed and proven in medium- to large-scale trials, it appears possible to produce cuttings at a price which can compete with that of seedlings. This applies even to certain species which are difficult to root, such as Norway spruce (*Picea abies* (L.) Karst.) and Sitka spruce (*P. sitchensis* (Bong.) Carr.).

One could then ask, what is the aim of using cuttings for direct planting in the forest, or in other words, what are the anticipated benefits? The aim is twofold. First, it is hoped to achieve large genetic gains through intensive selection and through using certain non-additive gene effects which cannot be used in propagation by seed. Second, it is hoped that greater uniformity may result from eliminating genetic variation. Both aspects are illustrated in Fig. 1.

To find out if these expectations are correct, and to estimate the gain and the variability for different characteristics in Norway spruce and Sitka spruce, two studies were made. The first study compared variability within clones with that of a seedling

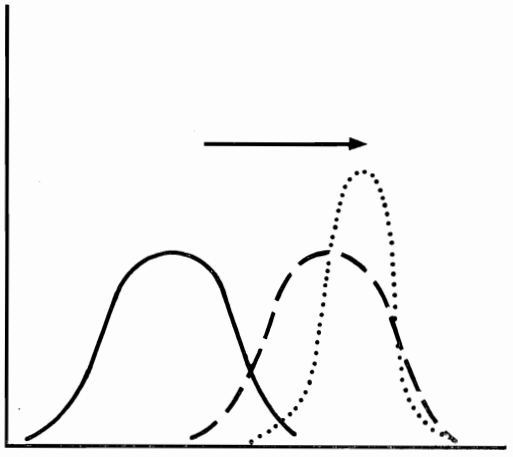

FIG. 1—The principle of the expected benefits of using clones. Frequency distributions for characters under selection in base population (solid line) and in select populations after sexual reproduction (dashed line) and after vegetative reproduction (dotted line).

lot during the first few years after planting, while the second compared the variability of a 29-year-old clonal planting with that of 16-year-old seedling families. The experiments are not yet concluded, so the results must be regarded as preliminary.

YOUNG CUTTINGS AND SEEDLING LOTS

Plant Material and Experimental Design

In the autumn of 1969 eight plus trees were selected from an eight-year-old stand of Sitka spruce and eight plus trees from a nine-year-old stand of Norway spruce. The trees were propagated as cuttings from second- and third-order branches. In the spring of 1970 the rooted cuttings were transplanted to a randomized block design with four blocks and 24 plants per plot. In the autumn of 1970, 2-year-old seedlings from a selected seed stand of each species were transplanted to plots which had been left vacant within the block. It must be stressed that neither the seedlings nor the cuttings were culled, or even sorted.

The Characters Studied

The characters studied were height, stem form, percentage of forked stems and time of flushing. Height growth was followed over a two-year period, measurements being made in 1970, 71 and 72, during the dormant season. The variation was expressed as the coefficient of variation (standard deviation divided by the mean).

The stem form was scored visually in 1971 and 1972 on a 1 to 10 scale. A score of 1 denoted vertical (fully orthotropic) growth, while 10 denoted horizontal (completely plagiotropic) growth. In presenting the data the standard deviation was used as a

measure of the variation. Percentages of forked stems were assessed in 1971 and 1972. The degree of flushing was measured about 20 May 1971, 1972 and 1973. The flushing was scored on a 1 to 5 scale, and the standard deviation was used as a measure of the variation.

TABLE 1—Summary of results after 3 years growth of the cuttings and seedlings, showing means, and either coefficients of variation or sample standard deviations (s.d.)

		Height 1972		Stem form 1972		Flushing 1973	
		cm	coeff. of variation	score	s.d.	score	s.d.
SITKA SPRUCE	mean of clones	58.5	20.5	2.95	1.09	2.73	0.07
	seedlings	38.8	27.7	3.00	1.97	1.52	0.63
NORWAY SPRUCE	mean of clones	27.4	22.4	3.41	1.44	2.47	0.07
	seedlings	32.7	22.4	1.50	0.71	1.16	1.16

Results

The results represented in Figs. 2 (height), 3 (stemform), 4 (stem forking) and 5 (flushing) of the three-year data are summarised in Table 1. These figures and the table may be evaluated in the following way —

Sitka spruce:

Within the clones the coefficients of variation for height averaged only about three-quarters that of the seedlings. The greater actual height of the clones means little since they were far taller than the seedlings in 1970, the year when the trial was established. With respect to stem form score, the use of clones has given no improvement of the mean value, although one of the clones is conspicuously straight. A greater uniformity is, however, obtained with the clones, corresponding to a reduction in the standard deviation of about one-half. With respect to flushing all the clones were earlier than the seedlings. Flushing date is normally of no importance in itself since the greatest frost risk for Sitka spruce is during the autumn, because of late ripening of the shoots. Time of flushing may be under stronger genetic control than almost all other characters. The average of the standard deviations of the clones is only about one-tenth of that of the seedlings.

