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The Structure of the Pinus sylvestris L. in the Insular Pine Forests of the South Russian Plain

By A. I. CHERNODUBOV

The Forest Cultures and Breeding Chair of the Voronezh Forest Engineering Institute, Timiryazev Str. 8, 394043 Voronezh, Russia. The Central Research Institute of Forest Genetics and Breeding, Lomonosov Str. 105, 394043 Voronezh, Russia

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Summary

Some morpho-anatomical traits of cones, seeds, pine-needles and biochemical traits (isoenzymes, essential oils) of *Pinus sylvestris* L. were studied with the help of factor analysis in disjunct forests of the south Russian plain.

It is found out that 56% of the variation is accounted for by the first factor, which is connected with isoenzymes.

The second factor accounts for 22% of the variation and is determined by needle length (weight coefficient 0.882), filled seeds (0.849) and by cone size, with diameter weight coefficient 0.793 and length, 0.728.

The third factor accounts for 9% of variation and is linked to the monoterpene fraction of the essential oils.

The borders of defined populations do not coincide with forest type boundaries but approach the eco-climatic zones of the Russian plain.

Key words: Population, insular pine forests, *Pinus sylvestris*, factor analysis.

FDC: 165.5; 174.7 *Pinus sylvestris*; (470).

Introduction

Pinus sylvestris L. growing in different ecological and geographical conditions has formed a great quantity of forms, ecotypes and subspecies in the process of evolution.

The variability of different traits is particularly high in island and relict pine forests of the south Russian plain (PRAVDIN, 1964; LARIONOVA, MILUTINA et al., 1988).

It is evident from the literature on this species that the search for morpho-physiological (PRAVDIN, 1964; MAMAEV, 1973; CHEREPNIN, 1980; MAMAEV and MAKHNEV, 1982, 1988; SIDELNIKOVA and MURATOVA, 1991) and biochemical traits (ALTUKOV, KRUTOVSKY, DUKHAREV et al., 1989; CHERNODUBOV and DERYUZKIN, 1990; GONCHARENKO, PADUTOV, SILIN et al., 1991) which would reflect the genetic structure of natural stands has been carried out intensively.

Some authers (VIDYAKIN, 1991a and b; YABLOKOV, 1980) assert that the most informative method involves indices.

Some researchers (KRAVTSOV and MILUTIN, 1981, 1985; SEMERIKOV, 1981, 1986; MILUTIN, 1982) consider that success is achieved only when studying a complex of traits and making use of multivariate analysis.

The purpose of this work is to select the most informative traits of some morpho-anatomical and biochemical indices in these pine forests for studying population structure.

Material and Methods

The chalk (calciphilic) "island" pine forests of the Privolzhskoy, the middle-Russian hills, the Donetsk ridge and sandy (acidophilic) pine forests of the Russian plain were the subject of the investigation (*Table 1*).

All these stands are native forests and they are protected areas (forest reserves, game reserves, genetic reserves, monuments of nature, etc.). Sample plots were laid out in these areas. Then 25 to 50 trees were randomly selected in each stand with the exception of the stand in Novo-Oskol where only 11 trees remained. In October-November, 1987, collections were made from the same trees, from the southern side of the middle part of the crown of 30 cones and samples of needles; part of these were fixed in 96% ethyl alcohol and glycerin in 3:1 mixture, and stored for studying morpho-anatomical traits. The other portion of needles in polyethylene bags was kept in a refrigerator for extraction of essential oils.

The length of 20 pairs of needles from every tree was measured by means of a ruler. The width and thickness on 10 microscopic cross-sections of every needle were determined by means of an eyepiece micrometer. The same preparations were used to count the number of resin canals (PRAVDIN, 1964; MAMAEV, 1973).

Table 1. — Description of the stands.

