Selection of New Poplar clones under various Spacings

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Summary

New poplar clones, selected within the best families derived from controlled pollination among native and introduced poplars, undergo a second phase of selection in the nursery stage, and a final one in the field. The design used for field test, provides evaluation of clone performance under competition and without competition.

Data on height and D.B.H. obtained at the end of the sixth year's growth, showed that competition masks the expression of these characters in certain clones, while under non competitive conditions the same clones would have been selected as satisfactory to excellent. Competitive ability should be under genetic control and it is an independent variable from growth rate. Tree breeders, especially when they are working with poplars, should consider competition as a factor that may seriously affect the effectiveness of selection.

Key words: New poplar clones, spacing, competition, selection.

Zusammenfassung

Neue Pappelklone aus den besten aus kontrollierten Kreuzungen entstandenen Familien zwischen einheimischen und eingeführten Pappeln unterliegen einer zweiten Selektion im Baumschulstadium und einer Schlußselektion im Feldversuch.

Der benutzte Feldversuchsplan erlaubt die Bewertung des Klonverhaltens mit und ohne Konkurrenz.

Ergebnisse über die Höhe und den BHD nach sechs Jahren beweisen, daß Konkurrenz die Ausprägung dieser Eigenschaften bei bestimmten Klonen überdeckt, während unter Bedingungen ohne Konkurrenz die gleichen Klone als zufriedenstellend bis ausgezeichnet ausgelesen worden wären. Konkurrenzfähigkeit scheint genetisch kontrolliert zu sein und ist eine von der Wuchsgeschwindigkeit unabhängige Variable. Insbesondere Pappelzüchter sollten den Konkurrenzeffekt als Faktor berücksichtigen, weil er die Wirkung der Selektion ernstlich beeinflussen kann.

Introduction

Poplar cultivation has greatly expanded since the release of fast growing Italien clones. In Greece the share of wood production from poplars equals about fifty per cent of the total timber coming out of the natural forests of the country (Garyphalos, 1976). The clones used in planting is mainly the well-known „I - 214", while some others of the same origin as „I - 262" and „I - 455" are planted in limited number.

This almost monoclonal cultivation is due to the growth superiority, wood quality, good form and astonishing plasticity exhibiting by the above mentioned clone. The risks, however, of such culture are obvious and the use of new clones with comparable merits has been considered as a matter of priority for partial substitution of clone „I-214" or in establishing mixed plantations. In this connection, besides introduction and testing of new clones, a breeding programme was initiated since 1965 one of its objectives being the selection of new clones from families, originating from controlled pollination among native and introduced poplars (Panetsos, 1967).

Individuals selected from the best families, were vegetatively propagated and tested for a second phase selection at the nursery stage (Panetsos, 1973). The best of them were outplanted in replicated field tests for final selection in areas where active poplar cultivation is practiced. This test is considered as the most critical one and the experimental design should be such that assesses the best conditions for selection. Two main factors affect the performance of individual plants: competition and soil heterogeneity (Fasoulas, 1979). Testing, therefore, poplar clones should use such a design so that it would be possible to gather information of how competition interferes with individual plant growth, a character of primary importance for selection, and also to provide means for assessing the performance of the new clones, under competition and without competition, and at the same time to minimize soil heterogeneity. In this paper results are presented which were obtained from a field test with seven clones in five spacings, six years after planting.

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Material and methods

Two year rooted plants, raised in the nursery from cuttings, were used for the establishment of a test plantation of seven clones. Six of the clones were new selections from our breeding programme, and the seventh was clone „I - 262" which served as control. The new clones came from a combined selection both between and within families and are the following:

A/a	Clone id.	Origin	Sex
1	He[1]- A/87	*Populus deltoides* var. *missouriensis* × *P. nigra* var *pubescens* (Parlat)	♂
2	He - Z/17	*P. deltoides var. missiouriensis* × *P. nigra* (Katerini)[2]	♀
3	He - Z/32	Same combination as above	♀
4	He - X/10	*P. deltoides* var. *missouriensis* × *P. "italica"*	♀
5	He - X/34	" "	♀
6	He - X/3	" "	♀

1. "He" stands for Hellas (Greece).
2. Pyramidal form growing in north Greece.

