"He - X/34" and "He - X/10" are the best, with respect D. B. H. growth, without significant differences among them, while clone "He - X/10" does not differ significantly from clones "I - 214" and "I - 262". Clone "I - 214" has been included in that particular test as a second control (PANETSOS 1979, in press). -

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Variation and Inheritance of Initial Shoot Growth Characteristics in White Oak[1])

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(Received January / April 1980)

Summary

Open-pollinated progeny from 15 clones in a seed orchard were used to evaluate genetic variance in epicotyl dormancy and early growth of white oak in the greenhouse. Epicotyl dormancy was induced by germinating seed at cool fall temperatures (10 - 15°C) and was subsequently broken by outdoor chilling until February. Average percents of seeds with normal shoot elongation were, respectively, 85, 53, and 87 for samples moved to a greenhouse in October, November, and February. Family variance in percent epicotyl dormancy ranged from 27 percent of total variance in seed germinated in the greenhouse in October to 15 and 16 percent for plants germinated out-of-doors and moved to the greenhouse in November and February, respectively. Total leaf area on the initial flush of shoot elongation varied widely among families, was under strong genetic control, and was positively correlated with dry weight of four-month-old seedlings (genetic correlation coefficient = .91).

Key words: epicotyl dormancy, leaf area/shoot growth correlations, container stock production.

Zusammenfassung

Titel: Variation und Vererbung von Eigenschaften des Beginns des Sproßwachstums von *Quercus alba*.

Frei abgeblühte Nachkommenschaften von 15 Samenplantagenklonen wurden benutzt, um die genetische Varianz der Epikotyl-Ruhe und des Früwachstums von *Q. alba* im Gewächshaus zu bewerten. Die Epikotyl-Ruhe wurde durch Keimen von Saatgut bei kühlen Herbsttemperaturen (10 - 15° C) induziert und durch Stratifizieren im Freien bis Februar gebrochen. Die mittleren Samenprozente mit normaler Sproßdeckung lagen bei 85, 53 und 87, wenn sie im Oktober, November und Februar ins Gewächshaus gebracht wurden. Die Familienvarianz in Prozent ruhender Epikotyle rangierte von 27 % der Gesamtvarianz bei Samen, die im Oktober im Gewächshaus gekeimt waren bis 15 und 16 % bei Pflanzen, die im Freiland gekeimt und im November und Februar ins Gewächshaus gebracht worden waren. Die Gesamtblattfläche des ersten Schubs der Sproßstreckung variiert zwischen Familien in weitem Rahmen, steht unter strenger genetischer Kontrolle und war positiv mit dem Trockengewicht vier Monate alter Sämlinge korreliert (genetischer Korr. Koeffizient = 0,91).

Introduction

Recent observations of white oak (*Quercus alba* L.) germination (FARMER, 1977) and early growth (FARMER, 1980) suggest that epicotyl dormancy and initial leaf area may substantially influence the speed of container or bareroot stock production. Epicotyl dormancy, apparently induced by fall germination temperatures (10 - 15°C), must be considered in growing container stock from fall collected seed since it is closely related to shoot elongation potential (FARMER, 1977). In interspecific comparisons of oaks, initial leaf area has been shown to be positively related to first year growth (FARMER, 1980). Therefore, genetic differences in these characteristics may give opportunities for quick, inexpensive improvement of early growth. This test is an evaluation of variation in initial shoot characteristics among open-pollinated progeny of grafted clones in a southern Appalachian breeding population of white oak.

[1]) This is a U. S. Government publication and is not subject to copyright.

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Methods

Seed were collected in mid-October 1977 from three ramets of 10 clones and from 2 ramets of 5 clones in a 10-year-old one-acre orchard near Norris, Tennessee. The orchard planting design included completely random location of ramets. Immediately after collection, nine 15-cm pots filled with a peat-perlite (1:1) potting mixture were each planted with 10 seeds from one of the 40 ramets. Three of these nine pots (replicates representing a single ramet) were placed in a greenhouse immediately after planting on October 18. Pots of the remaining six replicates were placed in a lathhouse where they were covered with sawdust to prevent freezing. On November 23, 1977, and on February 12, 1978, three replicates were moved from the lathhouse to the greenhouse. Prior experience (FARMER 1977) indicated that a November sample would have a relatively high percentage of dormant epicotyls, and chilling required for normal shoot growth would be completed by February.

