GENETIC DYNAMICS OF CONIFEROUS INTRODUCENTS IN THE CONDITIONS OF A FOOTHILL DESERT-STEPPE ZONE IN THE SOUTH OF KAZAKHSTAN

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Abstract: Forest breeding should be produced not only by the representatives of the local flora, which is not very diverse in some areas of the Republic of Kazakhstan, but by species and forms of trees growing in temperate zones of the worldwide. In particular, this refers to arboretums located in the conditions significantly different from the place of natural growth of the introduced species. One of this arboretum is the JSC "Forest nursery" of the Ministry of Science and Higher Education of the Republic of Kazakhstan which is located in the South-East of the republic.

The aim of this study was to study the ecological and genetic variability of coniferous introducents in the foothill desert-steppe zone and to determine the share of genetic and environmental factors. The variability and the relative stability of the expression of the quantitative trait in ontogenesis, which characterizes the species adaptation to the new conditions in 9 Yellow pine trunks, Crimean pine trunks and Scots pine trees, 7 Blue spruce trees and the same number of trees in European spruce, in which annual increments of the height of one morphological Location.

Beginning with the growth of 2014 and then sequentially down the trunk, so long as lateral branches of the first order in whorls were preserved or traces were observed in a good way.

Thus, the value of the mean squares differs significantly in the increments of a single morphological location and in the increments of tree groups, in the introductions species and in the periods of their life. Therefore we are allowed to conclude that there are still some parts and interference in the estimation of the ecological, genotypic and phenotypic dispersions that have different values and are manifested to a greater extent, or in the analysis of increments of tree groups, or increments of one morphological location, that is, they change the cause of their display.

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Introduction

The specific harsh environmental conditions of the desert-steppe zone of the Republic of Kazakhstan which are not suitable for forestry mean that afforestation should be performed not only with local flora, which in some areas of the Republic is not very diverse, but also using species and forms of trees growing in other countries of the temperate zones of the world. The study of forestry potential of the introduced most valuable species is of great importance. Such work is under the responsibility of the botanical gardens and arboretum. This applies in particular to the Arboretum located in the conditions that differ significantly from the natural habitats of the introduced species. This kind of arboretum is the JSC "Forest nursery" of the Ministry of Science and Education of the Republic of Kazakhstan which is located in the south-east of the country. It has a concentration (according to inventory 2014) of more than 1300 species, forms and varieties of trees and shrubs, representing 58 families and 153 species, introduced from different countries of Eurasia, the Mediterranean, North America, China, Korea and Japan.

The main features of the local climate should be considered relatively high air temperature from spring to late fall, especially in the summer months, the atmospheric dryness, coinciding with a period of high temperatures, dry winds domination, and therefore intensive evaporation resulting in a clear shortage of moisture.

The plantings of the arboretum are unique in the creation of a large enough biogroup collectively resembling the likeness of a forest environment; allowing to count per unit area (per hectare), important inventory indices of their growth and productivity. For the state with low forest cover it is extremely important to obtain marketable timber for the needs of construction, paper, wood chemistry and other purposes regardless of "vagaries" of the international market.

The arboretum's introducents are reached the age of about 60 years, it is enough to demonstrate its ability to adapt to harsh environments, and yet it is not enough to complete the process of acclimatization.

It is necessary to examine the results of acclimatization of the introduced tree species in order to better understand the process and learn how to manage them during this period of transition.

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The aim of the study was to evaluate the ecological and genetic variability of the introduced coniferous in the conditions of a foothill deserted-steppe zone and to the determine requirements in the variability of genetic and environmental factors, as well as the relative stability of expression of quantitative traits in ontogenesis, which characterizes the features of adaptation of a species to new conditions.

Material and methods

The growth dynamics of Pitch pine (*Pinusrigida* Mill) Crimea pine (*P. nigra*) Scots pine (*P. sylvestris* L.), Blue spruce (*Piceapungens* Engelm.) and Fir spruce (*Piceaexelsa* Link.) was studied in the JSC "Forest nursery" Arboretum, Astana, Kazakhstan. The annual increments in height since 2014 and in earlier years have been measured down on the stem in between consecutive whorls with lateral branches or clearly distinguishable traces of them. Seven from nine trees of each tree species were measured. The phenotypic variability of quantitative traits genetically diverse populations is a complex result of the interaction of genotype and environment (Turbin, 1961; Leper&Nikoro, 1966; Dyakov & Dragavtsev, 1975; Dyakov et al., 1976), competing plants relationship (Dyakov & Dragavtsev, 1975; Dyakov et al., 1976), the degree of stability of individual physiological processes and their relative autonomy from changes in external conditions (Shmalgauzen, 1942; Shmalgauzen, 1945).

