ABSTRACT

15 - YEAR PERFORMANCE OF EUROPEAN BLACK PINE
IN NORTH CENTRAL UNITED STATES

By

Nicholas Collins Wheeler

A provenance test of European black pine (Pinus nigra Arn.) representing 25 native stands and 2 plantations was established at 4 test sites in the north central United states in 1961.

Average plantation mortality varied from 18 to 47% among the 4 sites with the greatest mortality occurring within 2 years after planting, probably a result of transplant shock.

There were large differences among seedlots in tree height and diameter. Generally, the same seedlots grew fastest at all test locations. The slowest growing seedlots were from warm, mild climates; the fastest growing seedlots were distributed essentially at random throughout the range.

Natural infections of twig and needle blights in two plantations made it possible to evaluate genetic resistance to these diseases. Dothistroma pini caused serious defoliation of current and year-old foliage on trees grown in Nebraska. In Michigan, Cenangium ferruginosum infections resulted in the death of the entire upper third of many trees. One seedlot each from Yugoslavia, Austria and northern Greece were quite resistant, whereas seedlots from Corsica, southern Greece and Italy were most susceptible to both diseases; the differences

were significant. Insect damage also occurred but was not severe. Genetic differences in resistance to attack were found for black-headed pine sawfly (*Neodiprion sertifer*), Zimmerman moth (*Dioryctria zimmermani*) and European pine shoot moth (*Rhyacionia buoliana*). Many seedlots which appeared resistant to *Dothistroma* and *Cenangium* were damaged by insect attacks.

In addition to growth and pest resistance data, over 40 morphological, anatomical and physiological characters were measured in this provenance test.

Two seedlots from Spain were similar enough in several traits to be considered a separate variety (var. *pyrenaica*); so were three seedlots from Corsica (var. *poiretiana*). Trees from the Peloponnesian Peninsula of southern Greece were similar to each other in growth and pest resistance performance. Elsewhere in the range, there were no consistent geographic trends, differences among seedlots from neighboring areas were often as large as those among seedlots obtained from widely separated areas. Hence it is concluded that most taxonomically described varieties or subspecies are invalid.

Many distinctive characteristics of the Corsican variety can be explained in terms of isolation and natural selection favoring survival in a warm habitat. Genetic drift is a possible cause of the seemingly random variation found elsewhere.

Diseases have often been the limiting factor to growth of European black pine in our plantations. The three most resistant seedlots are, therefore, the most highly recommended for commercial planting even though they are slightly inferior in some traits (e.g. height and diameter growth) to other seedlots.

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INTRODUCTION

European black pine is a widespread tree species of central and southern Europe, Asia Minor and northern Africa. It is known by several common names such as Austrian, black, Corsican, and Calabrian pine. Strictly speaking, the name European black pine (*Pinus nigra* Arnold) refers to the entire species; the other common names typically refer to trees from specific geographic locations such as Corsican pine (*P. nigra* var. *poiretiana*) from the Island of Corsica. Considerable taxonomic confusion exists in the description of this species. Rehder (1940) presents a detailed list of the more than 80 different Latin names proposed for all or parts of the species.

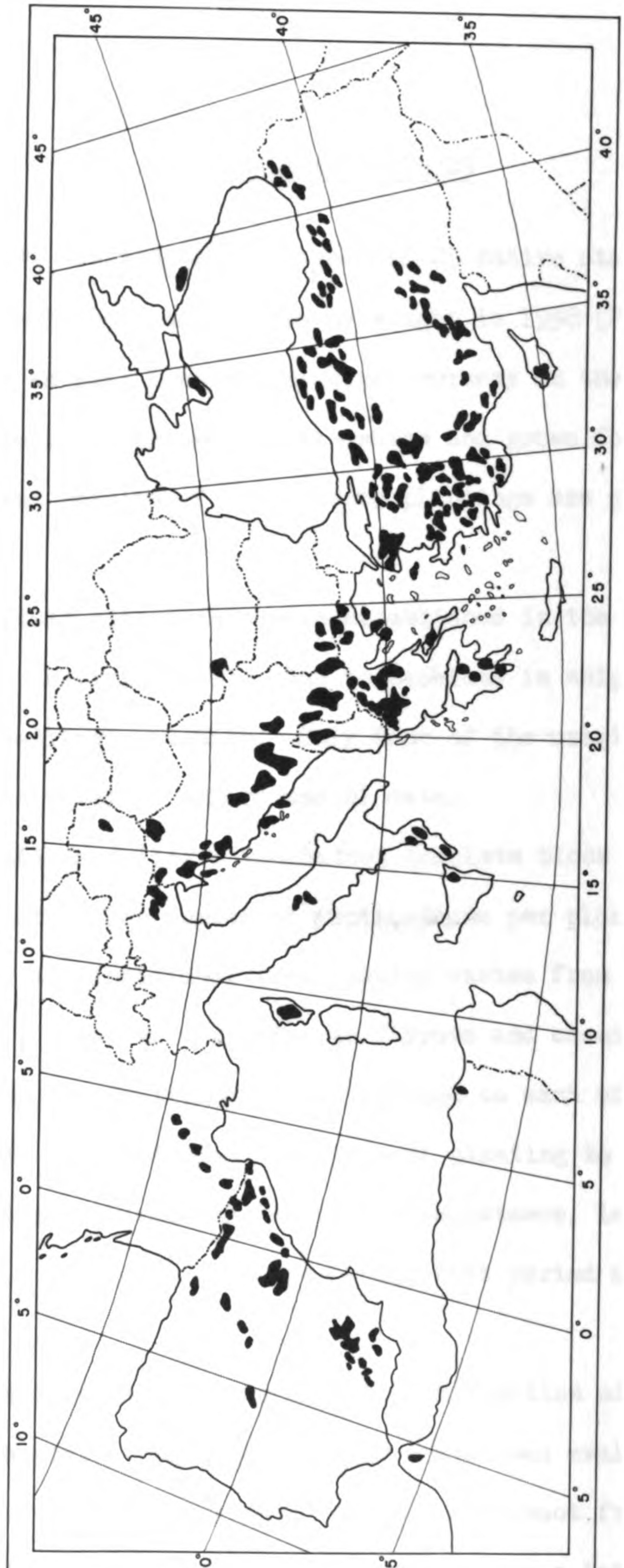
European black pine from Austria was one of the earliest tree introductions into the United States, arriving in 1759. It is popular as an ornamental and windbreak in many parts of north central United States. In recent years, *Pinus nigra* has proved one of the best trees for roadside planting because of its high salt tolerance. It is particularly well adapted to calcareous soils and will grow as rapidly as native pines when planted for timber on such sites, but the acreage of such plantations is small. European black pine is grown on a relatively small scale for Christmas trees in the U. S. because of difficulties encountered in shipping it in large quantities; the branches are brittle and apt to break if trees are piled high. However, the tree responds nicely to shearing and is preferred by many people.

As noted, the natural range of European black pine is large. The range is markedly discontinuous with isolated stands occurring from Algeria and Spain in the south and west to Austria and the Crimea SSR, in the north and east. It has a latitudinal range of 13° (35° to 48° N) and a longitudinal range of 48° (6° W to 42° E) (Fig. 1).

Very few genetic studies of European black pine have been reported. It has been the subject of some small unreplicated provenance trials conducted in Belgium, France, New Zealand and eastern United States. In addition, there are two previous replicated provenance tests. The first one, of about the same size and age as the present study, was conducted in West Germany and was described by Röhrig (1966). Prof. Dr. Röhrig (personal communication) stated that his plantations were so heavily attacked by a species of Scleroderris (insect) that they have been abandoned. The second study, established in the late 1960's in France was described by Arbez and Millier (1971). Details of these studies are summarized in Mirko Vidakovic's review paper (in press) on the genetics of European black pine. They have shown the presence of considerable genetic variability in traits such as height, foliage color, resistance to cold and other characters.

The present paper is a summary of the first 15 years' results of a replicated 4-plantation provenance test of European black pine conducted in north central United States as part of the NC-99 (formerly NC-51) project entitled "Improvement of Trees through Selection and Breeding". Previous papers on this NC-99 study have been published by Wright and Bull (1962), Lee (1968, 1970, 1971, 1972), and Peterson and Read (1971).

Figure 1. Natural range of *Pinus nigra* Arnold. (from Lee, Ph. D. Thesis, Michigan State University)



MATERIALS AND METHODS

Seed from 10 average trees in each of 25 native stands and 2 plantations was obtained from cooperators by Wright in 1958 (Fig. 2). The seed was sown in an East Lansing, Michigan nursery in the spring of 1959 following a randomized complete block design and grown for 2 years. Detailed methods and results of the nursery plantings are given by Wright and Bull (1962).

