RESULTS ON STUDIES OF SIXTEEN GEOGRAPHIC STRAINS OF PINUS STROBUS AND FOUR OTHER WHITE PINE SPECIES IN MARYLAND[1]

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INTRODUCTION

Eastern white pine (Pinus strobus L.) is one of the most planted trees in the northeastern United States. Unfortunately, it is susceptible to white pine weevil (Pissodes strobi Peck) and to white pine blister rust (Cronartium ribicola Fisch). Many past and current studies have been designed to develop more pest resistant and rapidly growing strains (Garrett et al., 1973; Gerhold and Soles, 1967; Wright, 1970). Also, feasibility of growing some selected exotic white pines is under consideration (Wright, 1958).

Two intensive white pine studies have been initiated in Maryland. One experiment includes geographic strains from over 100 different seed sources (Genys, 1968). The second, which is described in this report, was designed to compare the performance of 16 geographic strains P. strobus with two populations of Western white pine (P. monticola Dougl.), two progenies of planted Himalayan white pines (P. griffithii McClell.), one population of sugar pine (P. lambertiana Dougl.), and one progeny from an open pollinated Mexican white pine (P. ayachahuite Ehren.). The main objectives were to gather more information about the intra-specific variation in eastern white pine, studied in three different physiographic regions of Maryland, and to learn more about possibilities of using exotic white pines as substitutes to P. strobus.

MATERIALS AND METHODS OF STUDY

This study included two sets of 2-0 trees used for field plantings. The seedlings of ten geographic strains of P. strobus, originating from natural stands in Michigan, were grown at Michigan State University's experimental nursery. The planting stock of six other strains of P. strobus and four other white pines were grown at the State Forest Tree Nursery in Harmans, Maryland; their two-year growth rates were described by Genys in 1965.

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In March 1965, the 2-0 seedlings from both nurseries were planted in three different physiographic regions of Maryland: (1) Coastal Plain, (2) Piedmont Plateau and (3) Allegheny Mountains (Table 1). In each plantation the trees were arranged in a similar design: each strain in each of four blocks was represented by a square plot of 4 trees spaced at 8x8 feet. Plot sums or plot means were used for the analysis of variance with 21 degrees of freedom (df) for strains, 3 df for blocks, 63 df for error, and 87 df for total. Strains represented by less than 8 trees were not included in the analysis, and the degrees of freedom were adjusted accordingly. The data were also subjected to correlation analysis.

Table 1.--Location and description of test plantations

Plantation name, location, site and elevation	Planting data and experimental design
Coastal Plain, grounds of the Baltimore International Airport, Anne Arundel County, Md.; dry sandy soil at elevation of about 100 feet above sea level.	20 populations represented by 4-tree plots, in each of four blocks. Planted on March 5-11, 1964; dead trees were replaced in Spring 1965
Piedmont Plateau, grounds of the Patapsco Reservoir - Liberty plantations, Carroll Co., Md. well-drained former farm land at elevation of about 450 feet.	20 populations planted on March 9-12, 1964 in a similar arrangement as above; dead trees were replaced in 1965; volunteer hardwoods were cut out each year.
Allegheny Mountains, grounds of the Carey Run Bird Sanctuary, Garrett Co., Md.; a hill-top site, formerly farmland with shallow soil, only scarce competing vegetation; short growing season (120-150 days). The site is at elevation of 2,400 feet.	17 populations were planted on March 9-12, 1964; arranged in four randomnized blocks as above; one population of Pinus jeffreyi (Griseb.) was fincluded for comparison.

RESULTS

The data on the performance of different white pines studied in three locations are listed in Table 2. The relationships among the data from different plantations, and the data collected at different ages of trees are expressed by correlation coefficients in Table 3.

Table 2.--Survival and growth rates of different white pine species and some of their geographic strains in three research plantations in Maryland 12 years after planting. Height data listed in italics are based on a sample of less than 8 trees and are not included in the analysisof variance.