The planting site, which is located in the valley of Thessaly, had been in pasture for several years. Before plantation, the area was pan plowed to a depth of 50-60 cm and then disked. The soil comes from solonetz-like alluvial sediments, with not good draining, high level of ground water, with free carbonates and PH ranging from

6,6 - 7,7. This kind of soil is not considered very suitable for poplar culture.

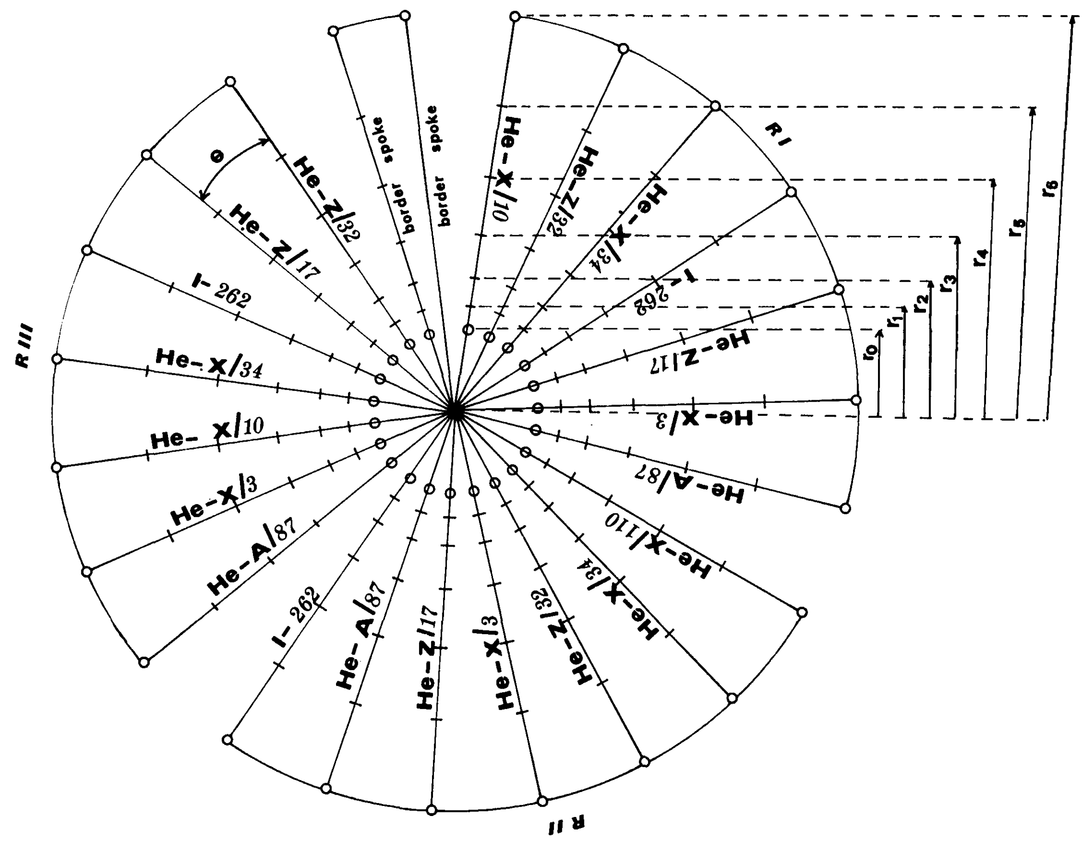
The plantation was established in spring 1972, the same day the plants were taken out of the nursery, in 50 to 60 cm deep holes and in a design developed by NELDER (1962) for spacing experiments. The application of the design was realized by following NAMKOONG's (1965) computations of planting points, for different densities and growing space shape, which appears in *figure 1*. It consists of a circle with 23 radii (spokes) and seven planting points per spoke (plot). The within spoke spacing equals that between spokes at any planting point. Each clone was planted in 5 different spacings along the spoke, while the innermost and the outer tree served as border trees. In this way each one of the seven clones was randomised within each block of seven spokes and was replicated three times. The 22nd and 23rd radii served as border plots. The design used permits simultaneous test of the seven clones in five spacings. As it can be seen in *figure 1* and *table 1*, the spacings used represent the most common ones applied today in poplar cultivation.

After planting, care was taken that the experimental site be kept clear of any vegetation by disking and hoeing in close intervals during the growth period. The plantation was irrigated systematically from the year the test was established until the last data was obtained. All trees were evenly pruned and care was taken in keeping one main leader. There was no use of any fertilizer or pesticide. At the end of each growing period the height of all trees and diameter at breast height (D. B. H.) were measured and recorded, with precision of 0.2 m and 0.1 cm respectively. Also recorded was the time of leafing, stem form, attacks of any kind and finally the sex of the individual clones.

