Top and Root Characteristics of Greenhouse Grown Seedlings of Different Black Cherry Provenances

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Black cherry (Prunus serotina EHRH.) is native over a wide geographic area in North America. MCVAUGH (1951) suggested that the species consists of several populations and that the range of the typical variety (P. serotina var. serotina) extends from Canada to Florida, west to eastern Texas, Oklahoma, Kansas, eastern Nebraska and Minnesota (Figure I). A number of other varieties have also been recognized, including P. serotina var. alabamensis (subsp. hirsuta), the range of which is found within that of var. serotina in portions of Georgia, Alabama and Florida. Black cherry is also found in eastern and southern Mexico, the Revilla Gigedo Islands, and Guatemala.

Although the natural range of the species is quite extensive, black cherry is of commercial importance in a rather limited area. Most of the black cherry wood is cut from stands in the northern Allegheny and Pocono Plateaus of Pennsylvania, adjacent areas in the Catskill Mountains of New York, and the mountains of West Virginia, Maryland and northeastern Ohio (HOUGH, 1960).

Within its natural range, there is a great deal of variation in the characteristics of black cherry. GENYS (1961) reported considerable variation among 12 sources collected in Maryland. A more intensive study was initiated at West Virginia University in 1966 to investigate range-wide variation in growth and wood properties of the species and to establish a source of material for selection and breeding of superior black cherry for use in the State. CECH and KITZMILLER (1968) and KITZMILLER (1968) reported on the variability in the characteristics of seed and one-year-old nursery-grown seedlings of 33 origins collected in this study. Seed from trees of southern sources were lighter in weight, smaller in diameter and had thinner endocarps than did those seed from those collections made in the central and northern portions of the range. For the first few weeks after germination, seedlings of southern origins growing in nurssery beds had red stems and small primary leaves, while those from more northerly areas had brown stems and large, yellow-green primary leaves. These differences were less pronounced later in the growing season, although sources originating from within or near the range of subsp. hirsuta remained distinctly different from other origins. At the end of the growing season, trees from the more southerly origins were generally taller than those from other areas. However, the overall relationship between height growth and latitude was not strong and sources from Vermont and Michigan ranked among the 10 tallest included in the study.

The purpose of the study reported here was to investigate the variation in tops and root system of black cherry seedlings from different parts of the species range.

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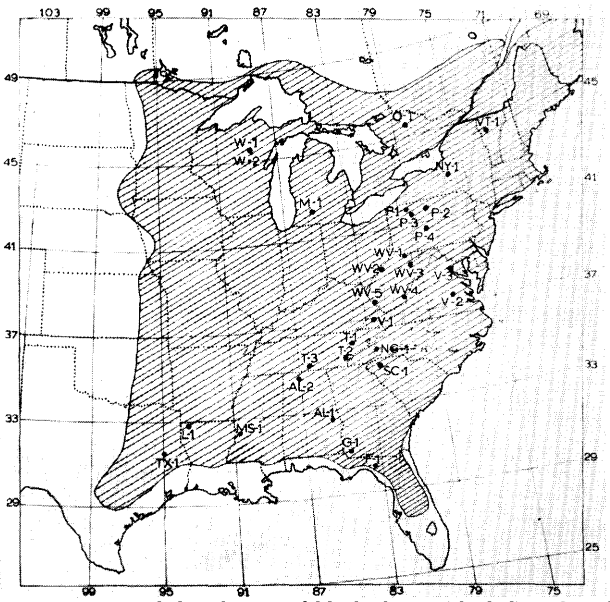

Figure 1. — Natural distribution of black cherry (shaded) in Canada and the United States and provenances included (numbered dots) in this experiment (Range map from LITTLE, 1953).

Procedure

Thirty seed sources of black cherry were used in this study. Individual seedlots were collected from three to five trees in naturally occurring stands of black cherry. These stands were located primarily in areas populated by var. serotina. However, seed from four stands in South Carolina (SC-1), Alabama (AL-1), Georgia (G-1), and Florida (F-1), may have been within the range of subsp. hirsuta (Table 1, Figure *1).*

In April 1967, seed which had been stratified for 90 days in moist sand at 34—38° F. were sown in flats in the greenhouse. During the last week in May and the first week in June, seedlings from each mother tree in each stand were transplanted into containers (9 inches X 4 inches X 4 inches) filled with a potting mixture consisting of one-half by volume each of builder's sand and peat moss. Sufficient 10-10-10 fertilizer was added to each container to provide approximately 150 ppm each of N, P_2O_5 and K_2O. One seedling was placed in each container and mother trees from each stand were grouped together to form the three to five-tree plots. Trees were watered at intervals to keep the moisture level near field capacity. Seedlings in two replications were harvested after nine months growth and the other two replications after twelve months growth. At the end of each period, containers were taken from the greenhouse, dumped and the root systems carefully washed. Trees were stored in plastic bags under refrigeration until measurements of individual trees could be completed.

