being smaller are genetically superior and that early results can be misleading.

Key words: Multiple-trait breeding, progeny tests, early tests, heritability.

Zusammenfassung

Auswirkungen klassischen Waldbaus auf die genetische Qualität der Nachkommenschaft.

Im Jahre 1914 begründete BUSSE einen vollständigen Blockversuch mit Kiefern-Nachkommenschaften, die von Elternbeständen verschiedener Altersklassen abstammten, die aber hinsichtlich ihrer Provenienz, ihres Standortes usw. identisch gewesen waren. In früheren Jahren wuchsen die Nachkommenschaften junger Mutterbestände besser, doch jetzt nach 59 Jahren ist das Gegenteil der Fall. Dies zeigt, daß die traditionelle Durchforstungspraxis einen genetischen Gewinn gebracht hat, der sich bei der Nachkommenschaft in einer Verbesserung des Stamm-Durchmessers und in der Grundfläche je ha äußert. Die Heritabilität des Umfanges scheint nicht geringer als 0,25 zu sein, und dies Merkmal ist ganz ähnlich dem, das bei den klassischen Durchforstungsmaßnahmen zugrunde gelegt wurde. Diese Ergebnisse zeigen, daß Saatgut von älteren Beständen trotz seiner geringeren Masse genetisch aber besser ist und daß eine zu frühzeitige Beurteilung solcher Versuchsergebnisse zu Mißdeutungen führen können.

Literature Cited

BUSSE, J.: Welchen Einfluß übt das Alter der Mutterkiefer auf die Nachkommenschaft aus? Zeitsch. Forst- u. Jagdw. 56 (5), 257—286 (1924). — BUSSE, J.: Einfluß des Alters der Mutterkiefer auf ihre Nachkommenschaft. Mitt. Deutsch. Dendrol. Ges. 43, 61—74 (1931). — DUNCAN, D. B.: Multiple range and multiple F tests. Biometrics 11, 1—42 (1955). — FISHER, R. A.: The design of experiments. Ed. 2. Oliver and Boyd, Edinburgh, 1937. — HUMMEL, F. C.: The volume-basal area line. For. Comm. Bull. 24, 1955. — NAMKOONG, G., ancl SNYDER, E. B.: Accurate values for selection intensities. Silv. Genet. 18, 172—173 (1969). — NANSON, A.: La valeur des tests precoces dans la sélection des arbres forestiers en particulier au point de vue de la croissance. Station de Recherches des Eaux et Forêts, Groenendaal-Hoeilaart (Dissertation, 1968). — SCHWAPPACH: Ertragstafeln der wichtigeren Holzarten. 4th ed. Vereinigung der Forstverwaltungen im Protektorat Böhmen und Mähren. Prag, Verlag „Merkur", 1943. TODA, R.: Heritability problems in forest genetics. IUFRO Genetics-SABRAO Joint Symposia Proceedings, Tokyo, A-3 (I), 1-9 (1972). — WILUSZ, W.: The influence of stand age on the quality of 50 years old Pinus *silvestris* progeny. Arboretum Kornickie 11, 259—266 (1966).

Hypocotyl Length in Pinus caribaea Seedlings: A Quantitative Genetic Variation Parameter

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Introduction

Estimation of genetic variability is one of the most urgent needs in subtropical and tropical tree species. Although vast gene pools still exist for many of these species, wild populations are under the constant threat of rapidly being reduced by slash and burn agriculture, selective cutting, etc., with the subsequent loss of genes and combinations that have been built up over the years through mutation and selection (GOMEZ-POMPA, VÁZQUEZ-YANES, and GUEVARA, 1972).

Currently, organized International Provenance trials are being under-taken throughout the subtropics, and within a relatively short period tree geneticist will be forced to select from among the provenances those seed sources considered to be best adapted to their country's environments (KEMP, 1973). Although the traditional parameters of height, diameter, stem form, volume, etc. must obviously be taken into consideration when selecting provenances for introduction into a country, these parameters should be considered as final objectives only when no follow-through, long-term breeding program is contemplated. Tree geneticists need accurate estimates of the relative genetic variability between provenances, and perhaps even more important they need to better understand the regulatory mechanisms of multiple inheritance traits.

Determination and classification of genetic variation can be done only if quantitative and/or qualitative differences can be detected among populations or individuals. Detection of genetic variation, of course, can be done at any level of organization in the individuals studied but the geneticist must recognize and compensate for the amount of wobble between the different levels of organization studied.