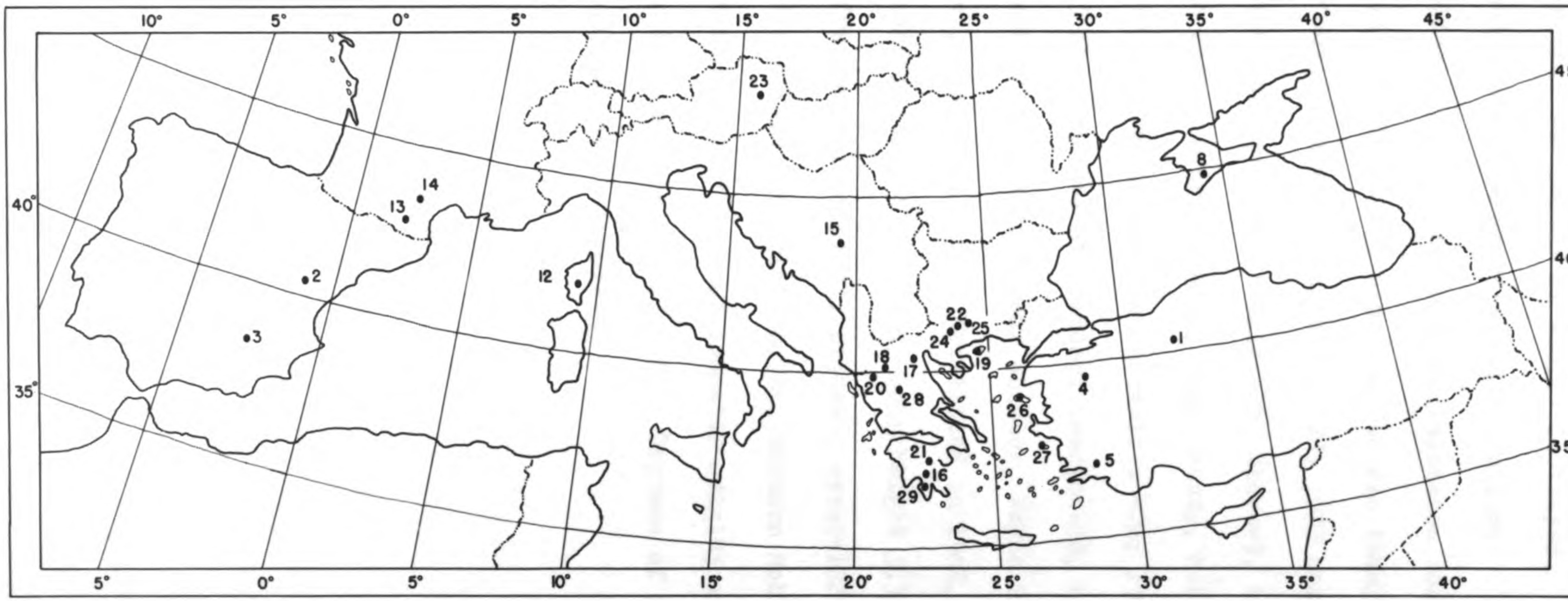
Fourteen field plantations were established in the spring of 1961 in several north central states. Due to problems in shipping, mortality of the seedlings was high. Only four of the original plantations had sufficient survival to afford useful data.

All plantations follow a randomized complete block design with 4-tree linear plots. The number of replications per plantation varies from five to ten and individual tree spacing varies from 7 x 7 feet to 10 x 10 feet. Trees were planted in furrows and chemical weed control (simazine, amino-triazole) was applied to each of the plantations.

Growth rate was monitored from time of planting to age 15. A number of additional characters (e.g. pest resistance, leaf morphology and anatomy etc.) were also measured during this period although seldom more than once.

Disease resistance was interpreted as a function of pathogen frequency. In Nebraska, *Dothistroma pini* damage was evaluated by the percentage of infected needles obtained from one shoot from each tree in a seedlot. A *Cenangium* infection was defined as a lateral branch or

Figure 2. Distribution of native stands of Pinus nigra represented in the present provenance study.


10°
5°
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15°
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8
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28
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21
16
27
5
29
5°
0°
5°
10°
15°
20°
25°
30°
35°
40°

terminal leader that was partly or wholly destroyed.

Individual plantation details are as follow:

W. K. Kellogg Forest near Augusta, Kalamazoo County, Michigan. Rolling hills, 0-25% slope on Oshtemo loamy sands, glacial derivation; average mortality 17%; 1973 mean height 15.6 ft. Degrees of freedom: seedlot-26, block-9, error-225.

Fred Russ Forest near Dowagiac, Cass County, Michigan. On flat, heavy clay soils; average mortality 47%; 1974 mean height 14.5 ft. Degrees of freedom: seedlot-20, block-6, error-101.

Apple Creek State Hospital near Wooster, Wayne County, Ohio. Level, clay-loam soil. Fertilized in 1962, 1967 and 1968. Average mortality 34%; 1967 mean height 5.3 ft. Degrees of freedom: seedlot-22, block-6, error-122.

Horning State Farm near Plattsmouth, eastern Nebraska. On 6% east slope, silt loam of loessial origin; average mortality 18%; 1973 mean height 17.3 ft. Degrees of freedom: seedlot-20, block-4, error-78.

RESULTS AND DISCUSSION

Mortality

Average mortality for all seedlots varied from 18 to 47% among the four plantations. Most mortality occurred within two years of planting, probably as the result of transplanting shock.

There was a weak geographic trend to mortality of *Pinus nigra* origins. Corsican and other French seedlots suffered noticeable winter injury while in the nursery as well as in the permanent plantations. Mortality was highest in these seedlots, averaging 49%. Mortality in the remaining non-Corsican and French seedlots averaged 25% in all plantations.

Growth Rate

With few exceptions, those seedlots which grew most rapidly at one site were among the tallest at other test locations (Table 1). Were it not for the diseases which are now damaging some of the plantations, there would be good reason to believe that the relative height differences shown in Table 1 would continue to exist in the future. In plantations such as the one at Kellogg Forest which have been measured at frequent intervals there were few changes in relative performance from 1965 to 1973. Twenty-four of the 27 seedlots which were below average or above average in the nursery at age 2 remained so at age 15.

There are serious disease problems in two of the test plantations, however. Entire tops of trees are dying, resulting in decreased height growth. As of 1973, the severity of damage was still so low as to not appreciably influence height growth, but if the damage continues, some seedlots can be expected to fall far behind their present rate of growth.

The three Corsican seedlots grew most slowly, as was similarly reported in Röhrig's (1966) West German study. This was probably a consequence of mild climate trees being grown under severe northern conditions, for Corsican pine has proved very successful in areas of New Zealand and Great Britain with mild climates.

Considering the other, non-Corsican seedlots , it is difficult to make any generalizations about geographic trends in height performance. For example, Greek seedlots were among the tallest and shortest; GRE-22 and GRE-24 from the same part of Macedonia differed in height by 23%. In that respect, European black pine differs from

Table 1. Relative heights of Pinus nigra seedlots in Ohio, Nebraska and Michigan.

Country[a] and Seedlot	Relative height, as a percent of plantation mean, when planted at: Wooster Ohio Age 8	Plattsmouth Nebraska Age 15	Kellogg Forest Michigan Age 15	Russ Forest Michigan Age 15
SPA-2	113	98	103	101
SPA-3	97	87	89	97
ITA-7	131	109	114	121
FRA-10[b]	122	--	114	95
FRA-14	89	--	89	85
COR-11[b]	55	--	89	85
COR-12	--	84	86	70
COR-13	--	--	84	70
CRI-8	113	107	114	109
YUG-15	111	111	106	102
AUS-23	105	105	106	103
GRE-16	--	--	68	--
GRE-17	101	110	108	98
GRE-18	107	105	105	115
GRE-19	109	106	111	113
GRE-20	95	106	111	113
GRE-21	76	85	84	87
GRE-22	95	106	108	113
GRE-24	95	80	86	87
GRE-25	116	--	110	102
GRE-26	95	91	97	104
GRE-27	--	106	105	99
GRE-28	101	104	105	97
GRE-29	--	--	81	87
TUR-1	91	96	95	96
TUR-4	95	97	111	103
TUR-5	95	95	103	94
Plantation mean (ft)	5.4	17.3	15.6	14.3
F-value (seedlot)	7.16***	7.88***	5.05***	2.19**
L.S.D. (.05)	18.0	11.0	17.00	19.0

(a)AUStria, CORsica, CRImea, FRAnce, GREece, ITAly, SPAin, TURkey, YUGoslavia.

(b)Parental stand was a plantation of the presumed origin shown.

, *)Indicates significance at the 1 and .1% levels, respectively.

Scotch pine, another south Eurasian species. Wright et al (1966) found that Scotch pines from Spain were consistently slower growing than southern French Scotch pines, which in turn differed consistently from Italian, Yugoslav, Greek, Turkish, etc. Scotch pines.

These same two species exhibited considerable differences in trunk diameter growth. When expressed as a proportion of height (height/diameter ratio), diameter in European black pine is nearly 50% greater than in Scotch pine. In absolute terms, this means a 15 foot tall black pine would have a diameter approximately 2 inches greater than a Scotch pine of similar height. Peculiarly, those Scotch pine seedlots from Spain that put on the least height growth had the largest trunks. The situation was reversed in black pine, with Spanish trees having the smallest trunks relative to trees from the rest of the range.

Disease Damage

Considerable disease damage has occurred at two of the European black pine test plantations. In Plattsmouth, Nebraska an epidemic needle blight, Dothistroma pini, began in 1967. More recently, a serious twig blight infection of Cenangium ferruginosum was observed at Kellogg Forest in Michigan. The extensive damage at these test sites made it possible to evaluate genetic resistance to both diseases.

Dothistroma pini has caused extensive losses to Pinus nigra plantings in several Great Plains states. It has been particularly damaging to shelterbelts of European black pine in Nebraska (Peterson, 1967). The disease has also been observed on Pinus nigra in Great Britain and a number of European countries and on Monterey pine in New Zealand, Chile and Africa.

Dothistroma is a disease that infects current and year-old foliage, resulting in browning and death of the needles. At the Nebraska plantation, defoliation became so severe at the peak of infection that few trees were believed capable of surviving. The disease was controlled shortly thereafter with a fungicide but once more reached epidemic levels in 1971. Very large and significant differences in resistance to the disease were observed between seedlots during both periods of infection (Table 2).