All analyses of variance were conducted using the means of the three to five-tree plots (mother trees per stand) as items.

Results

There were significant differences in characteristics of seedlings from different origins. Seedlings of the eight sources from the most southerly portion of the species

Table 1. — General location and climate at place of origin of black cherry seed sources used in study of top and root characteristics[1]).

Region or Origin[2])	Latitude	Longitude	Elevation	Temperature: Annual	Temperature: Apr. to Sept.	Precipitation: Annual	Precipitation: Apr. to Sept.
	°N	°W	feet	°F		inches	
Northern	41—46	73—89	850—2000	40—49	53—63	30—46	17—25
Central	35—40	77—85	200—4000	47—59	59—71	39—57	21—28
Southern	30—35	83—95	50—850	62—69	74—77	47—55	20—36

[1]) Specific locations and climatic data for each individual seed source can be obtained in the article by CECH and KITZMILLER (1968).
[2]) Seed sources from the following are included in each region:
Northern: Canada (Ontario), Wisconsin, Vermont, New York, Michigan and Pennsylvania.
Central: West Virginia, Virginia, North Carolina and Tennessee.
Southern: South Carolina, Alabama, Georgia, Florida, Mississippi, Louisiana and Texas.

range *(Tables 1 and 2, Figure 1)* formed a group which were consistently similar in a number of the characteristics. One of these, Texas-1, was taller and heavier than all other sources. There was no consistent pattern of the variation in individual traits studied among the other southern sources.

Seedlings of the 22 origins from the central and northern portions of the range formed a second group having characteristics which were common to all but with no predictable pattern to the variation in individual traits or relationship to latitude of origin within the group.

Seedlings from all sources had distinct but relatively short tap roots and differences between origins in tap root lengths were not statistically significant. Although lateral roots of some origins were approximately twice as long as those of other sources, there was no apparent pattern to differences between seed sources. There were noticeable differences in the type and appearance of the lateral root systems, however. For southern provenances, the major lateral roots were relatively small in diameter and a dense mass of fine roots proliferated from the tap root *(Figure 2)*. Seedlings from central and northern portions of the range generally had several relatively large lateral roots which originated along the tap root and the number of fine roots was usually not as great as that on southern origins *(Figure 2)*.

Although tap and major lateral root lengths were not significantly greater for southern origins than for central and northern ones, root weights (tap, major laterals and fine laterals) were consistently greater for southern sources. Data indicated that this did not result from roots which were larger in diameter but rather that the density of woody material in the root systems of southern provenances was greater. This same trait has also been noted in the root systems of southern seed sources of Scotch pine (BROWN, 1969).

Table 2. — Averages and range in values for root characteristics of black cherry seedlings from different regions[1]).

Seedling Characteristic	Average Value for: Northern Origins	Average Value for: Central Origins	Average Value for: Southern Origins	Range in Values for: Northern Origins	Range in Values for: Central Origins	Range in Values for: Southern Origins	"F" Value
Top:							
Length, cm	22.5	22.6	32.0	20—26	18—28	29—44	4.1**
Weight, gm	0.85	0.87	2.07	0.73—1.10	0.71—1.16	1.62—2.69	3.1**
Buds, No.	14.3	15.5	30.9	13—16	14—19	23—49	3.3**
Internode Length, cm	1.53	1.49	1.26	1.2—1.7	1.1—1.7	1.1—1.4	2.7**
Wt./Unit Length, gm/cm	.036	.037	.052	.032—.040	.032—.041	.048—.056	2.6**
Sweep, cm[2])	2.8	1.4	1.0	1.2—4.4	0.9—2.3	1.6—2.4	1.3
Crooks, No.	1.9	2.0	2.5	1.2—2.3	1.2—3.0	2.2—3.2	2.1**
Roots:							
Tap Root:							
Length, cm	32.9	32.2	33.5	31—34	27—37	30—38	1.2
Weight, gm	1.52	1.50	2.83	1.2—2.7	1.3—2.0	2.1—5.2	4.0**
Wt./Unit Length, gm/cm	.048	.049	.088	.041—.052	.038—.057	.073—.143	3.4**
Major Lateral Roots[3])							
Length, cm	261	239	274	236—299	178—276	246—360	1.9*
Weight, gm	1.12	1.02	1.57	0.8—1.5	0.6—1.4	1.2—1.9	2.3**
Wt./Unit Length, gm/cm	.0039	.0044	.0055	.0032—.0049	.0024—.0063	.0046—.0067	1.7*
Fine Lateral Roots[4])							
Weight, gm	0.99	1.03	1.68	0.6—1.3	0.9—1.3	1.3—2.2	2.6**
Root Weight ÷ Top Weight	4.57	4.43	3.66	4.0—5.4	3.3—5.7	3.1—4.3	1.7*

[1]) Data for individual seed sources within regions may be obtained from the authors upon request.
[2]) Sweep: Total stem deviation from a straight central axis.
[3]) Major lateral roots: Identified as roots at least 5 centimeters long and branching at least two times.
[4]) Fine Lateral roots: Small, generally unsuberized roots; usually less than 5 centimeters long.
* Significant at the 5 percent level.
** Significant at the 1 percent level.

