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Genetic parameters of wood density components in European Larch

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Abstract: *Genetic parameters of wood density components in European Larch.* Genetic parameters for wood density traits were estimated in 25-year-old trees of 389 full-sib families of European Larch growing in two seed orchards from northern Poland. The ring width and wood density traits of individual rings were determined by X-ray densitometry. Estimates of individual tree narrow-sense heritability of latewood density and maximum wood density were 0,97 and 0,98 respectively. Maximum wood density showed strong positive genetic and phenotypic correlations with latewood density (r_g = 0,98, r_p = 0,94) and minimum wood density showed strong positive genetic and phenotypic correlations with earlywood density (r_g = 0,96, r_p = 0,94). The narrow-sense heritability of ring density and early density increased and decreased in an oscillatory pattern. The genetic correlation between all wood density traits increasing with cambial age. The same trends was shown for the phenotypic correlation between wood density traits.

Keywords: European Larch, wood density, heritability, genetic correlations, phenotypic correlations

INTRODUCTION

Wood density is considered to be the most important wood property for most wood products [2]. Wood density is a combination of several wood properties. Ring density is the product of the proportion of each ring that is earlywood or latewood and the wood densities of each [9]. The minimum and maximum densities in each ring influence the overall wood density. A value of ring density can result from different combinations of all these components [5]. The knowledge of genetic parameters of wood density parameters and their interrelationships may improve understanding the genetics of overall wood density [8]. The main objective of this study was to describe trends in genetic parameters of wood density components of European Larch.

MATERIAL AND METHODS

Measurements were performed on larch wood samples (*Larix decidua* Mill.), coming from two seed orchards established in 1985 in the Forest Ranges Młynary and Zaporowo in northern Poland. The wood density traits were estimated in 389 trees of full-sib families. In 2007, two five-millimeter bark-to-pitch increment cores from each sample-tree were collected at 1,3 height. The increment samples were cut using twin blade circular saw to results two parallel cuts along the bore core with uniform thickness [6]. Resins was then extracted from cores with distilled water for 24 hours [4]. Thereafter, the samples were dried to moisture content of approximately 5-15% [12]. Intra-ring density and width information was obtained using an X-ray densitometry technique [1]. Each sample was scanned from the pith toward the bark. For each annual rings in the samples, various wood density components were obtained based on densitometric profiles: overall ring density, earlywood density, latewood density, maximum wood density, minimum wood density. Variance components for each traits were estimated using method of the SAS 9.2 Pl VARCOMP procedure, and estimated of the covariance between different traits were obtained from the MANOVA statement [7]. The narrow-sense heritability is given by the following formula on an individual tree basis [3]:

$h_i^2 = 4\sigma_F^2/(\sigma_R^2 + \sigma_{PF}^2 + \sigma_E^2)$

The standard errors of heritability σ_{hi} were computed as follows:

$\sigma_{hi} = [(1 – h_i^2/4)[1 + (Pn – 1)(h_i^2/4)]]/[(Pn/2)(Pn – 1)(F – 1)]^{1/2}$

The genetic correlation was calculated as follows [10]:

$r_{gxy} = Cov_{Fxy}/(\sigma_{Fx}^2\, \sigma_{Fy}^2)^{1/2}$

where:
σ_F^2 – family variance,
σ_E^2 – residual variance,
σ_{PF}^2 – family×seed orchard variance,
n – average number of trees in family,
s_i – number of trees in family i,
P – number of seed orchards,
F – number of families
σ_{Fx}^2 – family variance components for traits X and Y, respectively,
Cov_{Fxy} – family covariance components for traits X and Y,

RESULTS

The individual tree heritabilities for each density traits at ring were calculated for years from 1994 to 2005. From year to year, there were similar fluctuations in heritabilities for all traits (Fig 1). Maximum wood density and latewood density had generaly the highest heritability ranging from 0,48 to 0,98 and fom 0,25 to 0,97 respectively. The lovest value of individual tree heritability all density traits reached in 1999.