The most important feature of genetic variation of wood species is the ability of its adaptation in ontogenesis for changing environmental conditions. This property is due to genetic formulas overriding attributes that ensure survival, especially when changing the combination of factors that are limited. Overriding the genetic formula of quantitative traits of plants in ontogenesis was shown by Dragavtsev and Utemisheva (1975), Dragavtsev, Tsilke and others (Dragavtsev et al., 1984). If the wood species have a variety of systems that determine drought resistance, cold resistance, heat resistance, immunity, the adaptation to the new conditions will be successful due to their ability of genotypic dynamics in ontogenesis, unless the level override genetic formulas will not be exceeded of the change the limiting factors of the new environment.

Evaluation of phenotypic variability of annual increment in height (hereinafter - increments) for the small number of plants in biogroups (Table 1) should be performed using an analysis of variance, which allows to establish the significance of differences in growth rates between individual trees and makes it possible to determine the heritability coefficient in a broad sense (Lush, 1949). It is also possible to compare varieties of increments of one morphological address (comparison increments, grew up in the same year in different trees), which with increased environmental assessment base is the proportion of phenotypic variance increments variance in the preparation of its analysis in increments of tree groups.

Table 1: Comparative characteristics of coniferous species, annual increments of which were analyzed with the help of the analysis of ACF (autocorrelation function) and SA (spectral analysis) variance by the period of growth

All kinds of trees, age of biogroups	Number of trees , in biogroup, pieces	The number of measurements of	Inventory indices		Average annual increment in height / for number of years			The duration of the growing season, in days
			Average height, м	Average increment by height,	all measured increments, cm	the first period of increment, cm	the second period of increment, cm	
Pitch pine 52 years	7	9	18,3	41,67	54,10 32 years	57,75 16 years	50,45 16 years	83
Scotchpine 55 years	22	9	16,52	39,34	59,54 28 years	72,14 14 years	46,94 14 years	67
Crimeapine 49 years	8	9	15,0	41,66	56,03 28 years	56,07 14 years	55,99 14 years	66
Blue spruce 49 years	17	7	10,2	28,34	42,53 26 years	37,31 13 years	47,75 13 years	43
Fir spruce 49 years	9	7	13,81	38,36	49,22 30 years	50,30 15 years	48,14 15 years	55

Source: Author

Phenotypic variance of increments in both constructions of dispersion systems is the same. If the assessment of the environmental variance increments of one morphological address will be different from random there is a need to assess a large number of parts of the phenotypic variability of the test number of years, in general, and for periods of growth. Random variance increments are usually taken as an ecological, but including proportion of variance determined by the interaction genotype-environment competitive genotypic and environmental interference.

Separation of the phenotypic variance of quantitative trait / $\sigma^2 ph$ / on genotypic / $\sigma^2 g$ / and the environmental / $\sigma^2 e$ / part is not enough if there is evidence of the dispersion increments of one morphological address and the use of normalized autocorrelation function and the spectral density of a stationary random function to assess the level of plant competition with an unknown degree of relationship (Saharov & Markovin, 1988; Saharov, 1988).

Therefore, the distinction of phenotypic variance has a different scheme (Dragavtsev, 1983): $\sigma^2 ph = \sigma^2 g + \sigma^2 gcom + + \sigma^2 e\ \sigma^2 ecom$ (1).

On the right side of the equation is the allocated share of genotype variance due to competitive ($\sigma^2 gcom$) and dispersion, depending on the competition, determined by the environmental conditions ($\sigma^2 ecom$).

To the right-hand side of the equation it is necessary to include the variance determined by the interaction of the genotype environment, genotypic dispersion of adaptability, dispersion, estimating the accumulation of individual developmental differences, such as differences in the length of the growing season, which in new environmental conditions varies in each species, in accordance with its inherent features and is controlled by the limiting factors of the environment. But the evaluation of all components of phenotypic variance of quantitative traits in woody species always causes difficulties for a number of objective reasons: at first, the traditional methods of studying genotypic population structure based on known models of genetics of quantitative traits, have limited the conditions determining the validity of the method for obtaining estimates to quantify genetic parameters reflecting the structure of the population (Saharov, 1988). Failure to meet compliance requirements of limiting conditions of the used statistical method to the character of the target population will make cause a distortion in the evaluation results (Medvedev et al., 1998); secondly, distortion of the phenotypic variance components is possible because of the ambiguity and the integrity of the phenomena, when a number of effects practically do not divide and together affect the final expression trait in plants. This circumstance fully applies to introducents when it is impossible to estimate ecological consequences of the place of origin of the introduced offspring, influence of generality of the new environment on the offspring of different origin and contrast among parents on the environment of the new dwelling descendants, ontogenetic accumulation of differences due to the fluctuation of limiting factors and changing conditions of competition in the ontogeny of introducents of human origin; thirdly, there is no information about the ecological and genetic structure of populations of the original homeland of exotic species (USA, Canada, Europe, the North of the Republic of Kazakhstan); fourth, the unknown nature of the genotypic dynamics of quantitative traits at home conifer introductions.