Norway spruce:

The mean height of the eight clones was only 85% of that of the seedlings, but there was no difference in the coefficients of variation. It should be noted that both the Sitka and the Norway spruce seedlings were one year older than the cuttings, but at the time of first measurement in the Norway spruce trial the seedlings were of roughly the same size as the cuttings. One may state that the expected increase in growth, due to more stringent selection, has certainly not materialised for most of the clones with respect to uniformity of growth. In stem form the seedlings were much

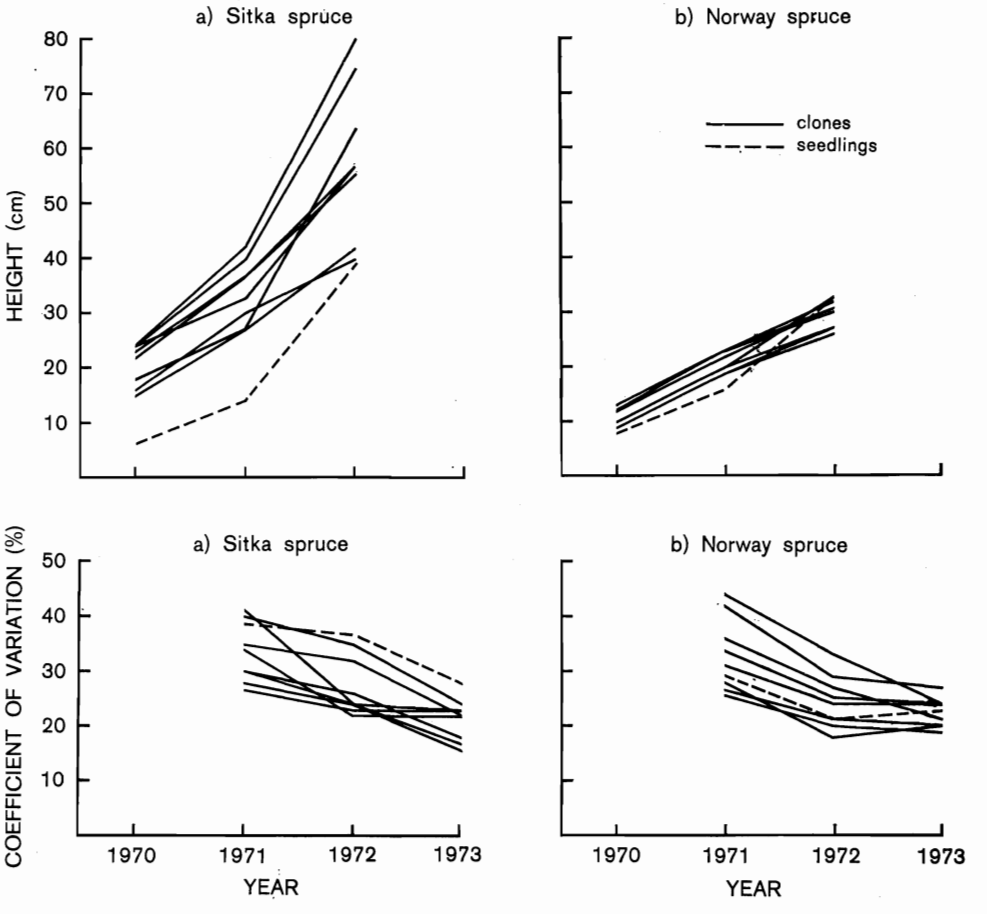

FIG. 2—Mean heights and coefficients of variation for 8 clones and a seedling population of (a) Sitka spruce and (b) Norway spruce over a 3-year-period.

better than the clones, and the variation, as expressed by the standard deviation, was only half of that within the clones. In flushing the clones are as a whole earlier, and each is extremely uniform. The average standard deviation within clones is thus about one-tenth of the standard deviation of the seedlings.

The contrast for the two tree species in height growth and stem form could have several possible causes, including: (1) greater genetic variation in Sitka spruce than in Norway spruce; and (2) high susceptibility to frost injury during the autumn in Sitka spruce, so that the clones had effectively been selected for frost resistance. Furthermore, all the Sitka spruce clones had lammas shoots, which was not the case for the Norway spruce.