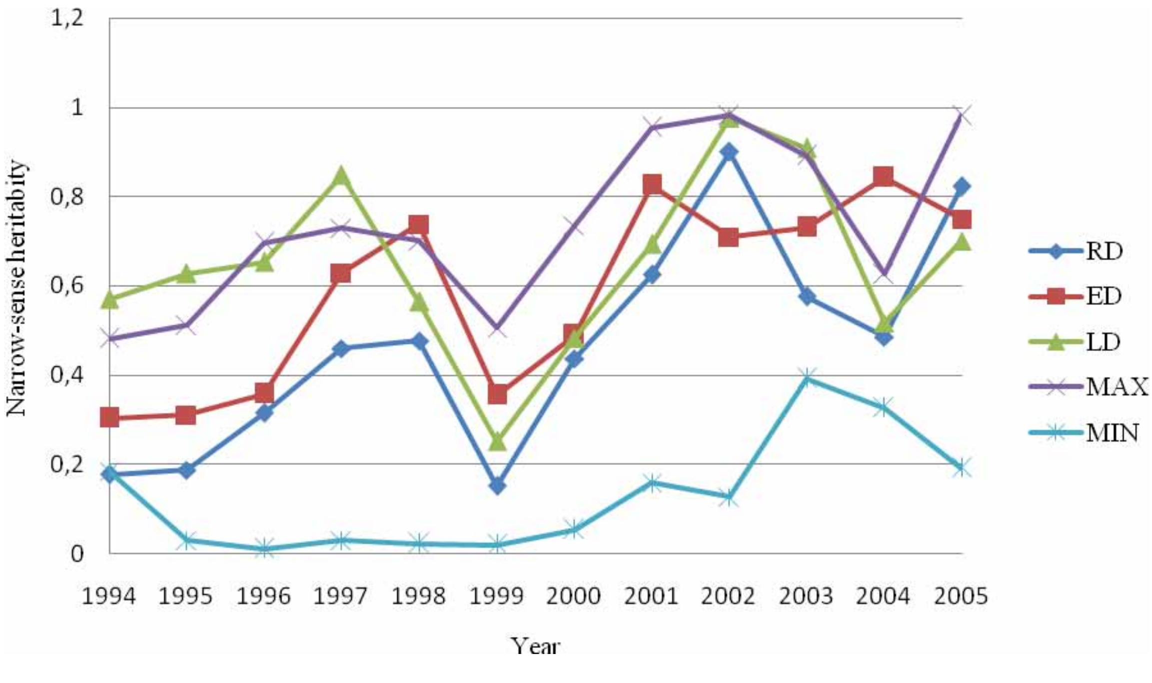

Fig 1 Age trends in individual tree heritability for wood density traits: overall ring density (RD), earlywood density (ED), latewood density (LD), maximum wood density (MAX), minimum wood density (MIN).

Estimated genetic correlations between wood density traits were high for all analyzed period. After 2000 (age 15) all genetic correlations reached value from 0,86 to 0,96 (Fig 2). Genetic correlations for most traits showed a trend with cambial age that can be separated in four periods. First, to 11, correlations were positive and increased. Second between 11 and 15, were correlations stabilized. Third, short period between 15 and 16, were correlations again rapidly increased and reached a maximum at ring 16. Fourth, started from 17, were correlations again stabilized.

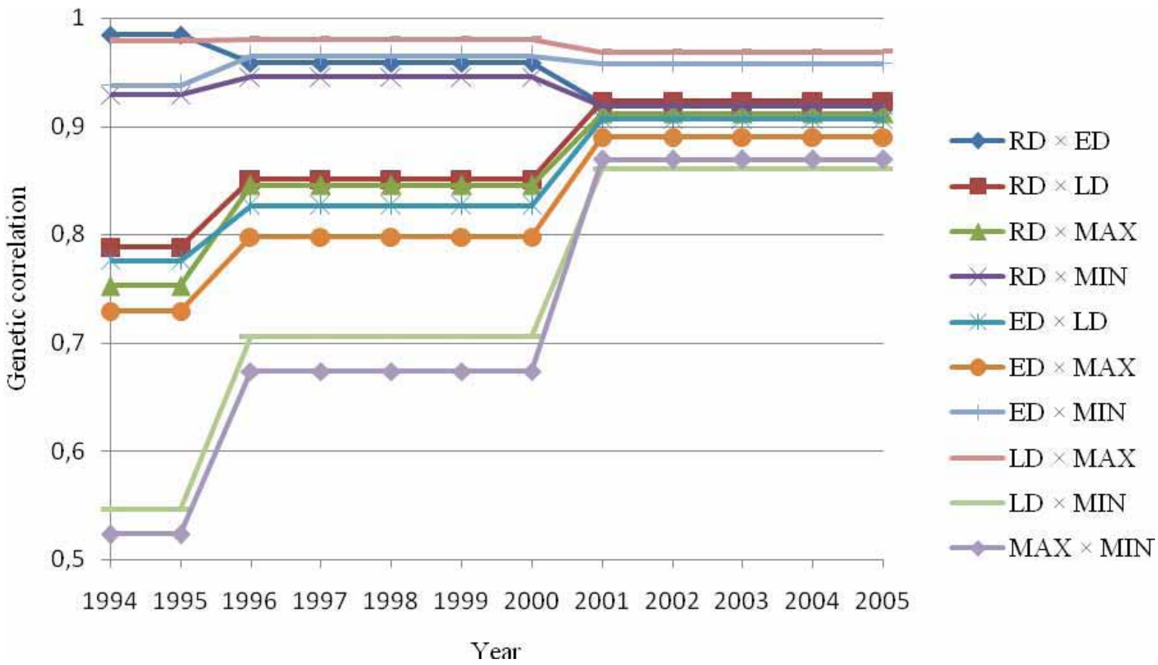

Fig 2 Age trends in genetic correlations between wood density traits: overall ring density (RD), earlywood density (ED), latewood density (LD), maximum wood density (MAX), minimum wood density (MIN).