Stand	Forest type	Storey	Age, years	D*, cm	N**, m	Site quality	Density of stocking
	Calciphilic pine forest						
Slavyanskoe (Donetsk region)	Chalk pine forest, grass-steppe	1	160-180	46,0	15,0	Y	02-03
		11	50-60	25,0	8,0		
Shebekinskoe (Belgorod region)	-"-	1	160-180	44,0	15,0	Y	02-03
Khvalynskoe (Saratov region)	-+-	1	120-140	38,0	13,5	Y	02-04
		11	70-100	29,0	7,5		
Zhigulevskoe (Samara region)	-"-	1	180-220	40,0	20,0	1Y	01-03
Novo-Oskolskoe (Belgorod region)	Chalk pine forest; compound	1	160-180	42,0	24,0	111	06-07
		11	30-40	-	11,0		
	Acidophilic pine forest						
Cherkasskoe (Cherkass region)	Various grass-pine forest	1	100-120	29,0	19,5	1Y	04-05
Novo-Moskovskoe (Dnepropetrovsk region)	-"-	1	100-120	20,0	20,0	111	05-07
Kremenskoe (Lugansk region)	-"-	1	100-120	32,0	20,0	111	05-07
Staro-Oskolskoe (Belgorod region)	-+-	1	100-120	30,0	18,0	111	06-07
Khrenovskoe (Voronezh region)	Steppe, pine forest	1	120-140	33,0	21,0	111	05-07
Usmanskoe (Voronezh region)	Sedge, various pine forest	1	120-140	34,0	23,0	111	05-07

*) — diameter
**) — height

The length (L) and diameter (D) at the broadest part of 30 cones from every tree were measured by meaes of calipers. The ratio of cone diameter to length (D/L) formed the index of cone form (MAMAEV, 1973).

After measurement every cone was dried and seed extracted. The number of full seed (full-seed %), the number of emply seeds and the total number of seeds were counted. The weight of 1000 seeds and colour code (1-black, 2-grey, 3-brown, 4-spotted) was also determined.

The essential oil was extracted and the qualitative and quantitive composition was determined by gas-liquid chromatography (CHERNODUBOV and DERYUZHKIN, 1990).

Isoenzyme analysis of the seeds was done at the Institute of Forest A. Sc. Belorus (GONCHARENKO, PADUTOV and POTENKO, 1989).

The data were analysed using the methods of mathematical statistics and multivariate analysis.

Results and Discussion

The cone, seed, needle, essential oil and isoenzyme data were subjected to one of the multivariate analysis — factor analysis (*Table 2*). According to the *table 2* data 56.2 % of all variation is accounted for by the first factor, related to the isoenzyme analysis. The second factor, whose contribution of 21.6 % of variation is determined mainly by the length of needles (weight coefficient 0.882), the full-seed % (0.849) and by the cone size (diameter 0.793 and length 0.728). The third factor (variation accouted 9.2 %) depends mainly on the components of the monoterpene fraction of the essential oils (weight coefficient from 0.981 to 0.623). The total variation accounted for by the 3 factors is 87.0 %.

Distribution of *Pinus sylvestris* L. in "island" pine forests of the southern Russian plain is given in *figure 1*, which shows that they form 2 groups: the first group consists of stands which are on the border of the steppe and the partially-wooded steppe (4-Zhigulevskoe, 1-Slavyanskoe, 2-Shebekinskoe, 3-Khvalynskoe, 7-Novo-Moskovskoe, 6-Cherkasskoe, 8-Kremenskoe) and the second group is composed of stands which are about 100 km to the north inside the partially-wooded steppe zone. These are 5-Novo-Oskolskoe, 9-Staro-Oskolskoe, 11-Usmanskoe. And it is the 10-Khrenovskoe pine forest which stands quite

Table 2. — **The matrix of the factor components of *Pinus sylvestris* L. in the insular pine forests of the south of the Russian plain.**