The nursery stage presents an excellent opportunity to measure genetic differences between provenances since the seedlings are exposed to approximately uniform conditions. Randomization and replication of the nursery plots can help to reduce error resulting from environmental bias.

The occurence of Pinus caribaea over a wide range of diverse habitats indicates that this species is highly adaptable and clinal gradations with genetic differences should be detectable among sub-populations. One of the current tenets of populations genetics is that populations with greater amounts of genetic variability are better able to adapt to changing habitats. Thus, it is important that genetic differences be detected for adaptive study.

Several reports have emphasized the general morphological variability of P. caribaea and in particular var. hondurensis, (LÜCKHOFF, 1962; NIKLES, 1971; and KEMP, 1973). However, few quantitative and qualitative genetic parameters have been described for this species. I have reported that seedling hypocotyls are polymorphic for the colors green and purple (in preparation, 1974).

In this report evidence will be given for variation of hypocotyl length among 16 provenances of the 3 varieties of *Pinus* caribaea.

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Materials and Methods

Sixteen seed sources of the Oxford *Pinus caribaea* International Provenance Trial were tested in Puerto Rico. Thirteen provenances came from Central America, 2 provenances came from Cuba, and 1 provenance came from Andros Island of the Bahama Islands (*Figure 1*).

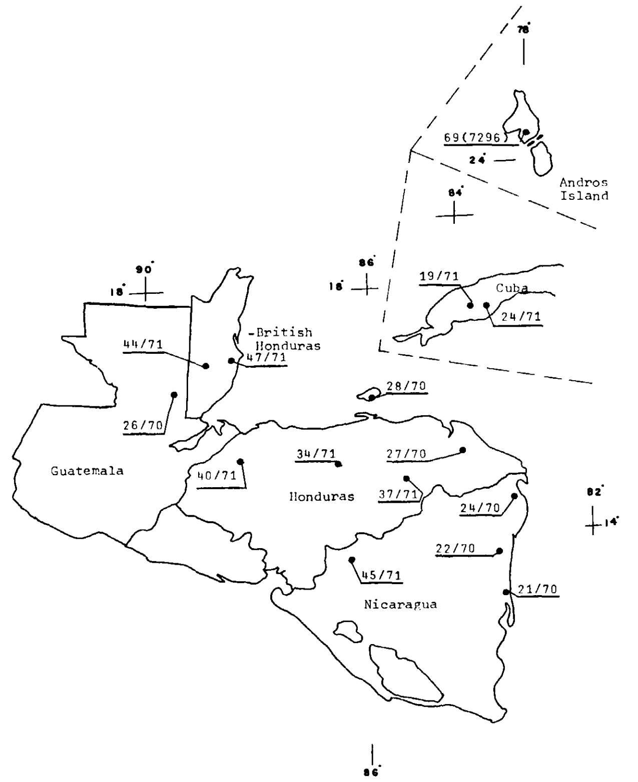

Figure 1. — Geographical distribution of *Pinus caribaea* provenances.

The seeds were sown to a depth of approximately 0.75 cm in vermiculite filled germination trays which were enclosed by a 20 percent saran shade box. Two separate sowings were made, one in January, 1973 and the other in March, 1973. All of the germination trays were watered equally throughout the germination period.

A total of 80 seedlings, 40 for each of the sowing dates were randomly selected from each provenance and measured from the root collar to the cotyledons. Seedlings selected for measurement were restricted by the following conditions: (1) Emergence within 6 days after initial germination was observed in the germination tray (The 6 day time limit was used to avoid measuring late germinating seedlings); (2) Individuals which were close to throwing the seed cap or which had already thrown the seed cap; and (3) The presence of a terminal primary flush. The latter two restrictions were imposed to ensure that the seedlings had utilized all significant available nutrients in the seed endosperm. The presence of a terminal primary needle flush was taken as a signal that germination vigor as maintained by the endosperm pool had ceased, and that seedling shoot development had begun through root absorption and cotyledon assimilation.

Results and Conclusions

The variances of the mean hypocotyl lengths for the 16 provenances ranged from 3.6 mm for provenance 37/71 to 6.2 mm for provenance 34/71. It is interesting that the extremes of the range ocurred in provenances close to each other geographically (*Figure 1*). The mean hypocotyl lengths for the 16 provenances ranged from 25.7 mm to 37.4 mm.