Seed lot No.	Species of Pinus State (or Province) and County	North Latitude	West Longitude	Trees Survived of 16 Planted: Coast Plane	Piedmont	Mountains	Height: Coast Plane	Piedmont	Mountains
	P. strobus				number			feet	
66	So. Carolina, Oconee	34 50'	83 10'	16	14	15	18.4	20.9	12.3
47	Maryland, Garrett	39 25'	79 24'	13	13	14	14.3	20.6	14.8
65	Maryland, ?	--	--	12	13	10	21.3	19.7	12.9
790	Michigan, Iosco	44 12'	84 38'	14	15	10	15.6	18.3	13.1
792	Michigan, Ogemaw	44	84	13	15	13	19.2	19.2	16.1
785	Michigan, Manistee	44 15'	86 05'	8	13	-	15.1	21.3	-
783	Michigan, Manistee	44 15'	86 05'	14	13	14	20.1	18.1	12.8
784	Michigan, Manistee	44 15'	86 05'	-	-	11	-	-	13.3
787	Michigan, G. Traverse	44 33'	85 55'	15	16	12	14.4	18.5	12.1
786	Michigan, G. Traverse	44 36'	85 29'	14	-	-	16.8	-	-
789	Michigan, Mackinac	46 02'	85 36'	8	14	14	14.1	17.9	11.7
788	Michigan, Chippewa	46 02'	85 06'	11	13	-	15.8	18.9	-
791	Michigan, Schoolcraft	46 05'	86 15'	10	9	-	8.1	11.2	-
3	Quebec, Coerthier	46 17'	73 25'	14	10	16	12.8	13.6	12.2
1	Minnesota, Itasca	47 19'	93 34'	14	11	15	17.4	14.5	12.2
13	Rochester, N. Y. **	--	--	-	10	-	-	16.4	-
	P. ayacahuite x ?								
12	Rochester, N. Y. *	--	--	4	5	12	*14.4*	*15.1*	7.9
	P. monticola								
45	Idaho, Benewah	43 03'	116 35'	9	9	11	8.4	11.4	10.9
42	Idaho, Benewah	43 03'	116 35'	4	11	10	*5.6*	7.5	10.6
	P. lambertiana								
11	Oregon, Lane	43 26'	122 20'	3	11	10	*7.4*	8.2	9.3
	P. griffithii								
15	Oxford, Md. *	--	--	2	10	2	*10.3*	10.5	*5.7*
14	Solomons, Md. *	--	--	11	14	4	9.5	11.4	*7.9*
The least significant differences (at .05 level):				10	7	8	7.5	6.3	n.s.

* planted trees of unknown origin; in Rochester and Solomons, trees were exposed to pollen of related species.
** planted tree labelled as *Pinus strobus* var. *fastigiata* (a cultivar).

Mortality

In the plantation on Maryland's Coastal Plain near Baltimore, more than one-third or 35 percent of all pines in this study died before the end of twelve growing seasons (Table 2). The major cause of mortality was attributed to dryness of the soil. Among the eastern white pines, survival varied from 50 to 100 percent. With the exception of the population of the Himalayan white pine from a planted tree in Solomons, Md., the exotic pines - sugar pine, Mexican pine and western white pine - showed a high rate of mortality.

In the Liberty Plantation on Maryland's Piedmont Plateau the average mortality of all planted pines was only 24 percent. Among the eastern white pines, mortality rates ranged from 0 to 44 percent. In this plantation, Himalayan white pine, western white pine and sugar pine had a satisfactory survival, while about 70 percent of the Mexican pine trees died. In the Allegheny Mountains (Garrett County, Md.), the overall mortality was 29 percent. Among eastern white pines, the mortality rates ranged from 5 to 38 percent. In this plantation, the Mexican white pine, western white pine and sugar pine showed a good survival, but more than 75% of Himalayan white pines died.

Variation in Heights

Heights in the Coastal Plain

On the grounds of Baltimore's International Airport the 14-year heights of different strains of P. strobus ranged from 8.1 feet (Schoolcraft Co. Michigan) to 21.3 feet (Maryland, source unknown). The four surviving trees of P. ayacahuite averaged 14.4 feet, but P. griffithii, P. lambertiana and P. monticola grew relatively slow.

Heights in the Piedmont Plateau

In the Liberty plantation, located 25 miles west of Baltimore, heights of P. strobus ranged from 11.2 feet (Schoolcraft Co., Mich.) to 21.3 feet (Manistee Co., Mich.). As in the Coastal Plain plantation, the progeny of P. ayacahuite grew rapidly (15.1 feet) while the other exotic white pines grew at rates similar to the slowest growing P. strobus. In decreasing order, these pines ranked as follows: P. griffithii, P. monticola, and P. lambertiana.