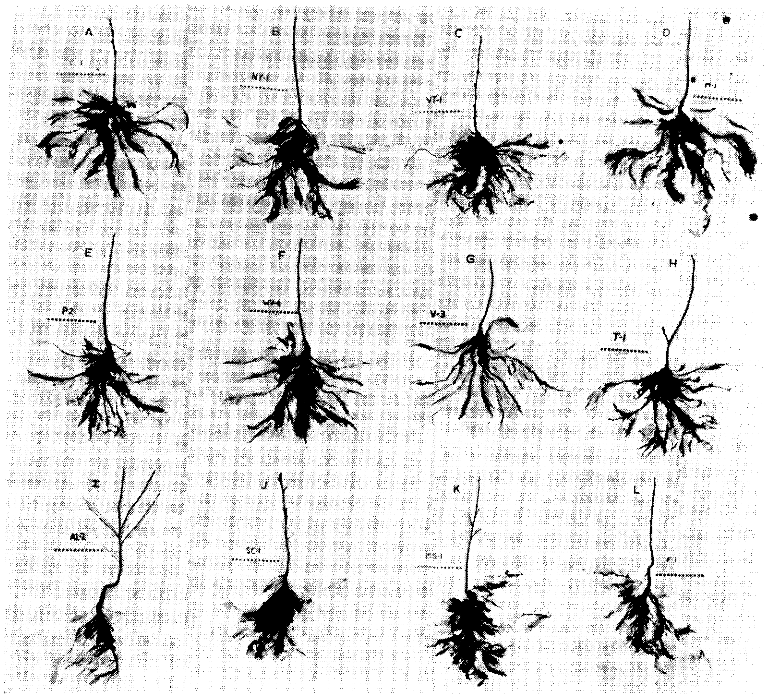

Figure 2. — Twelve-month old seedlings of different black cherry provenances: A. Canada-1; B. New York-1; C. Vermont-1; D. Michigan-1; E. Pennsylvania-2; F. West Virginia-4; G. Virginia-3; H. Tennessee-1; I. Alabama-2; J. South Carolina-1; K. Mississippi-1; and L. Florida-1.

Differences between different origins in top growth was great, with top lengths varying by nearly 150 percent and top weights by approximately 300 percent. As a group, lengths and weights of tops of the 8 southern origins were greater than those from other areas. There was considerable variation within the group, however, with no definite pattern or relationship to latitude, longitude or climate of the area of origin. Variation within the group of 22 origins from the central and northern portions of the range was even more indefinite. Variation in growth between individual origins was apparently completely random, with relatively fast as well as slow growing sources coming from throughout the area. There was no detectable relationship between top lengths and weights and latitude, elevation, or climate of the area of origin.

There were a greater number of lateral buds on tops of southern origins and the internode length between buds tended to be shorter for these sources than for those from central and northern areas. As a result, seedlings from southern areas were generally more branched in appearance. Seedlings of southern provenances also tended to have a greater number of crooks. However, the sweep or deviation from a straight central stem was greatest for seedlings from the northern portion of the species range.

As was the case with root systems, tops of southern seedlings were significantly heavier per unit length than those of sources from central and northern areas. This was apparently not caused by greater top diameters but probably resulted from greater density of woody material. Similar differences have been noted between northern and southern sources of slash pine (Goddard and Strickland, 1962) and loblolly pine (Zobel *et al.*, 1960).

As a group, root-shoot ratios calculated using seedling weights were most favorable (highest) for seed sources from the northern portion of the species range and least favorable (lowest) for seedlings of southern origins. These values may be somewhat misleading, however. Seedlings of southern provenances had larger amounts of fine, unsuberized roots. Although the weight of these roots is relatively small, total length would be great. The absorptive capacity of unsuberized roots has been found to be much greater than that for older, suberized roots (Kramer, 1946). As a result, the fine roots of southern source seedlings may thoroughly occupy the rooting zone, thereby greatly increasing the absorption of moisture and nutrients.

Abstract

Tops and root systems of seedlings of 30 provenances of black cherry from throughout the species range were studied after they had been grown from seed in the greenhouse for 9 to 12 months. Seedlings of 8 sources from the southern portion of the species range formed one group which were consistently similar in a number of characteristics, while the 22 origins from central and northern areas formed a second group also having similar characteristics.