The highly resistant YUG-15 and slightly less resistant AUS-23 and GRE-18 seedlots are of great interest. On trees from those seedlots, only 3, 16 and 22% of the needles were infected, respectively. Only three other seedlots had infection rates of less than 50%. In contrast,

Table 2. Damage by diseases and insects to Pinus nigra at plantations in Michigan, Nebraska and Ohio.

Country and Seedlot	Disease damage: Dothistroma pini	Disease damage: Cenangium ferruginosum	Insect damage: Zimmerman pine moth	Insect damage: Black-headed pine sawfly
	% needles infected	infections per tree	---% trees attacked --	
SPA-2	76	1.0	15	30
SPA-3	88	1.4	26	40
ITA-7	48	3.0	21	50
FRA-10	--	2.3	35	32
FRA-14	--	1.4	17	20
COR-11	--	3.8	19	3
COR-12	82	2.9	3	4
COR-13	--	3.6	29	0
CRI-8	51	.8	19	3
YUG-15	3	.1	4	26
AUS-23	15	.3	13	6
GRE-16	--	3.0	5	8
GRE-17	30	.6	10	30
GRE-18	22	.5	13	19
GRE-19	48	1.9	19	18
GRE-20	31	.5	8	21
GRE-21	98	2.0	9	1
GRE-22	--	.4	11	13
GRE-24	31	1.6	6	7
GRE-25	--	.4	12	5
GRE-26	65	1.4	6	20
GRE-27	61	1.4	11	3
GRE-28	55	.4	13	19
GRE-29	--	2.5	9	2
TUR-1	48	.6	3	6
TUR-4	57	1.4	16	14
TUR-5	49	1.8	30	9
Mean	50	1.5	14	16
F-value (seedlot)	(a)	3.93***	1.60*	4.39***
L.S.D. (.05)	(a)	1.50	25.0	23.0

*, **, ***) Indicates significance at the 5, 1 and .1% levels, respectively.

(a) Information not available.

75 - 98% of the needles were infected on Spanish and southern Greek trees, resulting in nearly complete defoliation.

Cenangium ferruginosum has had considerable esthetic and biological impact on European black pine. Commonly known as "pruning disease" because of its selective branch removal through infection, Cenangium has previously been reported to cause severe damage over large planted areas of Pinus nigra in Hungary and Germany (Laubert, 1926; Lengyel, 1963; Lorenz, 1967). In 1973, the disease caused extensive damage in the black pine plantation at Kellogg Forest in Michigan. At this site, disease expression was variable. On trees with slight infections, damage was characterized by a twig blight of vigorous lateral and terminal shoots, resulting in the death of the current year's twigs. More severe infections, however, killed the previous two or three year's growth. In such cases, the entire top third of a tree died. Over 44% of the 900 living trees in the plantation were infected. Half of the infected trees lost their leaders Although mortality due to the disease was low in 1973 (3 dead trees), many trees appeared so weakened that they might not survive the following season.

There were large and statistically significant (f=3.93, 26 and 225 degrees of freedom for seedlot and error, respectively) differences among seedlots in resistance to Cenangium (Table 2). The YUG-15 and AUS-23 seedlots were once again, as with Dothistroma, clearly superior in resistance. The few infections observed on trees of these seedlots were generally confined to the new year's growth on single lateral branches. They were the only seedlots not to suffer leader damage. The most severely damaged seedlots were of Corsican and southern Greek origin. In these, nearly 50% of the trees had dead leaders and half-dozen or more branches were simultaneously infected. However, there were individual disease-free trees in each of these seedlots.

It is important to note that the same two seedlots -- YUG-15 and AUS-23 were most resistant to both diseases and that ITA-7, COR-12 and GRE-21 were among the most susceptible to both diseases. However, there were some seedlots (e.g. TUR-1 and GRE-28) which showed more resistance to one disease than to the other. This indicated that two different diseases were involved, and that specific factors were responsible for resistance to each.

Of additional interest is the confusion that exists concerning the true pathogenicity of Cenangium. The disease is considered by some (Lorenz, 1967) to be primarily saprophytic while others feel it is a facultative parasite on trees predisposed to disease by unfavorable conditions. The bulk of the literature on Cenangium indicated the latter case may be more common. Lengyel (1963), in an extensive study of climatic variables, found that an outbreak of pruning disease in 7200 ha. of Pinus nigra in Hungary was strongly related to certain climatic factors, expecially drought, which may have resulted in a physiological weakening of the trees. Lukonski (1968) and Kobayashi and Maniya (1963) also found Cenangium to be a problem on weakened pines in Poland and Japan. An infection on a ponderosa pine plantation in British Columbia, Canada resulted in 25% of the 300 trees exhibiting flagging of vigorous branches in the upper crown. That infection was preceded by two years of drought (Molnar, 1954).

In Michigan, it did not appear that a climatic variable was responsible for physiological weakening of trees but rather that climatic conditions may have been optimal for the spread of this particular disease. The proper set of environmental conditions for spread of *Cenangium* is not know, however. The disease apparently occurs in serious proportions only every 10 to 15 years in Michigan. Such was the case in 1973 when seemingly healthy trees were damaged in much of central and southern Michigan. In addition to the *Pinus nigra* infection previously mentioned, severe damage was noted in plantations of Scotch pine Christmas trees and in pine hybrids of Japanese red pine and European black pine. The same hybrid pine was damaged by *Cenangium* in Fort Wayne, Indiana in 1973.

Insect Damage

Damage due to insect pests has been moderate in the black pine test plantations. At least one infestation of the black-headed pine sawfly, Zimmerman pine moth or the European pine shoot tip moth has been observed at every plantation with the exception of Plattsmouth, Nebraska. All three insect pests were observed at the Kellogg Forest plantation.

The most commonly occurring insect has been the black-headed pine sawfly (Neodiprion sertifer) which in the larva stage, feeds on year-old needles. The sawfly has been noted to occur in both Michigan plantations and in Ohio, the latter infestation being the most severe. Nearly 37% of all the trees in the Ohio plantation had sawfly larvae in 1968, while fewer than 10% of the trees were attacked at the Michigan test sites (Table 2). The differences in susceptibility to sawfly were large and statistically significant among seedlots. Peculiarly, some of the seedlots which were most resistant to the sawfly (e.g. GRE-21, GRE-29, COR-12, and COR-13) were among the most susceptible to the previously described diseases. The sawfly damage does not appear to have markedly influenced survival or growth rate in the infested plantations, but has made the trees unsightly.

The Zimmerman pine moth (Dioryctria zimmermani) is a phloem-borer whose presence can be recognized by large pitch exudations, normally at the main stem nodes. The insect has been seen only at the two Michigan sites, where approximately 14% of all trees were attacked.

Potentially, the Zimmerman moth is probably more capable of inflicting restricted growth, poor form and increased mortality damage than is the pine sawfly. However, infestations to date have been relatively light, both on an individual-tree and plantation basis. Differences among seedlots in susceptibility to the Zimmerman moth were significant (5% level, Table 2). The most resistant seedlots were widely scattered over the species' range and included COR-12, YUG-15 and TUR-1. There appeared to be no apparent relationship between a particular seedlot's resistance to Zimmerman moth and its resistance to the other insect and disease pests previously described.

The European pine shoot moth (*Rhyacionia buoliana*) was observed only once in the test plantations, at Kellogg Forest in the winter of 1974. Damage at that time resulted primarily in death of the lateral, 1973 growth, although death of a few leaders was attributed to the insect. Approximately 200 individual attacks were noted in the plantation. Differences in susceptibility occurred and were significant (5% level). Those seedlots suffering the fewest attacks were YUG-15, COR-11, AUS-23 and GRE-25.

The economic importance of this insect on *Pinus nigra* in Michigan has not yet been fully assessed because of its short period of infestation. At the time of this writing (summer, 1974) however, a rather extensive infestation of shoot moth was observed on *Pinus densiflora* x *P. nigra* hybrids at the Michigan State Tree Research Center in southern Michigan. Some trees lost up to 50% of their crown. Holst and Heimburger (1955), in a review of resistance to European pine shoot moth in hard pine species, reported that resistance was largely a function of resin production. *Pinus densiflora* is not very resinous and therefore quite susceptible to attack. They also reported that European black pine from Austria and Corsica were resinous and highly resistant which coincides with our data.

Geographic and Evolutionary Considerations

It is extremely difficult to identify any major trends in variation in response to geographical, elevational or climatological variables for most of the characters previously described in this study. Almost without exception, characters varied as much within regions as they did between regions. This was repeatedly illustrated in the 13 Greek seedlots, especially GRE-22, GRE-24 and GRE-25. These showed large differences in height, diameter, branch size and resistance to *Cenangium* twig blight, even though the parental stands were within 50 miles of one another.

Although there seems to be a lack of range-wide trends, a few specific geographic areas are worthy of note. Heavy winter damage, high initial mortality and poor growth were common to all three Corsican seedlots. The seedlots from the Peloponnesian Peninsula of southern Greece were also below average in growth rate. In general, these deficiencies were most noticeable during the early years of the experiment. As the plantations grew older, winter damage lessened and relative growth rate of these 6 southern Greek trees were extremely susceptible to disease but relatively resistant to insect attacks.

It would be valuable to be able to predict areas that would yield trees of superior growth or pest resistance. For the most part, this is not possible. Fast growing seedlots occurred from southern Italy to the Crimea. Strong resistance to insect attack was found in Corsica, southern Greece and northern Turkey. Perhaps of greatest interest were the disease resistance results. The most resistant seedlots to both *Dothistroma* and *Cenangium*, YUG-15 and AUS-23, were the only representatives of the northern extension of the *Pinus nigra* range in Europe. Whether strong resistance to the disease is an inherent character of these two northerly seedlots or whether it occurred merely by chance can not be determined solely on the observations reported in this study. The great amount of within-region variability over the rest of the range suggests the latter case may be true, although experience with Scotch pine gave different results. Wright et al (1966) found considerable regional uniformity in pest resistance, as well as large between-region differences.