Phenotypic correlations between all wood density components were moderate, ranging from 0,20 to 0,94. Phenotypic correlations for most traits slightly increased. The time trends and age period weren't as evident as for genetic correlation (Fig 3).

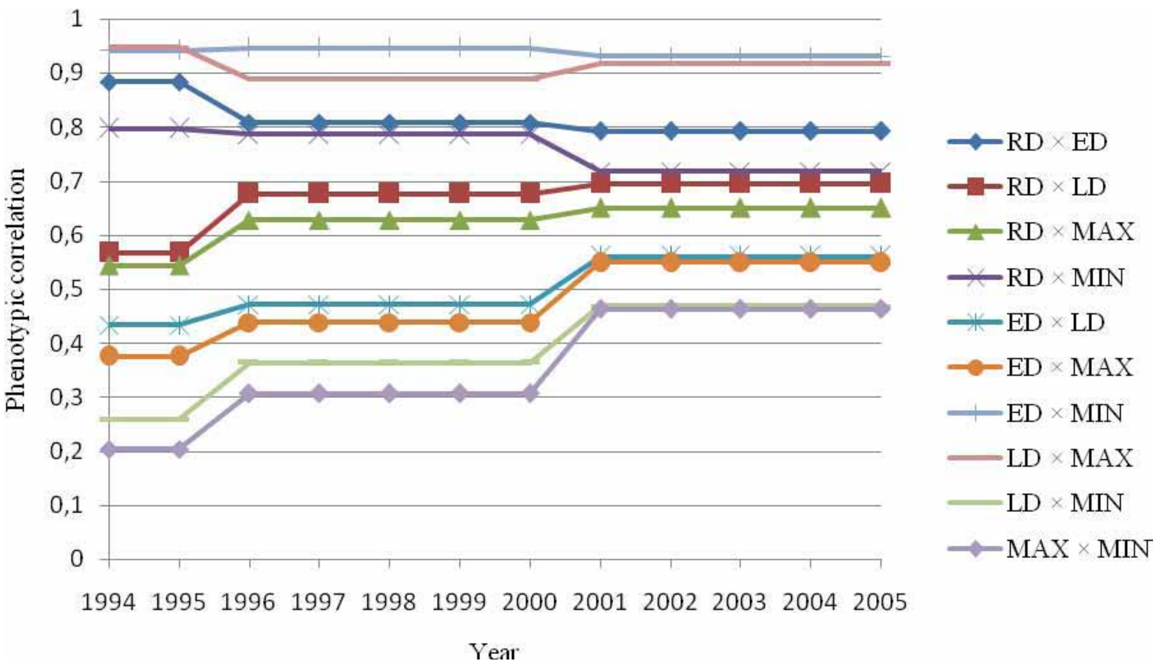

Fig 3 Age trends in phenotypic correlations between wood density traits: overall ring density (RD), earlywood density (ED), latewood density (LD), maximum wood density (MAX), minimum wood density (MIN).

CONCLUSIONS

The narrow-sense heritability of wood density components increased and decreased in an oscillatory pattern. From ring to ring, there were some fluctuations, however heritability successively increased. Similar patterns of time trends for genetic parameters shows Zamudio et all [11] for radiata pine. Wood density had strong positive phenotypic and genetic correlations with all of the wood density components. Furthermore, wood density components were strongly correlated among themselves. Phenotypic correlation between all wood density components shows growing tendency in cambial age. This was consistent with the studies of hybrid larch [8].

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Streszczenie: *Parametry genetyczne komponentów gęstości drewna Modrzewia europejskiego.* Dla pół-rodów modrzewia europejskiego z dwóch plantacyjnych upraw nasiennych obliczono parametry genetyczne cech składowych gęstości drewna. Trend czasowy dla odziedziczalności indywidualnej każdej z analizowanych cech gęstości charakteryzował się powtarzającymi się fluktuacjami przy ogólnej tendencji wzrostowej. Najwyższe wartości odziedziczalności zaobserwowano dla gęstości drewna późnego i gęstości maksymalnej drewna (odpowiednio: 0,97 i 0,98). W całym analizowanym okresie zarówno korelacje genotypowe jak i korelacje fenotypowe miały charakter silny dodatni. W trendzie czasowym korelacji genotypowych wydzielono trzy odrębne okresy wzrostu wartości korelacji po, których nastąpił okres stabilizacji na korelacji genotypowej na wysokim poziomie r = 0,86. Korelacje fenotypowe miały charakter dodatni dla wszystkich kombinacji cech przy silnie zróżnicowanej wartości współczynników korelacji. Trend czasowy wykazywał słabą tendencję wzrostową.

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