Upon inspection the variances of the hypocotyl lengths appeared to be heterogenous. Thus, they were subjected to Cochran's test for the homogeneity of variances. This test showed that the variances differed significantly, therefore, Bartlett's test for homogeneity of the variances was also run. This test also showed that the variances of the individual hypocotyl provenances were highly heteroscedastic ($p < 0.01$). On this basis a test for the equality of the means when the variances are heterogeneous was run. This test which relies on the F max value indicated that differences among the hypocotyl means were statistically significant ($p < 0.01$). Since the differences were significant the null hypothesis was rejected and it is concluded that the samples were drawn from statistically different populations. The coefficient of variation and standard error for the mean hypocotyl lengths are also given in *Table 1*.

The statistical differences observed suggest that quantitative genetic differences in hypocotyl length exist between seedlings of these provenances. Furthermore, due to the uniformity of the germination beds environmental pressure is estimated to be uniform for each provenance.

The provenance hypocotyl means were plotted graphically against longitude, latitude, and altitude of their respective collection areas. However, no clinal relationship was found between these parameters and hypocotyl length.

Measurement of hypocotyl length was restricted to 40 randomly selected seedlings which germinated within the first 6 days following initiation of germination in each seed bed. It is assumed that hypocotyl length is influenced by the germinative vigor of the seeds. The possibility that a linear relationship exists between hypocotyl length and the number of days required to germinate should not be overlooked. I have reported (1973) a linear relationship between germination time and seedling height growth. For the purpose of this paper, if a relationship as such does exist it is assumed to be constant between provenances. The selection of seedlings germinating only during the first 6 days, however, could be expected to reduce variation in hypocotyl length for each provenance.

Heritability of hypocotyl length in tomato seedlings is approximately 50 percent and is under monogenic control (Brewbaker, 1972). The results reported here suggest that the differences in hypocotyl length may represent inherent genetic variability between sub-populations of *P. caribaea.*

Summary

The mean hypocotyl lengths and variances of 16 *Pinus caribaea* provenances were found to be statistically different at $p < 0.01$, and it is concluded that the differences represent genetic variation among the provenances.

Abstract

Hypocotyls of newly germinated seedlings of sixteen provenances representing all three varieties of *Pinus caribaea*, were measured for homogeneity of length. The mean hypocotyl lengths and their variances were statistically different and it is concluded that the differences represent genetic variation among the provenances. No evidence for clinal differences among the provenances was observed.

Key words: *Pinus caribaea*, provenance, hypocotyl length, quantitative genetic variation.

Table 1. — Mean, standard deviation, coefficient of variation and the standard error of the coefficient of variation for hypocotyl length of 16 provenances of *P. caribaea*.

Oxon. seed source and variety	Mean hypocotyl length (mm)	Standard deviation (mm)	Coefficient of variation with standard error (%)
bahamensis			
69(7296)	25.7	3.9	15.32 ± 1.31
caribaea			
19/71	31.5	3.9	12.68 ± 1.52
24/71	29.1	4.4	15.10 ± 1.79
hondurensis			
21/70	32.2	4.2	14.64 ± 1.34
22/70	35.2	3.7	10.37 ± 0.90
24/70	28.9	3.8	13.03 ± 1.23
26/70	34.8	3.8	10.81 ± 0.94
27/70	29.0	3.7	12.75 ± 1.19
28/70	27.2	4.1	15.21 ± 1.73
34/71	32.1	6.2	19.20 ± 1.18
37/71	35.3	3.6	10.14 ± 1.14
40/71	37.4	5.3	14.28 ± 1.09
44/71	32.4	5.1	15.72 ± 2.12
45/71	31.4	4.7	15.07 ± 1.46
46/71	34.1	5.2	15.24 ± 1.58
47/71	27.9	4.6	16.55 ± 1.14

Zusammenfassung

Die mittleren Hypokotyl-Längen und ihre Varianzen wurden bei 16 Provenienzen von *Pinus caribaea* untersucht. Sie waren bei $p < 0{,}01$ statistisch gesichert verschieden. Daraus wird geschlossen, daß dies genetische Unterschiede zwischen diesen Provenienzen sind.