Heights in the mountain region

In Garrett County, a region of the Allegheny Mountains, the average height of the 11 strains of Pinus strobus varied from 11.7 feet (Mackinac Co., Mich.) to 16.1 feet (Ogemaw Co., Mich.). The So. Carolina source that grew rapidly in Maryland's Piedmont

Plateau and in the Coastal Plain, showed only a moderate growth rate in Garrett County. In this plantation, Himalayan white pine showed very poor survival and very poor growth rate. The other exotic species also grew slower than eastern white pine; P. monticola averaged 10.7 feet, P. lambertiana - 9.3 feet, and P. ayacahuite progeny - 7.9 feet.

Attack by Nantucket Pine Tip Moth

Himalayan White Pine - A Host of Nantucket Pine Tip Moth

This study led to the first observations ever reported that Himalayan white pine (P. griffithii) is susceptible to Nantucket pine tip moth (Rhyacionia frustrana (Comst.). There is no previous record of this insect attacking any white pine, series Strobi. The common hosts of this insect are Virginia pine (P. virginiana Mill.), pitch pine (P. rigida Mill.), loblolly pine P. taeda L.) and Scotch pine (P. sylvestris L.).

The first attacks of Himalayan white pine by R. frustrana were observed in the plantations in Maryland's Coastal Plain and Piedmont Plateau. The injury was similar to that on other pines as described by Yates and Beal, 1962. In the spring after the eggs are laid and larvae hatch, they migrate to the shoot tips and bore into the bud or the stem where they feed for about 4 weeks. The terminal 2 to 5 inches of the shoot are injured. When such shoot is killed, a side branch becomes dominant and the tree develops a crook.

In Himalayan white pines, the repeated attacks by Nantucket pine tip moth reduced the growth rate and resulted in many trees having mutiple stems. With increased age and height, the frequency of injury decreased and some previously injured trees resumed their normal growth patterns.

In this study, much of the growth potential of Himalayan white pines at the young age was affected by the Nantucket tip moth. Trees that escaped injury grew as rapidly as the best strains of P. strobus.

Relationship of Data on P. strobus from Different Plantations

The survival rates of different populations of eastern white pine in the mountains were negatively correlated with the survival rates of the same strains planted on the Coastal Plain ($r = -.59$). This inverse correlation was not significant (at 0.05 level), but it indicated that the major factors causing mortality in these two plantations were different. Also, no significant correlations were among the survival rates in other plantations.

The heights of eastern white pine in the Piedmont Plateau were significantly correlated with their survival rates (r = .74) and the heights in the Coastal Plain (r = .59). There was no significant correlation between the heights in the mountains and the heights of the same strains in other two regions. This indicates that selection of white pine seed sources for the mountain region cannot rely on the basis of studies in the Coastal Plain (r = .25) or in the Piedmont plateau (r = .41).

Table 3.--Relationships of data on survival and heights of different strains of eastern white pine planted in three different plantations. Significant (at 0.05 level) correlation coefficients (r) are marked by asterisks.

		Survival			Heights		
Data Code:		A	B	C	D	E	F
Data Code	Survival						
A	Coastal Plain	1.00					
B	Piedmont Plateau	.21	1.00				
C	Mountains	.10	-.59	1.00			
	Heights						
D	Coastal Plain	.36	.48	-.31	1.00		
E	Piedmont Plateau	.03	.74*	-.42	.59*		
F	Mountains	.03	.25	-.18	.25	.41	1.00

DISCUSSION

The results of this study indicated that all strains of eastern white pine had relatively good survival rates in all three regions of Maryland. Himalayan white pine survived well in the warmer regions but not in the mountains. Other exotic white pines - P. monticola, P. lambertiana and P. ayacahuite showed a better survival in the mountains than in either the Piedmont plateau or the Coastal Plain.

The growth rate of P. strobus was not surpassed by any of the exotic pines included in this study. However, western white pine had a good survival and moderate growth rates in the Allegheny region. On the basis of observed characteristics in these test plantings this species deserves serious consideration as a potential Christmas tree. In comparison to P. strobus, western white pines had darker green foliage, shorter needles and shorter branches. Because of their slower growth rate, they also had shorter internodes and more compact crowns. Since eastern white pine is occasionally grown for Christmas trees, it would be advisable to include some western white pine and compare its value in more detail. When growing Himalayan pines for ornamental or

other reasons, it is possible that they may become crooked because of attack by Nantucket pine tip moth.

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