From an evolutionary standpoint, European black pine poses an important question--what evolutionary mechanism has had the greatest influence on the species? Strong selection pressures and isolation surely have resulted in the adaptation of Corsican and southern Greek seedlots to warm, mild climates. These trees are uniform among themselves, yet as a group, differ considerably from the remainder of the seedlots.

Elsewhere European black pine also has a discontinuous range and tends to be a relatively uncommon tree. It is possible that some of the genetic differentiation occurred as the result of random gene fixation and could be interpreted as genetic drift.

Taxonomy

The taxonomic status of European black pine is extremely complicated. As previously mentioned, over 80 Latin names for species, subspecies, varieties and forms have been proposed for all or parts of the black pine range. Many of the names are mere synonyms resulting from improper publication procedure, but the entire synonomy cannot be so dismissed.

The most recent taxonomic treatments of European black pine consider it to be one species, Pinus nigra Arnold, consisting of a small number of lesser taxa. Gaussen et al (1964) and Blećić (1967) divided Pinus nigra into 5 subspecies while Lee (1968), recognizing different groupings, split the species into 5 varieties. The latter work was based on the combined data of 40 growth, anatomical and chemical characters measured in a replicated provenance test.

Even though these recent studies proposed a much more simplified taxonomy for Pinus nigra, their practical application is still questionable. Although varietal or subspecies differentiation may be justified from a strictly taxonomic standpoint, the characters utilized as a basis for the decision are often so obscure (e.g. number of hypodermal layers) as to be of little practical significance. Indeed, in our study only seedlots from Corsica and Spain were easily recognized. Lee (Ph.D. thesis) stated that although it is possible to differentiate populations of Pinus nigra after statistical study based on dozens of specimens, it is practically impossible to definitely assign any single specimen to a variety on the basis of its morphology. Even after an extensive study of 40 characters he found the only positive way of identifying a specimen was to know the geographic location of the parent tree.

If, in fact, such difficulty is commonly encountered in identification and classification of subspecies or varieties, then the question of what constitutes a valid intraspecific taxon needs to be given greater consideration. Justification for the recognition of intraspecific taxa should be based, at least in part, on the following points:

1. Geographical or ecological distribution. Theoretically, the entity in question should possess an identifiable range, the boundaries of which are geographical or ecological in nature.

2. Genetic similarity. A taxonomic entity should possess a basic genetic component common to all members.

3. Identifying characters. The ability to identify a common set of phenotypic characters among specimens is the foundation for taxonomic grouping.

4. Usefulness. The taxonomic classification should be applicable, not only under elaborate laboratory conditions or in genetics plantations, but under field conditions as well.

With these requirements in mind, a reassessment of the taxonomic status of *Pinus nigra* is certainly worth undertaking. From a strictly practical standpoint (e.g. improvement through breeding, ornamental planting), knowledge of individual stand performance is much more valuable than the taxonomic classification system thus far proposed. For purposes of identification in our study, only Corsican (var. *poiretiana*) and Spanish (var. *pyrenaica*) seedlots warrant separate varietal status.

PRACTICAL RECOMMENDATIONS

Growth rate, susceptibility to winter damage and insect and disease resistance are the most important considerations when selecting Pinus nigra seed for ornamental, timber or Christmas tree purposes. Differences among seedlots were large for all these characters and constitute a basis for improvement through selection of the proper seed source.

Corsican and southern Greek seedlots were the least satisfactory under northern United States conditions and their use is not recommended.

Variation patterns in the remaining seedlots do not follow any major geographical or climatological trends, thus recommendations by region are virtually useless. That is, the performance of one population cannot necessarily be predicted by knowing the performance of a neighboring population. The data obtained in this study indicated that to insure superior growth and pest resistance, it is necessary to return to specific stands from which the seed was originally obtained.

Two seedlots, YUG-15 and AUS-23, were superior in all-around performance at the four test sites. They grew rapidly and had high resistance to diseases and most insects. A third seedlot, GRE-25, was also quite successful and can also be recommended as one of the best geographic origins for planting in north central and northeastern United States. Listed below are the locations from which seed for the present study was obtained. The seedlots are listed in descending order of superiority.

YUG-15. Latitude 43° 52' N, longitude 19° 32' E. Seed collected from natural stand, 900 meters elevation, near Sumska Sekcija, Kremma, Yugoslavia.

AUS-23. Latitude 48°10' N. longitude 16°15' E. Seed collected by Franz Kluger at 500 meters, near Vienna, Austria.

GRE-25. Latitude 41°22' N. longitude 24°25' E. Seed collected from natural stands on Mt. Rhodopi near Paranestion, near Drama, in Macedonia, Greece, at elevation of 900 to 1000 meters.

Further improvement in Pinus nigra may be obtained by increasing the number of geographic origins tested, by large scale testing of individual tree progenies from within the superior stands and by crossing selected trees chosen for their desirable traits.

The trees in the NC-91 experiment are now beginning to produce seed, but not in enough quantity to meet ornamental or Christmas tree plantation requirements. One way to insure a source of genetically superior seed for future needs would be to establish a seed orchard containing the most desirable seedlots. This has not yet been done. For now, the grower must rely on other means of obtaining seed. If seed is being purchased from commercial seed dealers, the grower should specifically request that it be collected from the areas recommended, namely YUG-15, AUS-23 and GRE-25.

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APPENDICES

APPENDIX A

APPENDIX A

FIELD DATA

Table 3. Number of trees planted, current mortality and height growth of <u>Pinus nigra</u> at Kellogg Forest, Michigan (MSFGP 5-61).

Country & Seedlot	Trees Plant	Mortal-ity	Height, total					Height, total				
Age	15	15	5	6	7	10	15	5	6	7	10	15
Year	73	73	63	64	65	68	73	63	64	65	68	73
	no.	no.	----- number -----					---- % of mean ---				
COR-11	40	11	31	47	64	157	442	73	81	77	86	92
COR-12	40	18	31	44	60	146	411	73	76	72	80	86
COR-13	40	15	30	46	67	152	404	70	79	81	84	84
SPA- 2	40	3	43	61	86	182	495	101	108	103	100	103
SPA- 3	36	7	46	64	88	181	427	106	110	106	99	89
ITA- 7	36	2	43	66	95	214	549	101	114	116	114	114
FRA-10	40	7	42	63	89	198	549	99	108	109	109	114
FRA-14	40	9	44	59	77	166	427	101	102	93	91	89
AUS-23	40	4	42	57	80	181	511	99	98	96	99	106
YUG-15	40	4	48	66	92	202	511	117	114	110	110	106
GRE-16	40	29	36	49	65	145	328	85	84	78	80	68
GRE-17	40	6	43	62	84	193	518	100	106	101	106	108
GRE-18	40	7	46	61	83	192	503	107	104	100	106	105
GRE-19	40	3	46	64	94	206	526	107	108	113	113	110
GRE-20	40	1	40	58	75	163	533	90	100	90	90	111
GRE-21	40	10	34	51	69	155	404	79	87	83	85	84
GRE-22	36	2	48	64	86	187	518	113	109	103	103	108
GRE-24	36	2	50	64	87	162	411	116	109	105	89	86
GRE-25	40	10	61	80	106	218	526	142	137	127	120	110
GRE-26	40	1	41	57	80	166	415	97	97	97	91	97
GRE-27	40	6	45	66	93	182	503	104	113	112	100	105
GRE-28	40	7	42	65	89	206	503	99	111	107	113	105
GRE-29	40	14	42	58	78	179	389	98	99	94	98	81
TUR- 1	40	2	45	61	82	170	457	106	105	99	93	95
TUR- 4	40	2	46	66	92	198	533	106	113	111	109	111
TUR- 5	36	1	43	61	83	180	495	101	105	100	99	103
CRI- 8	40	0	50	70	100	214	549	117	120	120	117	114
Mean		7	43	58	83	182	477	100	100	100	100	100
F value (seedlot)			7.3	6.3			3.9					

Table 4. Floristic and vegetative characteristics of Pinus nigra at Kellogg Forest, Michigan (MSFGP 5-61).

Country & Seedlot	WI	Branch angle		Br. diam.	Cones	Male stob.	Date of Pol. Sh.	Deg. of Lf. Dev.
Age	5	6	10	10	15	15	15	15
Year	63	64	68	68	73	73	73	73
Char.	11	13	37	38	62	51	52	53
	T%	o		mm	no.	#T		
COR-11	58	57	39	7.6	34	5	8	12.9
COR-12	72	49	38	6.6	13	0	-	10.3
COR-13	68	52	38	6.5	0	3	11	10.0
SPA- 2	8	62	38	10.7	0	4	21	7.0
SPA- 3	8	61	36	9.2	1	3	4	7.7
ITA- 7	28	59	37	8.2	9	8	20	12.7
FRA-10	10	60	37	9.4	43	4	-	14.0
FRA-14	35	52	35	8.0	9	11	32	7.0
AUS-23	0	64	34	10.4	36	19	11	12.0
YUG-15	0	64	37	9.4	9	6	5	10.8
GRE-16	0	63	40	8.0	9	2	-	13.8
GRE-17	2	61	36	9.3	0	16	10	13.4
GRE-18	0	63	37	9.6	0	7	6	13.6
GRE-19	2	60	33	9.3	0	13	13	13.6
GRE-20	2	66	39	8.9	4	3	5	12.3
GRE-21	0	55	35	7.6	0	3	4	13.1
GRE-22	0	60	36	8.9	13	10	9	12.5
GRE-24	0	62	39	7.4	1	26	12	16.0
GRE-25	0	60	33	9.5	17	20	13	12.8
GRE-26	2	55	34	8.0	0	16	12	13.8
GRE-27	2	66	40	8.8	0	11	18	12.7
GRE-28	0	66	39	10.4	4	14	15	13.7
GRE-29	0	67	35	8.4	0	9	9	13.3
TUR- 1	0	59	39	8.2	0	6	11	13.5
TUR- 4	0	64	35	9.8	0	24	18	14.8
TUR- 5	2	65	43	8.4	0	7	8	13.4
CRI- 8	0	67	39	10.6	0	22	13	15.4
Mean	11	61	37	8.7	8	11	17	15.9
F value	61	3.8		3.8			1.0	2.2

for seedlot.