	Traits	Factors 1	11	111
SEEDS	Totol number of seeds	0,144	0,554	0,066
	Empty seed number	0,242	-0,004	-0,053
	Full-seed, %	0,180	0,849	-0,088
	Seed weight (1000 seeds),g	-0,235	0,642	-0,249
	Color (code 1-4)	-0,279	-0,034	0,769
CONES	Length, mm	-0,043	0,728	0,080
	Diameter, mm	-0,024	0,793	-0,131
	Index	0,019	-0,479	-0,563
PINE NEEDLES	Length, cm	0,100	0,882	-0,263
	Width, mm	0,118	0,344	0,102
	Thickness, mm	0,118	0,388	0,091
	The number of resin canals	0,206	0,336	-0,555
ESSENTIAL OIL	α-Pinene, %	-0,300	-0,523	-0,766
	Camphene, %	0,163	0,507	-0,917
	β-Pinene, %	0,021	0,397	-0,718
	Δ^3-Carene + Mercene, %	0,289	0,217	0,981
	Limonene, %	-0,060	0,378	0,918
	β-Phellandrene, %	-0,142	0,413	0,708
	Terpinolene, %	0,115	-0,030	0,623
ISOENZYMES	ADH-1	-0,572	-0,075	-0,016
	ADH-2	-0,557	-0,029	0,120
	GDH	-0,531	-0,083	-0,131
	AAT-1	-0,579	0,029	0,005
	AAT-2	-0,560	-0,027	-0,024
	AAT-3	-0,563	0,056	-0,088
	PGM-1	-0,576	-0,008	0,021
	PGM-2	-0,579	0,029	0,005
	LAP-1	-0,571	-0,016	-0,070
	LAP-2	-0,574	-0,024	0,029
	GPI	-0,574	0,021	-0,011
	MDH-1	-0,576	0,024	0,051
	MDH-2	-0,579	0,040	0,043
	MDH-3	-0,571	0,038	0,043
	MDH-4	-0,539	0,115	0,139
	DIA-1	-0,565	0,038	0,040
	DIA-2	-0,579	0,029	0,005
	IDH	-0,579	0,029	0,005
	6-PQH-1	-0,547	0,120	0,203
	6-PQH-2	-0,517	0,155	0,080
	FL-EST	-0,571	0,035	0,013
Variability, %		56,2	21,6	9,2
Accumulated variability, %		56,2	77,8	87,0

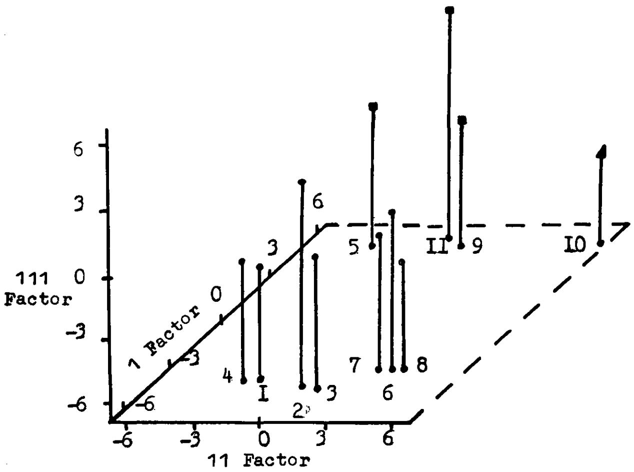

Figure 1. — Distribution of *Pinus sylvestris* stands of the insular pine forests of the south Russian plain — according to Factor Analysis (1-Slavyanskoe,. 2-Shebekinskoe, 3-Khvalynskoe, 4-Zhigulevskoe, 5-Novo-Oskolskoe, 6-Cherkasskoe, 7-Novo-Moskovskoe, 8-Kremenskoe, 9-Staro-Oskolskoe, 10-Khrenovskoe, 11-Usmanskoe).

separately. Its peculiarities have been noted by other researchers, including seed characteristics and wood quality (Veresin, 1971; Semenov, 1987).

Two alternative views exist concerning the borders of present populations; the first — population borders coincide with forest types (Pravdin, 1978) and the second — populations are vast and they have borders inside the forest vegetation zones (Semerikov, 1986). This study supports the second view as the native forest type which grows in clearcut, contrasting ecological conditions (chalk and sandy pine forests) coincide on the whole with the eco-climatic zones which are found in both groups (Meshkov, 1952).

Conclusion

On the basis of these studies it is established that: 1. When studying the stands of *Pinus sylvestris* L. it is advisabli to make use of the multivariate approach, and the structure of populations has to studied first with isoenzyme analysis as this method is the most informative one. From the morpho-anatomical traits the important contributions are the variation in needle length, cone size and fullseed %. The third factor is the qualitative and the quantitative composition of the essential oils.

2. The borders of populations do not coincide with the forest types but they tend to approach the natural climatic zones of the Russian plain.

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