Results and Discussion

The analysis of the components of phenotypic variance of increments for each tree group under Lash's scheme with the calculation of the coefficients of heritability in a broad sense showed that the phenotypic variance of increments is almost equal to random, which in a univariate variance analysis approximately assesses the environmental share in total dispersion of variance. Therefore, heritability coefficients in a broad sense estimating variability share which are defined with hereditary factors, are equal to zero except for the first period of growth in pitch pine and the last 15 years of life of fir spruce (Table 2). Due to the significant change in the average growth in height on the periods of growth of scotch pine, a few smaller differences in average growth for the period of pitch pine and blue spruce and stable average growth for the period of Crimea pine and fir spruce was necessary to assess the significance of differences increments by the periods of growth and interaction-period gains.

Table 2: The average value of the annual increments in the height of introducents for the time corresponding to the total number of measurements, by periods of growth and estimation of heritability coefficient in a broad sense

Types of trees	Average growth			Heritability coefficient		
	for years of studying, duration of periods	for the first period, duration of periods	for the second period, duration of periods	for years of studying, duration of periods	for the first period, duration of periods	for the second period, duration of periods
Pitch pine	54,10 32	57,75 16	50,45 16	0,081 32	0,157 16	0,030 16
Scotch pine	59,54 28	72,14 14	46,94 14	0,002 28	0,055 14	0,036 14
Crimean pine	56,03 28	56,07 14	55,99 14	0,031 28	-0,007 14	0,079 14
Blue spruce	42,53 26	37,31 13	47,75 13	0,059 26	0,026 13	0,092 13
Fir spruce	49,22 30	50,30 15	48,14 15	0,063 30	-0,016 15	0,214 15

Source: Author

The results of the analysis indicate a different character of increments variability increase in the periods of introducents growth and the interaction of the factors: Pitch pine and Scotch pine have significant differences in increments by the periods of growth at the level of 01significance, there are no significant differences in tree increments, the interaction of factors period – increments of Pitch pine is insignificantly and it is essential in Scotch pine with a probability of 95%.There are no differences in increments in the Crimea pine neither in the factors A, B nor on their interaction. There are significant differences in both factors with a probability of 99% and 95% in Blue spruce, there is no interaction between factors, and on the contrary, there are no differences of increments by factors, but their interaction is significantly at level 01.Thus, it becomes evident the need to analyse the variability of increments by groups of trees for the entire period studied and its parts, and the presence or absence of the interaction of factors determines the need for a more detailed analysis of the ratio of the variance increments of one morphological address, by tree-groups and periods of growth (Table 3).

Table 3: Changing of the size and nature of the phenotypic, environmental and genotypic variances of increments of one morphological address, groups of trees, periods of growth and the ratio of the increments dispersions

Types of trees	The periods of growth, the difference in variances $\Delta \sigma^2$	Dispersions of annual increments in height							
		one morphological address				by groups of trees			
		σ^2_{ph}	σ^2_e	σ^2_g	$\Delta g = \Delta\sigma_g^2 / \Delta\sigma^2_{ph}$	σ^2_{ph}	σ^2_e	σ^2_g	$\Delta g = \Delta\sigma_g^2 / \Delta\sigma^2_{ph}$
Pitch pine	1	320.0	214.2	105.8		319.71	269.34	50.37	
	2	189.0	131.8	57.2		189.47	183.86	5.61	
	$\Delta \sigma^2$	131.0	82.4	48.6	0.37	130.24	85.48	44.76	0.344
Scotch pine	1	488.0	453.1	34.9		486.46	459.60	26.86	
	2	328.0	279.8	48.2		320.83	309.47	11.46	
	$\Delta \sigma^2$	160.0	173.3	-/13.3/	-/0.083/	165.53	150.13	15.4	0.093
Crimea pine	1	355.0	315.1	39.9		355.84	358.29	-/2.45/	
	2	318.0	314.6	3.4		317.28	292.3	24.98	
	$\Delta \sigma^2$	37.0	0.5	36.5	0.986	38.56	27.43	-/22.53/	-/0.58/
Blue spruce	1	184.0	152.9	31.1		182.43	177.67	4.76	
	2	223.0	219.6	3.4		217.53	197.57	19.96	
	$\Delta \sigma^2$	-/39,0/	-/66.7/	27.7	0.71	-/35.1/	-/19.9/	-/15.2/	-/0.433/
Fir spruce	1	172.0	175.4	-/3.4/		168.89	171.52	-/2.63/	
	2	258.0	269.8	-/11.8/		257.54	202.29	55.25	
	$\Delta \sigma^2$	-/86,0/	-/94.4/	-/8.4/	-/0.098/	-/88.65/	-/30.77/	-/52.62/	-/0.594/