OLDER CUTTINGS AND FAMILIES

Plant Material and Experimental Design

Only a single clone was available for this study. The cuttings were taken from an arbitrarily chosen ten-year-oldNorway spruce. After rooting the cuttings were planted

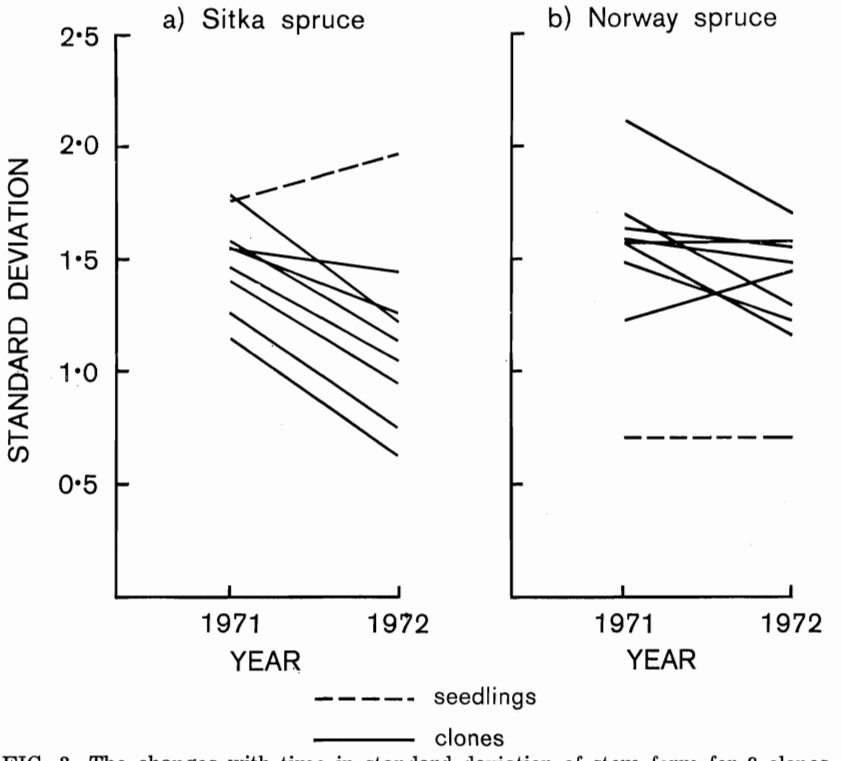

FIG. 3—The changes with time in standard deviation of stem form for 8 clones and a seedling population of (a) Sitka spruce and (b) Norway spruce.

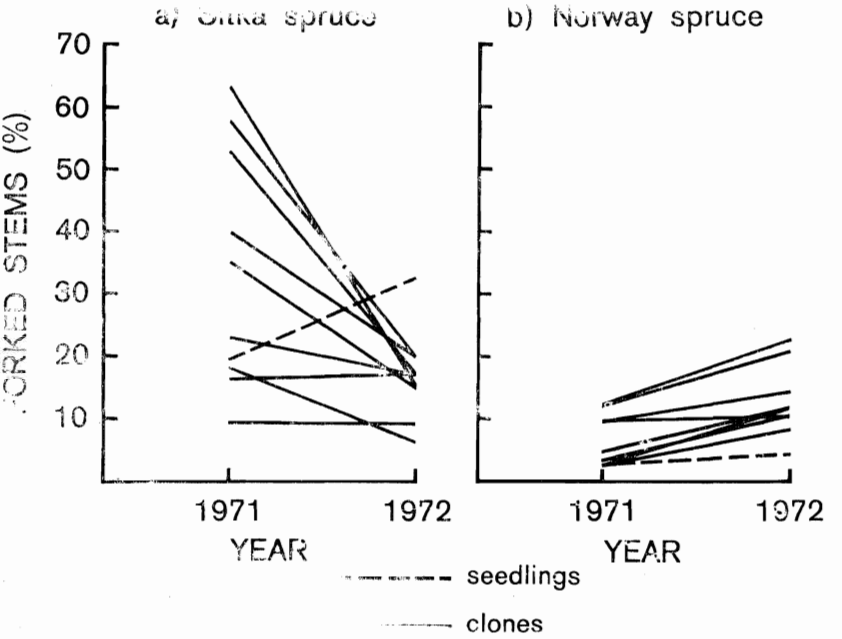

FIG. 4—The change with time in the percentage of forked stems in 8 clones and a seedling population of (a) Sitka spruce and (b) Norway spruce.