Results and discussion

Survival six years after planting was 100 per cent for all clones in the test, due to the quality of the planting material, the care taken during the plantation and afterwards, until the last measurement. Considering, that the testing area is only about 2.500 m² on a soil of the same origin more or less homogeneous, the number of clones tested, the origin of the planting material, the uniformity of the care taken, and that the three replications did not show significant differences, then the one tree plot per clone and spacing in three replications should be accepted as satisfactory sample for the purpose of this experiment.

From the measurements recorded only height and D. B. H. of the third and sixth year are given, because by the end of the third year the effect of competition has been



0 Border plants
\+ Experimental plants
Θ = 15.83°, constant angle between adjacent spokes.
r_0 = 5.414 m, r_1 = 7.125 m, r_2 = 9.377 m, r_3 = 12.339 m, r_4 = 16.239 m,
r_5 = 21.370 m, r_6 = 28.123 m, successive radial distances, computed by the basing formula, $r_n = r_0 a^n$. a = 1.316, constant, and r_0 = 5.414, the radial distance of the starting plant in each spoke.
(In R II: He — X/110 should read He — X/10)

Figure 1. — Circular design with three blocks of seven spokes, one clone per spoke with seven plants (2 border and 5 experimental plants). The shape of the growing space available for each plant is the same throughout the whole circular plot. The plants at different spokes but at the same radius have equal spacing (scale 1:400).

expressed, while by the sixth year its pattern of evolution can be seen. It should be noticed that the design of the experiment — one spoke one clone — calls for competition between genotypes (clones) of the adjacent radii, and density effect within spoke, since in the same spoke all the trees are of the same genotype. According to SAKAI (1972) "little effect of competition is observed between trees of the same clone or of the same genotype". Moreover, growth characteristics at the sixth year, for euramerican poplar clones, represent growth of about half rotation time, and could be used as reliable estimates of clone performance for selection purposes.

Mean heights and diameters of all clones by spacing, at the end of the third and sixth year's growth, are shown in *table 1*. The results from the analyses of variance, computed on single plant data, are given in *table 2*. The individual clone performance, for height and diameter in relation to spacing, and also the evaluation of clones to each spacing separately, are presented in *figures 3, 4,* and *5.* The performance of the clones, with respect to height at

Table 1. — Mean height and breast height diameter, of the three replications for each clone and spacing, at the end of the third and sixth year's growth

Clone / Spacings	He - X/10 (1)		He - X/3 (2)		He - Z/17 (3)		He - X/34 (4)		He - A/87 (5)		I -262 (6)		He - Z/32 (7)	
	Height (m)	D.B.H. (cm)	Height (m)	D.B.H. (cm)	Height (m)	D.B.H. (cm)	Height (m)	D.B.H. (cm)	Height (m)	D.B.H. (cm)	Height (m)	D.B.H. (cm)	Height (m)	D.B.H. (cm)
A. Third year														
a. 3,93 m^2	13.2	12.5	12.9	11.5	11.9	10.4	12.3	10.1	12.1	9.0	11.3	8.7	12.5	8.4
b. 6,80 m^2	13.4	14.2	13.1	12.8	12.6	13.6	12.3	13.0	12.9	10.6	12.6	12.1	11.9	9.0
c. 11,76 m^2	13.3	15.2	12.3	14.3	13.0	16.2	12.6	13.9	11.9	12.8	12.8	13.8	12.2	9.7
d. 20,38 m^2	12.8	16.6	12.6	15.4	11.6	16.6	12.2	16.6	11.3	13.7	12.6	15.5	12.3	11.6
e. 35,30	13.5	16.5	11.7	16.6	12.6	18.8	11.0	17.7	10.4	14.5	11.7	16.6	11.6	11.5
B. Sixth year														
a. 3,93 m^2	20.3	19.0	17.9	17.2	17.1	12.8	18.4	15.6	16.9	11.4	16.4	10.6	16.8	11.4
b. 6,80 m^2	20.6	21.8	20.1	20.9	19.0	19.6	18.8	19.6	18.8	15.0	19.1	18.0	17.6	12.6
c. 11,76 m^2	20.5	25.0	20.2	24.0	19.5	25.4	19.4	23.5	19.6	19.4	19.5	21.7	17.9	14.7
d. 20,38 m^2	19.9	27.0	19.1	26.3	18.7	26.3	19.2	27.7	18.6	22.4	19.5	25.7	18.2	18.9
e. 35,30 m^2	18.6	28.6	18.0	28.3	18.5	30.0	18.0	29.7	17.8	24.5	18.4	27.0	16.6	19.0

Figure 2. — Portion of the design, showing one complete spoke of clone "He — X/10". It can be seen the differences in D.B.H. related to spacing. From the seven plants in the spoke the outermost and the inner one are border plants.