WI = Winter injury, Male stob = male strobili, Date of pollen shed, and Degree of leaf development.

Table 5. Disease and insect damage in Pinus nigra at Kellogg Forest, Michigan (MSFGP 5-61).

Country & Seedlot	Tr. with Cenangium	Inf./ Tree	Leader Inf.	Sht.Moth Inf.	Zim.Moth Inf.	Eucosma Inf.	BHP saw Inf.
Age	15	15	15	15	15	11	11
Year	73	73	73	73	73	69	69
Char.	57	58	59	64	65	41	43
	%	no.	%	no.	no.	% trees	infected-
COR-11	45	3.8	35	2	3	10	14
COR-12	45	2.9	25	4	2	0	4
COR-13	42	3.6	32	4	0	0	0
SPA- 2	38	1.0	10	5	1	5	8
SPA- 3	32	1.4	18	10	1	6	6
ITA- 7	60	3.0	32	13	1	20	34
FRA-10	32	2.3	18	9	5	3	9
FRA-14	28	1.4	18	6	1	3	0
AUS-23	22	.3	0	3	5	8	0
YUG-15	10	.1	0	2	1	8	13
GRE-16	28	3.0	22	19	2	25	8
GRE-17	30	.6	2	5	0	5	37
GRE-18	25	.5	5	13	1	5	13
GRE-19	58	1.9	22	7	1	3	13
GRE-20	30	.5	2	10	2	13	13
GRE-21	50	2.0	25	36	1	16	3
GRE-22	32	.4	7	12	1	10	3
GRE-24	28	1.6	20	13	0	10	5
GRE-25	15	.4	2	3	0	3	7
GRE-26	58	1.4	30	26	0	25	10
GRE-27	40	1.4	15	29	1	10	0
GRE-28	20	.5	5	8	2	8	8
GRE-29	50	2.5	32	26	2	40	3
TUR- 1	30	.6	5	12	0	14	3
TUR- 4	48	1.5	18	11	3	13	5
TUR- 5	50	1.8	22	6	1	10	0
CRI- 8	40	.8	10	5	0	10	3
Mean	37	1.5	16	11	1.4	11	9
F value for seedlot	3.13	5.12	3.90	1.40	1.09	2.53	4.39

Columns 1,2 and 3 - Damage by Cenangium ferruginosum
Sht. Moth - European pine shoot moth (Rhyacionia buoliana)
Zim. Moth - Zimmerman moth (Dioryctria zimmermani)
BHP saw - Black headed pine sawfly (Neodiprion sertifer)

Table 6. Anatomical and wood property characteristics of Pinus nigra at Kellogg Forest, Michigan (MSFGP 5-61).

Country & Seedlot	Needle Endoderm			Scler. Layers	Sp. Gr. Branch	Tr. Len.	Between bundle dist.
Age	6			6	11	12	6
Year	64			64	69	70	64
Char.	28,29			26	39a	40a	27
	Len.	Wid.	L/W				
	-- microns --			#	$x10^4$	mm	microns
COR-11	778	395	1.96	.4	42831	.93	85.6
COR-12	728	372	1.96	.5	37942	.93	82.0
COR-13	733	383	1.91	.7	39158	.95	71.2
SPA- 2	738	375	1.97	.9	39464	.94	77.2
SPA- 3	799	393	2.03	.9	39962	.92	80.0
ITA- 7	770	397	1.94	.7	41955	.95	70.4
FRA-10	776	392	1.98	.7	42123	.97	78.4
FRA-14	732	384	1.91	.9	39266	.93	73.6
AUS-23	838	400	2.10	.8	40707	.94	81.2
YUG-15	746	367	2.03	.9	44742	.96	74.4
GRE-16	765	394	1.94	1.0	42113	.97	72.0
GRE-17	747	389	1.92	1.0	41537	.96	74.4
GRE-18	744	367	2.03	.9	42143	.97	85.2
GRE-19	722	379	1.91	.9	40762	.97	62.0
GRE-20	731	368	1.99	.9	41525	.96	70.4
GRE-21	763	380	2.01	.9	39476	.96	76.0
GRE-22	720	366	1.97	1.0	39733	.96	70.4
GRE-24	792	414	1.91	1.0	41270	.97	76.0
GRE-25	795	402	1.98	1.0	40592	.96	70.4
GRE-26	776	398	1.98	1.0	38635	.97	81.6
GRE-27	857	444	1.93	1.0	38572	.98	87.6
GRE-28	781	401	1.95	1.0	43588	.96	86.0
GRE-29	766	396	1.93	1.0	38841	.99	74.0
TUR- 1	762	381	2.00	1.0	40514	1.00	73.2
TUR- 4	814	418	1.95	1.0	40635	.99	76.4
TUR- 5	843	413	2.04	1.0	41063	.99	78.4
CRI- 8	846	441	1.92	1.0	41526	.99	78.0
Mean	772	393	1.97	.89		196	76.5
F value for seedlot	4.9	4.2	1.6	7.41	3.48	1.32	1.32

Scler= Sclerenchyma layers, Sp. Gr. = Specific gravity, Tr len = Tracheid length.

Table 7. Result of analyses of variance. Kellogg Forest, Michigan MSFGP 5-61.

Character	Degrees of freedom			Mean squares			F values	
	S	R	SR	S	R	SR	S	R
39a. Br. wood Sp. Gr.	26	9	234	.0026	.0163	.0007	3.48**	21.66**
40a. Tracheid length.	26	9	234					
48. 1972 Ht.	26	9	234	19.64		3.733	5.263**	
52. Date of Pol. Shed	23	9	110	9.37		.54	17.35**	
53. Deg. of Lf. Dev.	26	9	221	49.77		3.12	15.95**	
58. Cenangium total Inf.	26	9	233	170		43.2	3.93**	
57. Cenangium ,# Tr.Inf.	26	9	225	2.77		.855	3.13**	
59. Cenangium, # Leader	26	9	225	2.04		.525	3.90**	
63. 1973 Ht.	25	9	130	286.8		56.8	5.05**	
64. Pine shoot moth	26	9	233	7.40		5.29	1.39	
65. Zimmerman moth	26	9	233	.185		.169	1.094	

S = Seedlot
R = Replicate
SR = Error

CHARACTER DESCRIPTION

A description of the characters measured at the Pinus nigra plantation at Kellogg Forest, Michigan (MSFGP 5-61).

1. 11/15/61. Dead tree count. WAL, JWW.
2. 4/62. Replaced dead trees. No count made. WAL.
3. 9/25/62. Dead tree count. WAL.
4,5. 6/25/63. 3 fascicles of 1962 leaves collected for anatomical study. Carl Lee
6. 7/21/63. 10 fascicles collected pr tree in reps 1 to 4. Time 5 hours. J.W. Andresen, Heidi H. Schlosser.
7. 11/21/63. Height, half-inches. Carl Lee.
8. 11/21/63. Dead tree count. Carl Lee. No insect damage. south ends of reps 2,3,4, need weed control.
9. 4/10/64. Needle length, eighths-of-inches. Reps 1,2, 1963 nddeles. Carl Lee.
10. 4/10/64. Bud color, reps 1,2, Carl Lee. Measurements discarded.
11. 4/10/64. Winter damage, No. of trees per 4 trees having brown needles. Carl Lee.
12. 6/3/64. Count of spray-damaged trees. Carl Lee. 360 trees whitened, all recoved later same year.
13. 9/15/64. Branch angle. Measured to nearest 5 degrees of flattest 1963 branch with vertical. Carl Lee.
14. 9/25/64. Needle length. Collected 1 fascicle per tree. cm/4 C.L.
15. 9/25/64. Height, half-inches. A few lammas shoots. C.L.
16. 9/25/64. Needle width, mm/4. C.L. Fert + unfert. separately
17. 9/25/64. Needle serrations per 2 mm. Carl Lee. Fert. + unfert. separately.
18, 19. 9/25/64. No. of rows of stomata on ventral and dorsal side respectively. Carl Lee. Fert. + unfert. respect. sep.
20. Nov. 1964. Leaf color, judged from ground samples of leaves collected 9/15/64, ground for mineral analysis. 2 samples per origin graged. One sample was reps 1-10 ert., one sample was reps. 1-10 unfert. Color scoring by Wright and Lee. Grade 1=yellow-green=Munsell 5.0Y6/6. Grade 17=blue-green- 5.0Y6/8.

Measurements by Carl Lee on the 1-needle-per-tree samples collected 9/25/6.