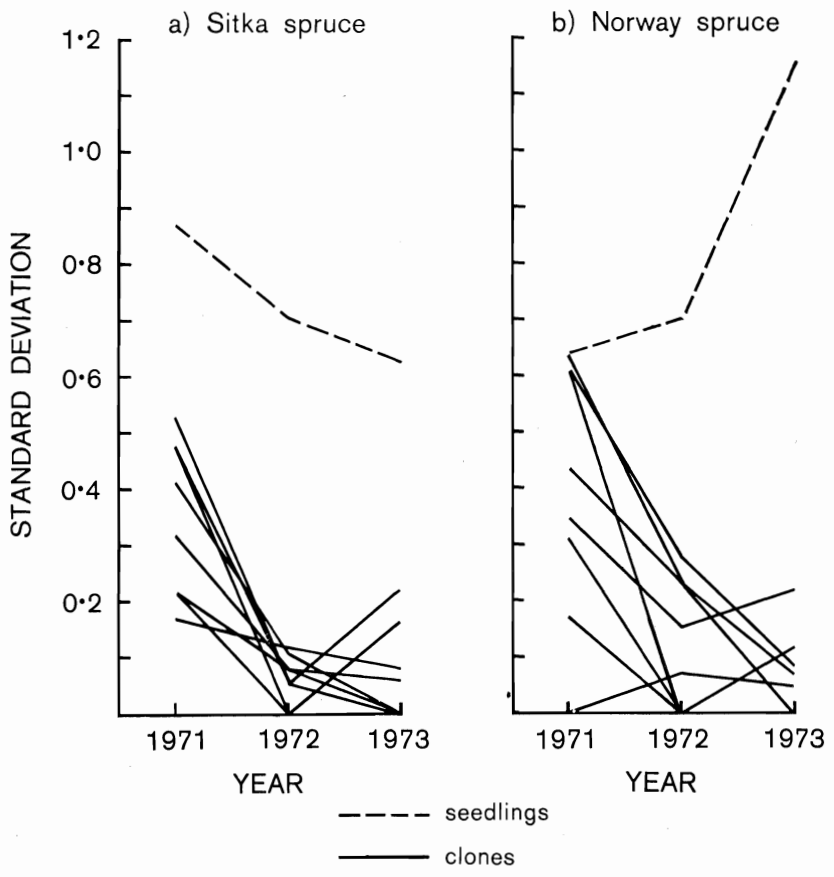

FIG. 5—The change with time in the standard deviation of flushing scores for 8 clones and a seedling population of (a) Sitka spruce and (b) Norway spruce.

in two square blocks, the first spaced at 2 × 2 m, and the second at 1 × 1 m. The number of ramets were 100 and 360 respectively. Unfortunately, there was no replication and there were no plots of seedlings for immediate comparison.

The cuttings were measured 29 years after planting, and will be compared with measurements from seven families of sibs which were growing in the neighbourhood.

The seven families of sibs are 16 years old and are on similar soil about 500 m from the cuttings. Each family of sibs is represented by 15-20 individuals spaced at 2.5 × 1.25 m. The experiment is without replication, but a measurement of heights indicates that there is no systematic change in the growth conditions inside the area.

The Characters Studied and Results

The material has been measured in detail, but this study is concerned only with the following three characters, viz height growth, breast height diameter, and relative

diameter of the branches, i.e. the average of all branch diameters in a cluster divided by the stem diameter above the cluster. Height and diameter are shown in Table 2.

TABLE 2—Mean heights and mean diameters, with coefficients of variation, for the 29-year-old clone at different spacings, and the seven families of sibs

Clone (V) and progeny (S)	Spacing (m)	Height dm	Height coeff. of variation	Diameter cm	Diameter coeff. of variation
V525	2 × 2	134.8	0.128	15.8	0.228
V525	1 × 1	110.4	0.167	10.0	0.270
S3033	2.5 × 1.25	75.8	0.095	10.8	0.089
S3044	2.5 × 1.25	77.1	0.081	11.0	0.083
S3041	2.5 × 1.25	72.3	0.074	9.9	0.109
S3048	2.5 × 1.25	72.9	0.059	10.9	0.074
S3038	2.5 × 1.25	79.5	0.053	11.7	0.111
S3039	2.5 × 1.25	72.2	0.077	11.6	0.097
S3040	2.5 × 1.25	78.8	0.049	11.8	0.116

Relative branch diameter ratios were found to be independent of the degree of competition between trees, and are therefore particularly suitable, when results from different experiments are compared. The data are shown in Fig. 6 as a diameter/branch cluster number regression.