Pots in each of the three samples (October, November, February) were arranged randomly on a single greenhouse bench; during the test period, pots were under an 18-hour photoperiod at a temperature of 18 - 27°C. Temperatures were about the same during shoot elongation periods for each sample. Shoot emergence was recorded daily, and after the initial flush of shoot elongation was completed, each plant was examined and its shoot classified as normal or showing epicotyl dormancy (i. e., elongation less than 7 cm and failure to develop leaves). In the October and February samples, shoot length and total length of all leaves were measured on three normal plants per pot after the initial shoot elongation and leaf maturation. After these measurements, all but one plant per pot in the October and February samples were removed; the remaining plant was grown until late May 1978 and harvested for measuring shoot and leaf characteristics and ovendry weight. Growth of plants in the November sample was not studied due to insufficient numbers with normal shoot elongation.

Samples of leaves were harvested and photocopied and their areas were determined by planimetry. The regression of $\log_{10}$ leaf area on $\log_{10}$ leaf length, which had an r^2 of .87, was computed and used to determine leaf area of all measured plants.

The analysis of variance outlined in Table 1 was used to evaluate the relative contribution of parent clone, ramets within parents, and within ramet differences to total variance in germinaton and growth characterstics.

Results

An average of 85 percent of the unchilled seed placed in the greenhouse in October exhibited one flush of normal shoot elongation and leaf development *(Table 1)*. Parent clones and ramets within parents were significant sources of variation in this percentage, with families having from 56 to 95 percent normal shoots. As in a previous study (FARMER, 1977), seed incubated at lower out-of-door temperatures until November had a reduced percentage of normal shoots (53 vs. 85) when removed to the green-

Table 1. — Shoot characteristics of white oak grown in October, November, and February.

Parent Number	Percent Normal Shoot Elongation			Leaf Area on Initial Flush, cm²		Number Leaves on Initial Flush		Shoot Length of First Flush, cm		
	October	November	February	October	February	October	February	October	February	
00	71	45	77	133	105	5	5	15	13	
01	87	61	88	137	109	5	5	16	16	
14	93	38	87	196	119	5	5	16	14	
18	95	45	82	154	115	5	5	16	15	
51	80	58	85	172	132	6	5	17	16	
53	86	52	73	158	101	5	4	16	14	
55	89	47	91	105	92	4	5	15	14	
57	74	38	90	142	107	5	5	16	15	
71	88	66	97	132	121	5	5	15	15	
72	56	64	82	60	52	4	4	11	11	
75	86	37	90	110	82	5	5	16	14	
81	93	66	90	146	109	5	4	16	15	
82	93	76	99	166	148	5	5	16	16	
84	90	60	86	150	127	5	5	17	16	
86	90	38	92	110	92	4	4	14	15	
Mean	85	53	87	138	107	4.9	4.7	15	15	
	Variance Components Expressed As Percent of Total Variance									Expected Mean Square
Parent	27*	15*	16*	66*	61*	40*	20*	46*	44*	$\frac{\sigma^2_W}{K} + \sigma^2_P + 3\sigma^2_R + 7.98\sigma^2_C$
Ramet/ Parent	17*	11	11	12*	6	3	11	6	8	$\frac{\sigma^2_W}{K} + \sigma^2_P + 3\sigma^2_R$
Pots/ Ramet	56	74	73	5	3	26	33	30	3	$\frac{\sigma^2_W}{K} + \sigma^2_P$
Within Pots[1]	—	—	—	17	31	31	36	18	45	$\frac{\sigma^2_W}{K}$

* Source of variation significant at .05 level of probability.

[1] Computed with data from every tenth pot via $\frac{\sigma^2_W}{K}$ where K = harmonic mean of plants per plot.

Table 2. — Growth characteristics of white oak seedlings established in October 1977 and February 1978 and grown until June 1978.