21. No. or resin canals.
22. Position of resin canals.
23. No. of hypodermal layers, ventral side
24. No. of hypodermal layers, corner.
25. No. of hypodermal layers, dorsal side.
26. No. of sclerenchyma layers.
27. Distance between fibrovascular bundles, in .04=mm units..
28. Length of endoderm, 104-mm. units.
29. Width of endoderm, 104-mm. units.
30. 1965 height, 1/2-inch units. Carl Lee. Nov. 1965
31. 1963 height, 1/2-inch units. " " " "
32. 1964 growth = 1964 - 1963 height, 1/2 inch units. C.L.
33. Dead tree count, 8/22/68. C.L. Heavy weed competition responsible for increased mortality in reps 4 to 7.
34. 8/22/68. No. of trees with flowers or cones. None were seen.
35. 8/23/68. Height, fortieth-of-foot units. C.L.
36. 8/24/68. Number of insect-damaged trees. Damage on 1964 to 1967 whorls. Apical portion of twig dead. Eucosma damage?

Character description (continued)

37. 8/24/68. Branch angle, 5 degree units. Angle with vertical of flattest branch of 1968 whorl. Carl Lee.
38. Branch diameter, southernmost branch of 1968 whorl, measured by steel calipers in mm/4 units. Branch severred, taken to Stevens Point for study. Carl Lee.
39, 40. 7/23/69. Height, eighth-of-foot units. Measured fertilized and unfertilized trees respectively. No significant diff., d data combined. JWW. Corrected heights by a 5-tree running average. Correction reduced error term only slightly.
41. 7/23/69. Trees per plot with Eucosma damage. 1-2 twigs per damaged tree
42. 7/23/69. Trees per plot with cones. JWW.
43. 7/23/69. Trees per plot with black-headed pine sawfly damage Damage per tree slight.
44. Deviations from variety mean. JWW. 7/23 height.
45. Correction to 7/23 height on basis of 5-tree running average.
46.. 7/23/69. Trees per plot which are Scotch pine.
47. 7/23/69. Corrected 7/23 height on basis of 5-tree running average.
48. Dead trees, by position in plot. 5/10/73. Kim Steiner.
49. Tree, per 4-tree plot, with 2 year cones. 5/10/73. K.S.
50. Trees, per 4-tree plot, with 1-year cones. 5/10/73. K.S.
51. Trees, per 4-tree plot, with male strobili. 5/10/73. K.S.
52. Date of pollen shed. 1=May 26, 2=May 29, 3=June 1, 4=June 4, 5=June 7. K.S.
53. Leaf phenology grades-sum for 4 trees. K.S. 6/4/73. 1=needle still in sheaths, 2=needles just barely out, 3=needles $\frac{1}{4}$" out of sheaths, 4=needles $\frac{1}{2}$" out of sheaths, 5=needles $\frac{1}{2}$-1" out of sh.
54.to 56. Preliminary data taken on disease. Discarded.
57. No. of trees infected in each plot. Disease is Cenangium ferruginosum. Some damage was confounded with shoot moth and was subsequently removed in character summary, 64a. Nicholas Wheeler 1/17/74.
58. Total no. of branches + terminal infected per 4-tree plot. N.W.
59. No. of leaders infected per plot. N.W. 1/17/74.
60. No. of whorls where every branch has been infected. N.W. 1/17/74.
61. Square root transformation of no. of cones observed per plot. Nicholas Wheeler 1/17/74.
62. Dead trees, by position in plot. 1/17/74. N.W.
63. Ht., in $\frac{1}{4}$ feet. Mean of two tallest trees in plot. N.W.
64. Pine shoot tip moth-total no. of shoots infected per 4-tree plot. N.W. 3/30/74.
64a. Revised Cenangium damage to remove confounded shoot tip moth. N.W. 4/28/74.
65. Zimmerman moth-total no. of trees infected per 4-tree plot. N.W. 4/13/74.

Table 8. Plantation establishment and growth characteristics for Pinus nigra at Russ Forest, Michigan (MSFGP 6-61).

Country & Seedlot	Trees Plant	Mortal-ity	Height, total				Height, total				Diameter
Age	2	15	3	5	8	15	3	5	8	15	15
Year	61	73	62	64	67	73	62	64	67	73	73
Char.		31	6	12	23	29	6	12	23	29	35
	no.	no.	centimeters				-- % of mean-				in.
COR-11	28	25	24	39	98	408	78	90	93	94	5.0
COR-12	28	27	28	38	130	305	93	88	122	70	3.0
COR-13	28	24	21	35	90	305	74	82	83	70	3.6
SPA- 2	24	4	32	47	115	442	113	108	110	101	5.4
SPA- 3	28	13	34	55	120	424	119	127	114	97	5.4
ITA- 7	28	5	29	48	129	527	101	110	122	121	5.9
FRA-10	28	16	34	47	128	410	118	108	121	95	4.8
FRA-14	28	12	25	38	93	372	86	88	87	85	4.6
AUS-23	28	9	34	53	114	451	117	121	108	103	5.1
YUG-15	28	6	32	50	123	445	111	116	117	102	4.9
GRE-16	28	27	28	48	109	--	98	111	104	--	—
GRE-17	28	16	27	43	96	430	96	100	91	98	5.4
GRE-18	28	6	28	48	118	503	98	110	113	115	6.0
GRE-19	28	10	30	43	104	446	105	99	99	102	5.8
GRE-20	28	8	28	45	102	491	99	103	96	113	5.8
GRE-21	28	9	25	33	91	378	86	80	87	87	5.0
GRE-22	24	5	30	42	104	491	105	98	99	113	5.4
GRE-24	24	10	30	43	110	378	105	99	105	87	5.2
GRE-25	28	17	35	44	106	445	124	101	101	102	5.4
GRE-26	28	10	26	36	85	454	94	84	81	104	5.9
GRE-27	28	8	23	36	95	433	80	84	90	99	5.4
GRE-28	28	18	28	43	116	424	99	99	109	97	5.4
GRE-29	24	18	34	43	93	382	107	99	89	87	5.2
TUR- 1	28	9	23	35	79	376	80	82	71	86	4.8
TUR- 4	28	11	26	41	101	451	90	94	96	103	5.8
TUR- 5	28	24	28	42	101	408	97	97	96	94	5.6
CRI- 8	28	7	27	43	98	476	92	100	94	109	5.8
Mean		13	29	43	105		100	100	100	100	5.3
F values, sig.			*	**	**	**	*	**	**	**	

Table 9. Foliar and insect damage characteristics for <u>Pinus nigra</u> at Russ Forest, Michigan (MSFGP 6-61).

Country & Seedlot		Crown dia/ht.	Foliage color	Zimmer injury	La	Lf L.	WI	BA	LA	BHP saw	Frost injury
	Age	11	11	11	3	5	5	6	5	6	6
	Year	69	69	69	62	64	64	65	64	65	65
	Char.	26	27	25	7	13	14	15	16	20	21
		cm/cm	grade	% of Tr.	T%	mm	T%	o	o	T%	Lf%
COR-11		.64	6.0	25	0	74	10	49	55	25	74
COR-12		.63	5.0	--	0	95	56	57	--	--	--
COR-13		.58	6.2	--	0	85	56	57	48	0	26
SPA- 2		.65	5.8	28	8	96	13	51	35	15	21
SPA- 3		.68	5.6	53	19	85	28	48	38	48	6
ITA- 7		.57	7.1	30	5	78	10	52	50	28	49
FRA-10		.57	6.6	58	6	80	28	49	49	23	34
FRA-14		.73	4.9	28	0	95	20	58	45	6	55
AUS-23		.62	4.8	15	20	72	10	56	55	19	36
YUG-15		.57	4.8	8	0	55	13	56	56	9	48
GRE-16		.67	6.5	--	0	73	0	--	--	--	--
GRE-17		.62	5.6	12	7	50	10	58	64	0	56
GRE-18		.62	5.8	21	5	54	20	54	61	17	51
GRE-19		.64	4.3	35	0	72	3	54	64	20	63
GRE-20		.63	6.2	8	5	54	28	52	73	14	47
GRE-21		.70	4.6	15	10	55	3	51	63	0	76
GRE-22		.61	6.0	27	4	59	7	54	61	22	62
GRE-24		.85	4.1	14	12	73	3	55	66	14	57
GRE-25		.58	6.0	35	0	51	0	55	59	0	44
GRE-26		.60	4.6	4	14	72	7	51	63	0	66
GRE-27		.64	4.6	25	5	79	0	58	56	10	86
GRE-28		.82	5.4	31	12	60	10	56	61	9	78
GRE-29		.71	5.0	25	0	64	17	51	62	0	45
TUR- 1		.68	3.9	12	10	64	10	55	61	5	66
TUR- 4		.63	6.6	21	10	73	0	51	56	5	83
TUR- 5		.67	4.7	50	14	73	0	56	61	14	62
CRI- 8		.60	5.2	25	0	74	10	56	61	0	75
Mean		.65	5.2	23.2	4	70	13	54	56	12	54

T% = Tree percent, Lf% = Leaf percent LA, LA = Leaf angle,
WI = Winter injury, BA = Branch angle, La = Lammas shoots,

Table 10. Flowering and insect and disease damage characteristics of *Pinus nigra* at Russ Forest, Michigan (MSFGP 6-61).