Discussion

Comparisons are made difficult by the various imperfections of the experiment. It is nevertheless possible to get a picture of the variability within the different groups. In Table 2 it can be seen that the stronger competition associated with the closer spacing has given larger coefficients of variation.

Comparing the 29-year-old clone with the 16-year-old sib-families it is clear that the non-genetic effects, as compounded by competition over the additional 13 years of growth, are so important that the variation within the clone is conspicuously larger than within the seedling families.

The relative diameter of the branches is clearly smaller for the families than for the clone, but the greatest difference comes in the variation about the regression line. Expressed as a standard deviation, this is 0.0548 for the clone, and 0.0254 for the families (mean values). The double variation within the clone is not easily explained because it can hardly be the effect of competition.

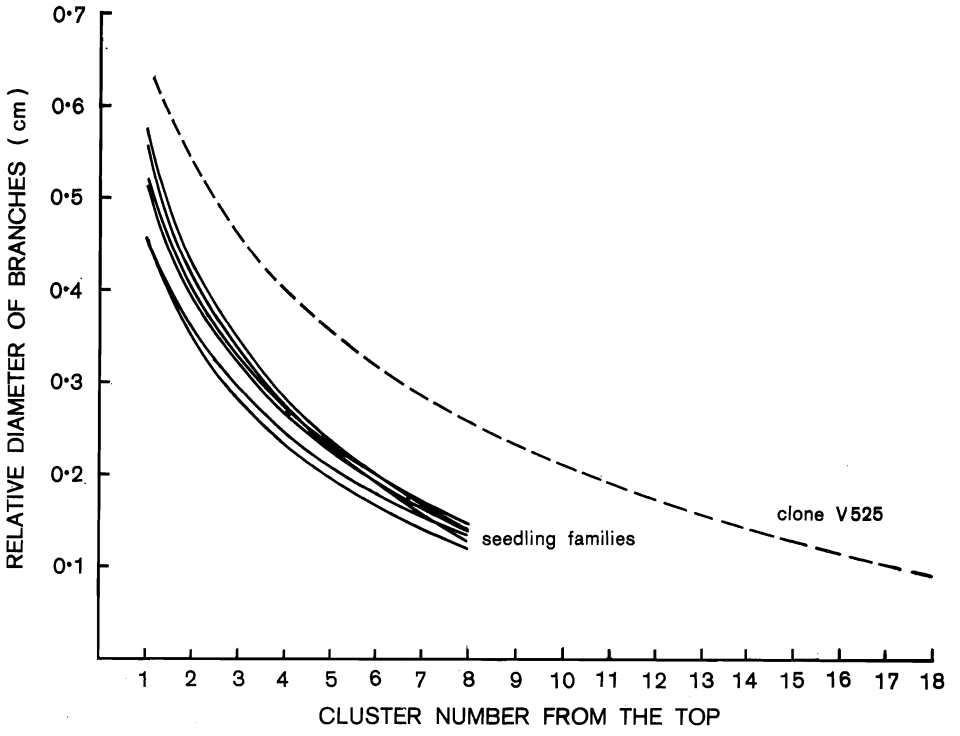

FIG. 6—The regressions of the relative diameter of the branches on the branch cluster number for 7 seedling families and one clone of Norway spruce.

GENERAL DISCUSSION AND CONCLUSION

The variation within a clone may be divided into three components.

1. The variation due to environment after the cuttings are taken.
2. The variation due to anatomical and physiological differences, i.e. size of the cuttings, root development. nutritional status etc.
3. The variation representing irreversible or partly irreversible differences relating to positions in the tree i.e. the topophytic effect.

Ruden (1968) has taken special care with the topophysis problem, and therefore obtained his experimental material from the same parts of the respective trees, and only used shoots of the same order of branching. R. Kleinschmit (1961), in a large experiment, found a negative correlation between the size of ortets and of their 5-year-old ramets. M. Werner (pers. comm) found in a 10-year-old experiment with Norway spruce, consisting of 3 clones and 2 seedling families, greater variation in height and diameter within the clones than within the families.

From the literature and the studies reported here, then, one may conclude that the

clonal propagation of Norway spruce does not in itself ensure greater uniformity of height growth, diameter, or stem form.

In the Sitka spruce experiment it appears that the population of seedlings used for comparison is very sensitive to frost. It is certain that frost injury has strongly influenced height growth and stem form. Conclusions may therefore be premature.

Other characters, such as number of branches per cluster, branch angle, wood density, form factor, and ripening of the shoots, will be investigated later. A series of clonal experiments is also being established with selected plus trees and a standard population.

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