Source: Author

Increment of phenotypic, environmental and genotypic variances of increments, as well as the ratio of the increment of genotypic varies to phenotypic changes by type of introducents and by periods of growth. Dispersions signs and their increments indicate in what period this or that dispersion is more. In Pitch pine, all dispersions are more in the first period of growth and the ratio of the increment of genotypic variance to phenotypic increments are equal to a group of trees and a morphological address. In Scots pine, there are inverse values of the relationship of increment values of the phenotypic variance or increments of one morphological phenotypic address and the group of trees. There are the same values σ^2e of increments of one morphological address by the periods of growth and reverse of the ratio in the Crimea pine.

In Blue spruce σ^2ph, σ^2e increments of one morphological address is more in the second period and σ^2g In the group of spruce trees barbed all dispersion increments are more in the second period. Therefore, the increment ratio $\Delta\sigma_g^2\kappa\Delta\sigma^2_{ph}$ of the group of trees is opposite to a similar ratio for the increments of the morphological address. Fir spruce shows a special relationship not only for increment dispersions, all dispersions are more in the second period, but for the excess of environmental variance increments of one morphological address of phenotypic variance and a similar excess of increments of tree groups in the first period for a second σ^2ph is more than σ^2e. Genotypic variance of increments of one morphological address and increments the group of trees of Fir spruce is more in the second period of growth.

Change of the value and the "sign" of increment relations of genotypic proportion of increments variance of one morphological address and a group of trees to the increment of phenotypic leads to the conclusion that there are possible differences in the nature of the override genetic formulas of exotic species in ontogeny. Having obtained zero estimates of the level of genotypically determined variability in increment by tree groups and differing variance increments, it can be concluded that all species in new environmental conditions, due to a small number of measured trees or a small number of biogroups after a multistage artificial selection, do not have a genotypic variety of the trait under study. The entire phenotypic variance of increments is determined by changes in environmental conditions or genotypically caused differences are "smeared" by other shares of phenotypic variability, that is, competitive genotypic, competitive environmental, genotype-environment interaction, accumulated ontogenetic disturbances. In this regard, a change in the influence of the growth period factor on growth, the factor of the group of trees, was established. There is an interaction of these factors and a change in the average growth over the periods of spruce, pine and yellow, and especially in Scots pine. During the first period, pines have a higher average growth than in the second. Average growth of blue spruce in the first years is less and in future it will be more. Crimea pine and fir spruce differ with stability of average increment in life periods (Table 1). So, there is reason to assume the existence of the reasons determining the differences in the observed average increments and dispersions by periods of growth.

After the analysis of variance, increments of one morphological address, in which the random variance is indeed environmental and ecological competitive part of the phenotypic variance, it was possible to highlight the proportion of genotypic variance, but again not for all types and periods (Table 4).

Table 4: Estimates of heritability coefficient in a broad sense, calculated by the variance of annual increments of one morphological address

Types of trees	Heritability coefficient		
	for the years of studying / years	for the first period / years	for the second period / years
Pitch pine	0,352 / 32	0,331 / 16	0,303 / 16
Scotch pine	0,352 / 28	0,07 / 14	0,147 / 14
Crimea pine	0,06 / 28	0,112 / 14	0,01 / 14
Blue spruce	0,19 / 26	0,169 / 13	0,015 / 13
Fir spruce	-0,035 / 30	-0,02 / 15	-0,046 / 15

Source: Author

Ecological and phenotypic variance of increments of Pitch pine as by periods and for all the years of study remains at the same level.

In the first period, the phenotypic variance of Scotch pine increments is almost equal to the environmental, a small proportion of genotypic variance appeared in the second period of growth, and in general during the 28 years of recording, about a third of the phenotypic variance accounted for genotypic share. Crimea pine showed little genotype variability due to increments only in the first period of life. Blue spruce has several large hereditary variables of growth for 26 years and in the first period of life. Fir spruce in all cases has an exceeding environmental variance of increment over the phenotype that determined the negative marks of zero heritability coefficient values in the broadest sense and indicates the presence of noise, overstating the environmental variance.

The analysis of variance increments of one morphological address gives only a glimpse of the ability of introducent species to adapt.

Conclusion

Thus, the value of the mean squares varies considerably by the increments of morphological address and increments of tree groups, introducent species and the periods of their lives, which leads to the conclusion about the presence in the environmental, genotypic and phenotypic variances of some interference which has a different value and are developed in a greater degree or in the analysis of groups of trees, or increments of one morphological address, i.e., change in the cause of its symptoms. Therefore, the scheme of separation of dispersions of increments on the genotypic and environment is insufficient and it is necessary to use other methods of determining the components of phenotypic variation of annual increments in the height of the introduced species.

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