Country & Seedlot	Zimmer. Moth	Male Flow	Female Flower	Diplodia	Pine shoot Moth
Age	16	16	16	16	16
Year	74	74	74	74	74
Char.	30	28	32	33	34
	(a)	(b)	(c)	(a)	(a)
COR-11	8	6	0	0	1
COR-12	0	0	0	28	0
COR-13	20	0	0	0	7
SPA- 2	5	0	0	0	2
SPA- 3	9	0	0	0	0
ITA- 7	11	3	0	6	0
FRA-10	13	1	0	9	1
FRA-14	7	1	0	0	1
AUS-23	3	6	2	0	0
YUG-15	0	3	2	0	0
GRE-16	-	-	-	-	-
GRE-17	6	3	3	0	0
GRE-18	5	7	4	0	0
GRE-19	7	9	2	6	0
GRE-20	3	6	5	0	0
GRE-21	3	2	0	1	0
GRE-22	2	9	1	0	0
GRE-24	2	7	3	2	0
GRE-25	2	7	3	2	0
GRE-26	5	10	2	0	0
GRE-27	2	8	0	0	0
GRE-28	2	5	1	0	0
GRE-29	0	1	1	0	0
TUR- 1	0	3	3	0	1
TUR- 4	7	8	2	8	0
TUR- 5	14	0	0	6	0
CRT- 8	11	8	5	0	1
Mean	4	4	1	2	.5
F value	1.98*	3.0*	1.4		

Table 11. Result of analyses of variance. Russ Forest, Michigan (MSFGP 6-61).

Character	Degrees of freedom			Mean squares			F values	
	S	R	SR	S	R	SR	S	R
6. Ht. cm 1962.	20	6	113	91.8	170	46.0	2.0*	3.72**
12. Ht. cm 1964.	20	6	113	219.5	459	96.9	2.27**	4.64**
23. Ht. cm 1967.	24	6	120	1068	5640	469	2.24**	11.8**
7. Lam. growth, trees	25	9	164	.259	.446	.210	1.23	2.13*
13. Lf. len, mm	20	6	106	1312	521	138	8.94**	3.50**
14. Win. Inj. T%	20	6	106	656	2285	458	1.40	4.98**
15. Br angle 20	20	6	106	1519	1638	2040	.75	.80
16. Lf angle	20	6	106	12180	4660	2026	6.00**	2.29**
17. Lf Stiffness	20	6	106	.451	.091	.232	1.94*	.39
18. Bud color	20	6	106	.o476	.032	.052	.92	.61
20. Bhp sawfly, trees	25	9	164	.431	.177	.270	1.60	.61
21. Frost injury	25	9	164	3450	1150	730	4.73**	1.57
28. Male flowers	20	6	101	1.44	.19	.47	3.03**	.40
29. Ht. 1/4 ft, 1974	20	6	101	216	400	98.6	2.20**	4.18**
30. Zimmerman moth	20	6	101	1.94	.66	.98	1.98*	.678
32. Female flowers	20	6	101	.39	.57	.27	1.433	2.09 **
35. Stem diameter	20	6	101	116	169	75	1.547	2.253*
37. Needle angle	20	6	101	.98		.44	2.22**	
38. Branch size	20	6	101	.81		.68	1.19	

Character description, Russ Forest, Michigan (MSFGP 6-61).

1. 6/13/61. Dead tree count, J. L. Ruby and J. W. Wright.
2. 6/13/61. Count of trees which have started growth. Ruby, Wright.
3. 12/5/61. Dead tree count. Bright.
4. 4/26/62. Count of trees replaced. Soil dry, temp. 76 F., windy. Bright, Hollenbect.
5. Dead tree count, Bright, Wright. Killed one 3-foot rattler. In June Bright sprayed amino-triazole around trees. June weed control ineffective, now 100% weed cover.
6. 8/13/62. Height, cm., JWW, JNB.
7. 8/13/62. Trees per plot with lammas growth. JWW, JNB.
11. 3/23/64. Dead tree count. Carl Lee.
12. " Height, half-inches. Carl Lee.
13. " Leaf length, eighths of inches. C.L.
14. " Trees/4 trees with winter injury, brown needles. C.L.
15. " Angle of 1963 branches with vertical, to nearest 5 degrees.
16. " Angle of 1963 needles with leader, to nearest 5 degrees.
17. " Needle stiffness, 1 = stiff, 2 = less stiff. No diff. C.L.
18. " Bud color. No differences. C.L.
19. 6/9/64. Dead tree count. JNB.
20. " Trees/4 trees with black-headed pine sawfly attack. J.B.
21. " Frost damage, spring 1964. % of levs. brown, to nearest 5%.
22. 1/9/67. Dead tree count. Hanover and Wright.
23. " Height, inches. Hanover and Wright.
28. 6/1/74. Male flowers, 0 = none, 1 = 1 to 100, 2 = more than 100. Nicholas Wheeler/
29. " Height in 1/4 feet of two tallest trees in the pl0t. N.W
30. " Zimmerman moth, no. of trees infected in 4 treeplot. N.W
31. " Dead tree count by position.
32. " Female flowers 0 = none, 1 = 1 to 25, 2 = more than 25.
33. 6/2/74. Diplodia, number of branches infected per 4 tree plot.
34. " Shoot tip moth, number of branches infected per 4 tree plot. N.W.
35. " Diameter at 2nd internode in 1/10 inches.
36. " Color, 1 = yellow, 4 = green. Data discarded.
37. " Needle angle, 1 = closely appressed, 4 = widely divergent from stem. N.W.
38. " Branch size, 1 = fine, 4 = robust.

Table 12. Plantation establishment, growth and winter injury data for *Pinus nigra* at Dunbar Forest, northern Michigan (MSFGP 13-61).

Country & Seedlot	Trees Plant.	Mortal-ity	Height		Winter Injury	
Age	3	7	7	9	7	9
Year	61	65	65	67	65	67
	no.	no.	--cm---		--- grade(a)-	
COR-11	40	23	21	48	96	8
COR-12	40	22	23	58	88	8
COR-13	40	28	20	53	72	8
SPA- 2	40	16	42	61	43	8
SPA- 3	36	8	43	85	54	8
ITA- 7	36	14	32	81	74	6
FRA-10	40	26	32	79	54	8
FRA-14	36	36	--	--	--	-
AUS-23	40	5	45	147	30	1
YUG-15	32	6	47	137	24	0
GRE-16	0	0	--	--	--	-
GRE-17	40	12	36	116	44	1
GRE-18	36	6	45	147	33	4
GRE-19	36	16	43	--	46	-
GRE-20	40	7	35	119	48	4
GRE-21	40	31	29	--	67	-
GRE-22	40	6	41	119	49	3
GRE-24	40	25	30	91	68	8
GRE-25	0	0	--	--	--	-
GRE-26	40	11	30	68	51	4
GRE-27	36	20	31	96	64	8
GRE-28	40	7	41	144	45	2
GRE-29	40	21	21	94	68	8
TUR- 1	40	10	30	79	59	2
TUR- 4	40	17	35	137	54	4
TUR- 5	36	18	29	76	65	1
CRI- 8	40	15	37	94	51	3
Mean	-	41%	35	98	57	4.7

(a)
Grade, age 7: 0 = low, 100 = very high
age 9: 0 = low, 8 = severe

Table 13. Plantation establishment, mortality and growth characteristics of *Pinus nigra* at Plattsmouth, Horning Farm, Nebraska (MSFGP 63-61).

Country & Seedlot	Tr. Pl.	Tr. Dead	Total height							Total height				
Age	2	4	6	7	8	10	11	13	15	6	10	11	13	15
Year	61	63	64	65	66	68	69	71	73	64	68	69	71	73
	no.	no.	--- centimeters --------							-- % of mean ----				
COR-11			--	--	--	--	--	--	--	--	--	--	--	--
COR-12	25	6	27	37	67	149	214	329	442	51	66	69	78	84
COR-13	25	12	--	--	--	--	--	--	--	--	--	--	--	--
SPA- 2	25	2	58	77	127	250	310	402	518	107	101	101	96	98
SPA- 3	25	3	47	69	114	202	256	368	460	87	82	83	88	87
ITA- 7	25	2	57	90	147	278	342	448	573	104	113	111	107	109
FRA-10	25	--	--	--	--	--	--	--	--	--	--	--	--	--
FRA-14	4	4	--	--	--	--	--	--	--	--	--	--	--	--
AUS-23	25	2	72	117	171	290	352	451	554	133	117	115	107	105
YUG-15	25	2	66	103	165	288	370	490	585	121	117	120	117	111
GRE-16	0	--	--	--	-	--	--	--	--	--	--	--	--	--
GRE-17	25	0	74	117	169	296	357	475	579	136	120	116	113	110
GRE-18	25	1	63	105	158	280	340	466	554	117	112	110	111	105
GRE-19	25	0	64	102	155	280	346	466	559	118	112	112	111	106
GRE-20	25	2	54	88	137	252	318	438	559	99	102	104	104	106
GRE-21	25	7	33	57	100	185	238	353	448	61	75	77	84	85
GRE-22	8	1	--	--	139	--	294	--	--	--	--	91	--	--
GRE-24	25	6	46	77	115	208	258	353	424	86	84	84	84	80
GRE-25	0	--	--	--	--	--	--	--	--	--	--	--	--	--
GRE-26	25	5	53	85	129	230	280	378	482	97	93	91	90	91
GRE-27	25	3	51	80	123	242	308	445	557	95	98	100	105	106
GRE-28	25	0	57	95	140	266	326	426	548	104	107	106	101	104
GRE-29	25	3	--	--	--	--	--	--	--	--	--	--	--	--
TUR- 1	25	1	54	89	136	241	304	414	509	99	98	99	99	96
TUR- 4	25	3	47	73	118	228	284	384	512	87	92	90	91	97
TUR- 5	25	0	48	77	128	236	289	396	502	89	95	94	94	95
CRI- 8	25	1	54	91	140	260	328	445	566	99	105	106	106	107
Mean		16%	54	87	135	247	308			100	100	100	100	100

Table 14. Foliar and fruiting characteristics of *Pinus nigra* at Plattsmouth, Horning Farm, Nebraska (MSFGP 63-61).