Literature Cited

Brewbaker, James L.: Agricultural Genetics: Prentice-Hall, Englewood Cliffs, New Jersey, pp. 156 (1972). — Gómez-Pompa, A., Vázquez-Yanes, C., and Guevara, S.: The Tropical Rain Forest: A non-renewable resource. Science 177: 762—766 (1972). — Kemp, R. H.: International provenance research on Central American pines. Commonwealth Forestry Rev. 52: 55—66 (1973). — Lückhoff, H. A.: The natural distribution, growth and botanical variation of *Pinus caribaea* and its cultivation in South Africa. Annale Universiteit Van Stellenbosch 39: Series A No. 1: pp. 160 (1964). — Nikles, D. G.: A 15-year study of *Pinus caribaea* Morelet in sub-tropical coastal lowlands of Queensland, Australia. Fifteenth International Union Forestry Res. Organ. Congress, Gainesville, Florida, U.S.A. Section 22 (1971). — Venator, C. R.: Hypocotyl color: An example of polymorphism in *Pinus caribaea* seedlings. Submitted to Silvae Genetica (1974). — Venator, C. R.: The relationship between early germinating seeds and height growth in *Pinus caribaea*. Turrialba, Vol. 23 (4): 473—474 (1973).

Buchbesprechungen

Züchtung, Anbau und Leistung der Pappeln. Von H. J. Fröhlich und W. Grosscurth. Aus der Hessischen Forstlichen Versuchsanstalt und dem Forschungsinstitut für Pappelwirtschaft, Hann. Münden. Mitteilungen der Hessischen Landesforstverwaltung, Band 10. 267 Seiten, mit 99 Abb., 36 Tabellen, 1 Ausschlagtafel sowie einem 22seitigen Tabellenanhang. 1973. J. D. Sauerländer's Verlag, Frankfurt a. M. Kartoniert DM 49,60.

Das Buch stellt eine Aufarbeitung und Zusammenfassung der züchterischen Bearbeitung der Pappel seit mehr als 20 Jahren dar. Auf der Grundlage eines umfangreichen Materials an Sorten und Versuchsanbauten haben Verfasser es unternommen, mit modernen Methoden der Versuchsstatistik weitgehend verschiedenartige Versuchs- und Demonstrationsanlagen in einer Gesamtauswertung zusammenzufassen und zur Klärung folgender, für die weitere Pappelwirtschaft und Pappelzüchtung gleichermaßen bedeutungsvollen Fragen beizutragen:

„1.) Welche Sorten können nach Beurteilung ihrer Wuchsleistung, Qualitäts- und Resistenzeigenschaften künftig mit Erfolg angebaut und hinsichtlich ihrer Standortseignung empfohlen werden?

2.) Nach welchen Maßstäben müssen Handelssorten und insbesondere Neuzüchtungen beurteilt werden?

3.) Welche Ertragsleistungen können wir von Pappelbeständen erwarten?

4.) Welche Konsequenzen ergeben sich aus dem Ergebnis der Pappelzüchtung als Test- und Weiserobjekt für andere Baumarten?" —

Trotz der Schwierigkeiten, die das komplexe Untersuchungsmaterial (Ungleichheit in Wiederholungen, Pflanzabständen, Zahl und Anordnung der Prüfglieder u. a. zwischen den einzelnen Versuchsanbauten) einer exakten Gesamtauswertung entgegensetzt sowie der hieraus resultierenden Unsicherheiten bei einigen Resultaten finden die Verfasser den Mut zu klaren Aussagen. Wo die Analysenergebnisse allein zweifelsfreie Interpretationen nicht zulassen, sind sie überprüft und ergänzt durch okuläre Sichtung der Versuchsglieder am Standort. Besondere Beachtung verdient nach Ansicht des Rez. die kritische und differenzierte Anwendung moderner mathematisch-versuchsstatistischer Methoden, für die das vorliegende Versuchsmaterial weitgehend ungeeignet erscheint. Insbesondere mag das zutreffen für die sog. Genotyp-Umwelt-Interaktionen, die mit biometrischen Standardmethoden nicht zuverlässig zu schätzen sind, von den Verfassern dennoch mit Hilfe spezieller Gruppierungen und Auswertungstechniken hinsichtlich ihrer praktischen Bedeutung eingeschätzt werden.

Im Aufbau und in der Bezeichnung vor allem der ersten Abschnitte zeigt das Buch einige Schwächen und Unsicherheiten, die offensichtlich aus den Schwierigkeiten resultieren, das komplexe Sammelmaterial für eine Gesamtübersicht systematisch aufzuarbeiten und zu ordnen. Aufgewogen wird dieser Mangel schließlich durch eine übersichtliche und detaillierte Gliederung nach Orten, Sorten, Eigenschaften, Methoden, Schlußfolgerungen und Empfeh-