Table 2. — Analysis of variance: for height and diameter at breast height (D.B.H.)

Source of variation	Degrees of freedom	Mean square Height 6-year	Mean square Diameter 3-year	Mean square Diameter 6-year
Blocks	2	0,22 NS	12,87**	4,45 NS
Treatments	34	3,70**	24,38**	98,34**
Clones	6	8,82**	48,21**	157,46**
Spacings	4	12,91**	122,78**	558,66**
Clone X Spacing	24	0,88 NS	2,02*	6,84**
Error	68	0,63	1,08	2,79

* Significant at the 5% level
** Significant at the 1% level
NS Non significant

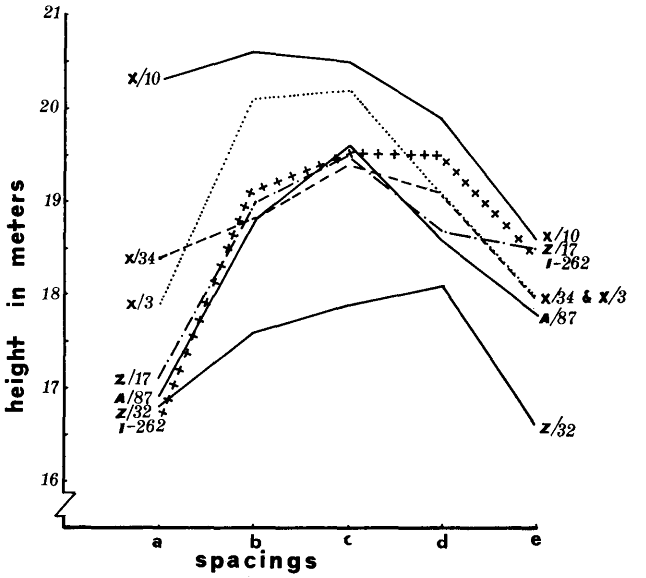


Figure 3. — Height by clone and spacing, at the end of sixth year's growth.