Parent Number	Established in October: Ovendry Weight, g	Leaf Area, cm^2	Shoot/Root	Established in February: Ovendry Weight, g	Leaf Area, cm^2	Shoot/Root
00	4.17	163	.38	3.33	317	1.27
01	4.68	229	.42	2.96	218	1.11
14	8.62	251	.28	4.15	354	1.06
18	5.72	200	.29	2.87	174	.83
51	5.76	260	.42	4.26	378	1.45
53	3.81	149	.35	3.52	269	1.13
55	3.93	187	.48	2.60	271	1.43
57	2.84	94	.59	3.20	247	1.07
71	5.85	362	.63	3.30	347	1.44
72	2.03	93	.43	1.51	135	1.34
75	3.09	177	.48	2.29	153	1.14
81	5.09	214	.58	3.62	328	1.14
82	7.04	416	.69	4.44	417	1.41
84	6.41	422	.64	3.84	295	1.14
86	3.45	199	.42	2.52	252	1.37
Mean	4.83	228	.49	3.23	279	1.21

Source of Variance	Percent of Variance			Expected Mean Square
Parent	30*	33*	14*	$\sigma^2 + 3\sigma^2_R + 7.89\sigma^2_C$
Ramet/Parent	11	10	0	$\sigma^2 + 3\sigma^2_R$
Within ramets	59	57	86	σ^2

*Source of variation significant at the .05 level of probability.

house, though all seed in this sample exhibited root growth during lathhouse storage. Plants chilled until February had an average of 87 percent normal shoots. Family variance in proportion of normal shoots was 15 to 27 percent of total variance, depending upon sample date. In November, family means ranged from 37 to 76 percent; the family range was less in October and February, with 12 of the 15 families having over 80 percent normal shoots.

After the first flush, leaf area was slightly but significantly (.05 level) lower in the February sample than in October. However, there were major differences in leaf area among families which accounted for over 60 percent of the total variance. Family variance was also significant for leaf number and shoot length, though the ranges in family means were not as large as for leaf area. Ramets within parents accounted for a small percentage of variance, and ramet effects were statistically significant only for October leaf area.

Less than 10 percent of plants left in the greenhouse from October 1977 to May 1978 showed a second flush of normal growth *(Table 2)*. Many lost apical dominance in April and developed lateral shoots with normal leaves, giving a bushy appearance to these plants. Almost all plants starting shoot growth in February showed two flushes by May. Family differences accounted for about 30 percent of the variance in final weight and leaf area of the February sample, while variance associated with ramets within parents was nonsignificant.

The large variance in leaf area and ovendry weight was accompanied by strong correlations between these two characteristics. Simple correlations of family means had a coefficient of .88 for leaf area versus plant weight at the May harvest, and a coefficient of .92 for leaf area after first flush versus harvest weight. The correlation of family means for first flush leaf area of the October sample versus May weight of the February sample had a coefficient of .91. The genetic correlation coefficient was .91 for the relationship between first flush leaf area and the May weight of the February sample; the phenotypic correlation coefficient for individual plant values was .55.

Conclusions

Data from this study show substantial variation among open-pollinated families in the degree of epicotyl dormancy. They also support the hypothesis that seed germinated before chilling in the fall have only a single flush of normal shoot elongation under long photoperiods in the greenhouse. Total leaf area on this initial flush of shoot elongation is widely variable, under strong genetic control, and highly correlated with early growth. Leaf area seems more related to individual leaf size than to number of leaves per plant. There is little variance among ramets within clones (i. e., environmental preconditioning) for any of the germination and growth characteristics.

In this orchard, selection of open-poliinated families with leaf areas around 40 percent greater than the test mean produced four-month-old seedlings, 30 percent heavier than the test mean weight. However, when the family variance accounts for over 30 percent of total variance computation of narrow-sense heritabilities (assuming family variance as one quarter of additive variance) would give heritabilities of over 1.0 and is probably not appropriate in computing genetic gain. It is, nevertheless, clear that substantial gains in early growth can be made through selection based on leaf area immediately after the first flush of shoot elongation.

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