Country & Seedlot	Ndl. ln.	Ndl. dia.	Ndl. ln.	Ndl. dia.	Cones		WI
Age	15	15	15	15	10	15	6
Year	73	73	73	73	68	73	64
	mm	mm	---- % of mean --		no.	no/pl.	gr.
COR-11	--	--	--	--	--	--	--
COR-12	151	1.59	110	96	0	30	1
COR-13	--	--	--	--	--	--	--
SPA- 2	163	1.44	119	87	0	155	1
SPA- 3	157	1.30	115	78	0	40	1
ITA- 7	149	1.66	109	100	0	235	1
FRA-10	--	--	--	--	--	--	-
FRA-14	--	--	--	--	--	--	-
AUS-23	136	1.82	99	110	11	220	0
YUG-15	129	1.67	94	101	0	75	0
GRE-16	--	--	--	--	--	--	-
GRE-17	133	1.65	97	99	0	125	0
GRE-18	139	1.70	101	102	0	120	0
GRE-19	125	1.57	91	95	0	75	0
GRE-20	121	1.56	88	94	1	105	0
GRE-21	111	1.63	81	98	0	95	1
GRE-22	--	--	--	--	--	--	-
GRE-24	126	1.84	92	111	1	110	0
GRE-25	--	--	--	--	--	--	-
GRE-26	128	1.74	93	105	0	105	0
GRE-27	148	1.70	108	102	0	75	0
GRE-28	127	1.55	93	93	0	130	0
GRE-29	--	--	--	--	--	--	-
TUR- 1	135	1.79	98	108	3	190	0
TUR- 4	131	1.66	96	100	0	100	0
TUR- 5	133	1.74	97	105	0	65	0
CRI- 8	152	1.80	111	108	0	125	0
Mean	136	1.65	100	100	.8	94	

Ndl. = Needle, ln. = length, dia. = diameter, WI = Winter injury, grade: 0 = none, 1 = some.

Table 15. Plantation establishment, growth and foliar characteristics of *Pinus nigra* at Wooster, Ohio (MSFGP 66-61).

Country & Seedlot	Trees Plant.	Trs. Dead	Total Ht.			Total Ht.			Leaf Len.	
Age	3+	3+	6	7	8	6	7	8	6	6
Year	62	62	65	66	67	65	66	67	65	65
	no.	no.	---- cm ---			-- % of mean			mm	%mean
COR-11	40	40	43	64	88	70	53	55	79	81
COR-12	40	39	50	--	--	82	--	--	90	93
COR-13	0	--	--	--	--	--	--	--	--	--
SPA- 2	40	32	63	134	180	108	112	113	133	137
SPA- 3	40	29	57	116	155	93	97	97	111	114
ITA- 7	40	31	67	152	210	111	127	131	121	125
FRA-10	40	34	63	131	195	104	109	122	84	87
FRA-14	40	34	55	110	143	90	92	89	125	129
AUS-23	40	22	62	119	168	101	99	105	97	100
YUG-15	40	18	68	134	177	115	112	111	89	92
GRE-16	40	40	--	--	--	--	--	--	--	--
GRE-17	40	29	56	119	162	92	99	101	91	94
GRE-18	40	31	62	128	171	101	107	107	95	98
GRE-19	40	28	61	131	174	100	109	109	86	89
GRE-20	40	25	55	116	152	89	97	95	79	81
GRE-21	40	38	43	88	122	71	73	76	80	82
GRE-22	40	22	58	119	152	95	99	95	86	89
GRE-24	40	30	58	119	152	95	99	95	103	106
GRE-25	40	30	67	143	186	110	119	116	91	94
GRE-26	40	35	51	116	152	84	97	95	94	97
GRE-27	0	--	--	--	--	--	--	--	--	--
GRE-28	40	27	60	122	162	98	102	101	94	97
GRE-29	40	40	--	--	--	--	--	--	--	--
TUR- 1	40	31	55	110	146	91	92	91	99	102
TUR- 4	40	35	54	116	152	89	97	95	92	95
TUR- 5	40	29	54	113	152	88	94	95	97	100
CRI- 8	40	26	64	137	180	105	114	113	105	108
Mean		77%	61	120	160	100	100	100	97	100
F value			12.1	7.38	7.15				10.6	

Note: Mortality, as noted above, is not a true indication of permanent plantation representation. Many trees were replaced the second year.

Table 16. Foliar, insect damage and fruiting characteristics of *Pinus nigra* at Wooster, Ohio (MSFGP 66-61).

Country & Seedlot	Foliage Color	BHP Sawfly	Female Strob.
Age	9	9	9
Year	68	68	68
	grade(a)	# trs. inf.	trs/plot with
COR-11	4.0	6	1
COR-12	--	--	--
COR-13	--	--	--
SPA- 2	5.0	22	1
SPA- 3	4.0	23	0
ITA- 7	6.0	27	5
FRA-10	6.0	21	2
FRA-14	4.5	18	2
AUS-23	4.0	1	5
YUG-15	4.5	17	3
GRE-16	--	--	--
GRE-17	4.5	14	5
GRE-18	4.0	9	2
GRE-19	4.0	7	1
GRE-20	4.0	11	5
GRE-21	3.5	0	1
GRE-22	3.5	5	1
GRE-24	4.5	1	1
GRE-25	4.0	2	3
GRE-26	4.5	15	0
GRE-27	--	--	--
GRE-28	4.0	13	0
GRE-29	--	--	--
TUR- 1	3.5	3	9
TUR- 4	4.5	10	0
TUR- 5	3.5	5	2
CRI- 8	4.5	6	6
Mean	4.3	10.5	2.6
F value	3.19*	5.54*	1.67

(a) grade: 0 = yellow, 10 = blue-green

Table 17. Plantation establishment and growth characteristics of *Pinus nigra* in Mason County, Illinois.

Country & Seedlot	Trees Planted	Trees Dead	Trees Alive(a)	Total height	
Age	3	3	5	5	5
Year	61	62	64	64	64
	no.	no.	no.	cm	% mean
COR-11	24	23	4	18	62
COR-12	24	22	1	9	31
COR-13	24	12	2	18	64
SPA- 2	24	12	14	33	114
SPA- 3	24	15	14	28	98
ITA- 7	24	21	4	21	74
FRA-10	24	13	5	32	111
FRA-14	24	18	4	27	96
AUS-23	24	4	20	26	89
YUG-15	24	8	19	32	111
GRE-16	0	--	--	--	--
GRE-17	24	12	11	28	99
GRE-18	24	11	14	29	102
GRE-19	24	15	11	36	127
GRE-20	24	15	15	25	86
GRE-21	24	15	10	25	88
GRE-22	0	--	--	--	--
GRE-24	24	11	10	26	89
GRE-25	0	--	--	--	--
GRE-26	24	5	13	27	94
GRE-27	24	9	13	33	115
GRE-28	24	--	--	--	--
GRE-29	24	16	8	31	106
TUR- 1	24	17	15	27	95
TUR- 4	24	11	12	33	114
TUR- 5	24	14	12	31	107
CRI- 8	24	21	2	24	85
Mean		58%	42%	28.6	100

(a) Number of trees remaining alive after replacement of original mortality two years prior.

APPENDIX B

APPENDIX B

NEEDLE AND BRANCH CHARACTERS

Since the establishment of the geographic origin tests in *Pinus nigra*, a number of morphological, physiological and anatomical characters have been measured by Carl Lee and others. Most of this information was obtained from the Kellogg Forest Plantation because it had the lowest mortality and most complete representation of seedlots. Lee (1968) measured 16 different needle characteristics in *Pinus nigra*, 10 of which exhibited statistically significant differences among seedlots. In addition, several branch characters were observed including branch-wood specific gravity and tracheid length (Lee, unpublished data). This information is valuable in the identification of genetic variability patterns and more specifically, identification of individual seedlots that may provide a basis for improvement through breeding.

A few generalizations may be made concerning patterns of genetic variability in leaf and branch characters of European black pine. Lee (1968) noted that Western seedlots (Spain, France, Corsica and Italy) were characterized by long, fine needles with a blue-green tinge. The needles were often closely appressed to the stem. With the exception of the Spanish seedlots, western trees had relatively fine branches. Some individual western seedlots could be distinquished relatively easily because of their particular combination of characters. Spanish trees had an airy appearance due to their long needles, short needle retention and very robust branches. Corsican seedlots had fine, orange branches and long, curly needles. Anatomically, western seedlots had leaves with more resin canals and fewer hypodermal and sclerenchyma layers than did trees from the remainder of the species' range.

In contrast, eastern seedlots (Yugoslavia, Austria, Greece, Turkey, and Crimea) normally had short, stout needles on robust branches. Although large between-seedlot differences existed in most characters measured, it was essentially impossible to identify specific eastern seedlots. Considerable within-region variation existed.

Two important wood properties, tracheid length and specific gravity, were also found to differ considerably among seedlots. Although statistically significant (1% level), the absolute differences in tracheid length were so small as to be of little practical importance. Specific gravity was relatively uniform over much of the species' range with the single exception of YUG-15 which had a far higher specific gravity than the other seedlots (specific gravity = .44 for YUG-15 and .41 for all others, approximately). Perhaps the most valuable information obtained about specific gravity was its relationship with tree height. Although weak (correlation coefficient r = .37, 25 degrees of freedom), the positive relationship between 1968 height and branchwood specific gravity implied that selection for faster growing individuals does not necessarily result in selection for wood of lower specific gravity.