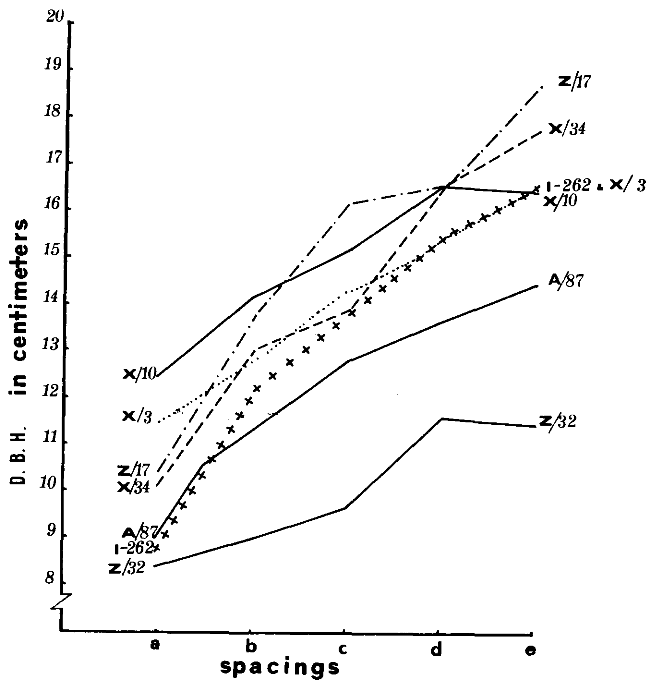


Figure 4. — D.B.H. by clone and spacing, at the end of third year's growth

the third year, is not presented, since no significant differences were found between clones, or within clones related to spacing. It appears that by the third year there is no significant differentiation among clones on their height growth potentialities and also that competition due to spacing does not affect height in this age. This finding is in agreement with SAKAI's (1972) conclusion, concerning the effect of competition on height growth of forest trees, and also with KRINARD and JOHNSON (1975) who report that height growth of cottonwood appeared unrelated to spacing. However, by the sixth year, the analysis performed *(table 2)* shows significant differences between trees of the same clone, and also among clones, but no clone × spacing interaction, which indicates that all seven clones behave in the same manner to competition related to spacing. The general trend which appears is that trees at the medium spacing are taller than the ones at close and wide spacings. This behaviour of all clones in the test, shows that competition can stimulate height growth to a certain level, after which its effect is suppressing, as in this case on spacing 3.93 m^2. It is anticipated that later on, inhibition on height growth due to competition, can appear on wider spacings too. The lack of interaction between clones and spacing, with respect to height, makes selection effective regardless of spacing if the only criterion is just height. It should, however, be taken into consideration from the results obtained, that height at early age does not express the potentialities of poplar clones on that particular character.

As far as diameter is concerned, significant differences were found between clones, even in the third year after planting. These differences remain almost the same in the sixth year. Selection, therefore, of the best clones for this particular character can be effective as early as three years after the establishment of the test. Considering,

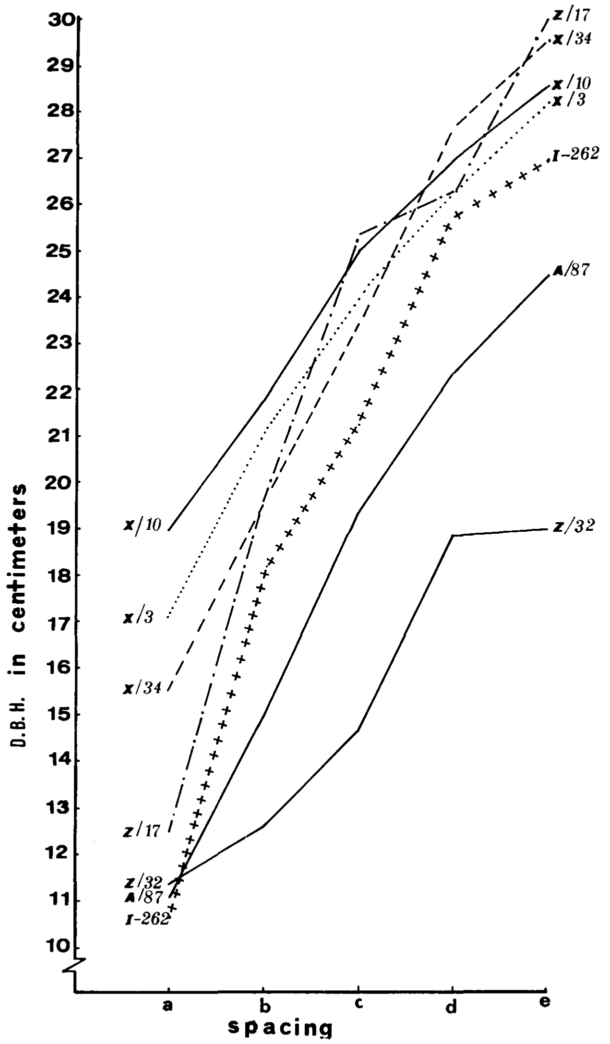


Figure 5. — D.B.H. by clone and spacing, at the end of sixth year's growth.

however, that yield is a combined character of height and diameter of the tree, then selection will be more efficient in the sixth year.

Diameters of trees within clones, i. e. trees growing in the same spoke but at different spacing, were significant affected in the third year. This differentiation related to spacing became more severe in the sixth year, so that in most of the clones only trees growing in the two wider spacings were not significantly affected at that age (*Table 2*).

The most important finding, however, in this experiment is the reaction of the individual clones, with respect to diameter growth, under various spacings. The analysis performed showed significant interaction of clone × spacing in the third year, which by the sixth year became highly significant. It appears, therefore, that under the impact of competition, due to spacing, clones are affected differently and consequently the superiority of a clone in a particular spacing might be not so in another. This can be seen clearly in *figure 5*. To be more specific, if selection for D. B. H. was applied, in a test plantation of 3.93 m^2 spacing, clone "He-X/10" would have been selected as the best among the seven clones of that test. If, however, the same criterion was used for selection of the same clones in a test of 35.30 m^2 spacing, then clone "He-Z/17" would have been selected as the best, which in the first case has been evaluated as slow growing. It is anticipated that later on, as the plantation grows, the competition will become more severe, even for middle spacings, and the differences in behaviour more and more pronounced.