Seedlings of all provenances had distinct, but relatively short tap roots. The major lateral roots of southern provenances were relatively small in diameter and a dense mass of fine roots proliferated from along the tap root. Seedlings from central and northern origins had several relatively large lateral roots and the number of fine roots was usually not so great as that on southern origins.

Tops of southern seedlings were generally longer, heavier and had a greater number of lateral buds than seedlings from central and northern seed sources. There was considerable variation within each group, however, with no detectable relationship to latitude, elevation, or climate of the area of origin.

The weight per unit length of tops, tap roots and major lateral roots were significantly greater for southern seedlings than for those from central and northern portions of the species range. This was apparently not caused by greater top and root diameters in the southern seedlings but rather probably resulted from greater density of woody material.

Zusammenfassung

Von *Prunus serotina* sind im Gewächshaus von 30 Samenherkünften aus dem gesamten Verbreitungsgebiet in Canada und den U.S.A. Pflanzen angezogen worden, die nach 9 bis 12 Monaten auf ihre Sproß- und Wurzelsysteme untersucht wurden. Es konnten 2 Gruppen von Herkünften unterschieden werden: (1) 8 Herkünfte aus dem südlichen Gebiet und (2) 22 Herkünfte aus den mittleren und nördlichen Gebieten, die jeweils ähnliche Merkmale aufwiesen. — Alle Provenienzen zeigten nur relativ kurze Pfahlwurzeln. Die Seitenwurzeln der südlichen Herkünfte waren relativ dünn, und von der Pfahlwurzel ging eine dichte Masse feiner Wurzeln aus. Die anderen Herkünfte hatten größere Seitenwurzeln, dagegen weniger feine Wurzeln. — Die Sprosse der südlichen Herkünfte waren im allgemeinen länger, kräftiger und hatten eine größere Anzahl Seitenknospen als die anderen. Innerhalb jeder Gruppe war die Variation erheblich; sie stand aber mit Breitengrad, Höhenlage oder Klima der Herkunft in keiner Beziehung. — Das Gewicht je Längeneinheit des Sprosses, der Pfahlwurzel und der größeren Seitenwurzeln war bei den südlichen Herkünften signifikant höher als bei den anderen. Verursacht wird dieser Unterschied bei der ersten Gruppe wahrscheinlich nur durch die größere Dichte des verholzten Materials.

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Altitudinal Variation in Photosynthesis, Growth, and Monoterpene Composition of Western White Pine (Pinus monticola Dougl.) Seedlings

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Introduction

Evidence for genetic differentiation within tree species is common but much less is known about the inheritance of morphological and physiological responses of species to environmental gradients, such as those found in mountainous topography. Many previous studies of intraspecific variation have involved widely separated portions of a species' range. The objective of this investigation was to determine the pattern of genetic variation among western white pine seedlings grown from seed collected at different elevations within four areas of northern Idaho — a small portion of the total range of the species. Northern Idaho is characterized by steep and broken topography, with wide climatic and altitudinal ranges and associated habitat variations. Western white pine occurs over a broad elevational belt from 1000 to 6000 feet, in irregular, often attenuated bodies following the more moist creek bottoms, lower benches and flats, and northerly slopes (Wellner, 1962). Thus there exists opportunity for selective forces to act upon populations separated by relatively short distances. The existence of local ecotypes in western white pine has been reported previously by Squillace and Bingham (1958).

The seed used in our work was collected from 24 parent trees located in altitudinal plots of one-half to one acre each (*Figure 1*). A portion of the seed was sown in the fall of 1965 in the Michigan State University Nursery at East Lansing. During 1968 and 1969 the following seedling characteristics were studied: (1) cortical oleoresin monoterpene concentrations; (2) photosynthesis and respiration; (3) total height and weekly growth throughout the growing season. The methodology and results of the three studies are reported here.

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Monoterpenes

Large differences in terpenoid levels both within and between plant species have stimulated their extensive use in biochemical systematic studies (Alston and Turner, 1963; Hanover and Furniss, 1966; and Zavarin *et al.*, 1966). Hanover (1966 a) demonstrated strong genetic control of *Pinus monticola* monoterpene concentrations, and suggested their use as markers for population genetic studies involving diverse environmental gradients.

In their study of cortical oleoresin in trees from 12 geographic sources of slash pine (*Pinus elliottii*), Squillace and Fisher (1966) found significant differences in myrcene, β-pinene, and β-phellandrene. Both β-pinene and β-phellandrene showed geographic variability patterns very similar to those expressed for height, needle length, and stomata number.

Tobolski and Hanover (1971) reported significant differences in 11 cortical monoterpenes collected from trees