The question arises then, and it is a critical one: can we select in poplar breeding efficiently under competition, when the selections are destined to be cultivated in wide spacings, as is the usual practice in many countries today? or vice versa, can we select without competition and then use these clones for dense plantations? There is yet another question. What is going to be the behaviour of a clone when it grows best under competition, as clones "He-X/10" and "X/3" in this experiment, if it is planted in monoclonal plantations of close spacing?

To the questions raised above, from the results obtained, we may give some reasonable answers to the first two but not to the third one. a. Selecting under competition is not an efficient procedure, because valuable clones can be discarded if the selections are destined to be planted in wide spacings. b. Selecting the best clones in a test without competition, is the most efficient operation, if the clones selected are going to be planted in wide spacing. The use, however, of the same clones in dense plantations can be a misleading procedure, since the results of this experiment have shown the existence of clones sensitive and insensitive to competition due to spacing. It is, therefore, a matter of chance in such a test, for a clone to be selected which combines growth merits and competitive ability, or a clone with excellent growth rate but being a poor competitor.

The behaviour of the clones as it has been discussed to this point, indicates that competitive ability of a clone (genotype) should be under genetic control and also it is an independent variable from growth rate. This inference comes in agreement with what Sakai (1972) has stated: "Competitive ability of individual trees is a character controlled by genes which are assumed to be genetically independent from genes controlling characters such as height, growth rate etc".

In spacing experiments with F_2 plants of wheat, for selection purposes, Fasoulas (1978) arrived to the following conclusions, which are quite comparable with what has been stated in this discussion.

a. Interplant competition renders selection completely ineffective and b. Selection in the absence of competition was extremely effective and progress made ranged from 17 to 19 per cent. He attributes his findings to the fact that competition suppresses the expression of the genotypes, while under non competitive conditions genotypic differentiation is allowed to be manifested, maximizing effectiveness of selection.

An answer to the third question, i. e. behaviour of clones under density has significant economic implications, because if it is the case that good competitors are also able to grow well under monoclonal close spacings, then by using the proper clone, especially in short rotation plantations, wood production per unit area can be maximized.

The results presented, concerning the performance of individual clones without competition, are in full agreement with those obtained from a similar test at the same age, but established in a randomized complete block design with four replications of six plants per plot, at spacing 6 × 6 meters, in northeastern Greece. Clones "He - X/3", "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). -

References

FASOULAS, A. K.: Selection for yield in the absence of the masking effects of competition and soil heterogeneity, XIV International Congress of Genetics, Abstracts, Part II, Sections 21—32 Moscow, (1978). — FASOULAS, A. K.: The Honeycomb Field Designs. Depart. of Gen. and plant bred. Ar. Un. of Thessloniki, Greece. Pub. No. 9, 69 pp. (1979). — GARYPHALOS, I.: For an overall utilization of poplar wood. Dassika chronica. 10—11: 266—271 (1976). — KRINARD, R. M., and R. L. JOHNSON: Ten-Year results in a cottonwood plantation spacing study. U. S. Dep. Agr. For. Ser. Res. Pap. SO - 106, 10 pp. (1975). — NAMKOONG, G.: Application of Nelder's designs in tree improvement research. N. Car. Agr. Exp. Station. Pap. No. 2021, (1965). — NELDER, J. A.: New kinds of systematic designs for spacing experiments. Biometrics. 18: 283—307 (1962). — PANETSOS, C. P.: Artificial hybrids between the native(*Populus nigra* L. *var. pubescens* Parlat) and introduced clones and species. Publ. of the For. Res. Inst. Athens. No. 18, 44 pp. (1967). — PANETSOS, C. P.: Breeding of poplars in Greece. Annals of the Ar. Un. of Thessaloniki, IE (B): 179—188 (1973). — PANETSOS, C. P.: Greek poplar clones, growth-shape-adaption. Annals of the Ar. Un. of Thessaloniki, School of Agr. and For. (1979 in press). — SAKAI, K. I.: Problems of selection in forest trees. Paper presented to workshop in applications of quant. gen. to forestry, Tokyo. (1972).

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

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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 bare-root 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.

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