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IMPROVEMENT BY SELECTION OF ACACIA *(ROBINIA PSEUDOACACIA* L.) IN ROMANIA

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Abstract

In the broadest sense, the selection involves choosing from a plant population, based on well-established criteria, a certain number of plants that will participate in obtaining the next generation of the respective population, but which similarly follow towards the objective principle of improvement in the case of acacia, that of productivity of wood biomass. Certainly, besides the productivity of woody biomass, there are also other criteria that are worth remembering such as: resistance to pedoclimatic factors, nectar productivity, resistance to pollution, resistance to diseases and pests or the quality of wood.

There are a large number of selection variants, differentiated according to a number of methodological criteria. The present work presents a synthesis of the evolution in time of the improvement works regarding the acacia, with references from the most extensive theses elaborated by researchers of Romanian origin, theses that provided for the selection of trees plus and the creation of stands seed sources, up to current data on the selection and productivity of current varieties of acacia.

Key words: black locust, plus trees, selection, improvement by selection

INTRODUCTION

The ways of penetration of the acacia tree in the areas of Europe located in the south-east of the Carpathians, namely in the eastern part of the Balkan Peninsula, in European Turkey, in Macedonia, Bulgaria, old Romania, up to Bukovina and Bessarabia, are not from the west, from France, through Austria and Hungary, but vice versa, from the south-east, from Constantinople, the intercessors being, very probably, the Turks, and the period when this happened, it was a few decades before 1777. Constantinople seems to have been, thus, in the 18th century, the center from where the acacia tree spread in South-Eastern Europe (Drăcea, 2008;1926).

In Romania, the acacia culture has received special attention, especially since the second half of the Nineteenth century, being cultivated throughout the country, as an ornamental tree, but also in forest crops, in the lands with a lot of summer heat. It became naturalized, becoming a subspontan, from the plains to the lower mountain area. The first acacia forest crops were established in 1852, in Băileşti Dolj, so that, subsequently, the species to be planted on larger and larger areas, especially in Oltenia, on lands with moving sands. Besides that area, it was also used in other resorts with continental sands, such as those in the north-west of the country, between Oradea and Carei, or those in Moldova, at Hanul Conachi etc. (Doniţă, 1999).

In Europe, by far, the largest acacia grower is Hungary, with 345,000 ha covered with this species (Németh and Molnár, 2005). According to the data published by DeGomez and Wagner (2011) as well as Keresztesi (2013), at the end of the 80's, large areas cultivated with acacia were also found in the USSR (144,000 ha, mainly in Ukraine and Moldova), Romania (120,000 ha), France (100,000 ha), Bulgaria (58,000 ha), Yugoslavia (50,000 ha), Czechoslovakia (28,000 ha). In Asia, large acacia cultivators are the Republic of Korea (1.22 million ha) and China (1.0 million ha).

Today in Romania, acacia has an area of over 255 thousand hectares forested with acacia, representing a percentage of about 3.71% of the total area of forests reported in the forest system.

In all crop plants, selection is the main method of exploiting the natural or artificial variability existing, at a time, in the species with which they work. In forest species, selection, as a method of improvement, has many peculiarities imposed by the particular biology of each species. The fundamental principles of selection, for the forest species, were enunciated by Wright (1963) and are discussed in detail in valuable treaties of forestry improvement from our country (Stănescu, 1983; 1997; Enescu, 1975; 1985; 2002; Savatti, M. and Savatti Jr., 2005).

MATERIAL AND METHOD

The research was carried out between 2010 and 2021 in Bârzeşti, Arad County, Romania.

The main objective pursued in the improvement programs for acacia as well as for other crop species is the productivity of woody biomass. The character is very complex and depends on a fairly large number of elements of which the most important are: the height of the trees, their diameter, the tendency to infuriation, the growth rate, the resistance to winter frosts, the resistance to diseases and pests.

The researches afferent to the present study aim to evaluate the behavior of the selections of ***the Oltenian variety*** compared to ***the rectissima variety*** in the pedoclimatic conditions of the submontane area of the Apuseni Mountains (Bârzeşti, jud. Arad), following the ways of growing, acclimatizing and manifesting the respective variety in the installation period and the next period.

RESULTS AND DISCUSSION

The data obtained by measurements made on 50 individuals selected from each acacia variety taken in the study show that, in the period 2010-2021, *the variety rectissima* presented average values of diameter growth between 1.26 and 3.1 cm, values recorded at the height of 1.30 meters from the ground (fig.1).

For the *Oltenian variety*, the variability limits of this character were equally extended, with values between 1.19 – 2.8 cm and a coefficient of variability very close to that obtained in the *rectissima variety.*

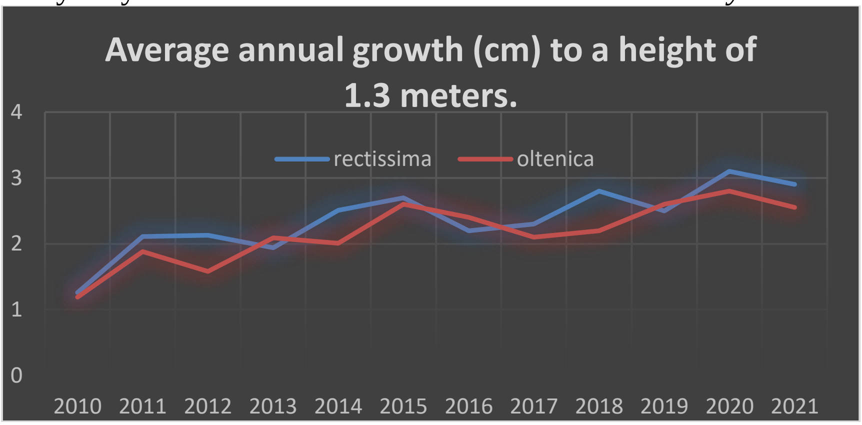

Fig. 1. Average annual growth (cm) to a height of 1.3 meters.

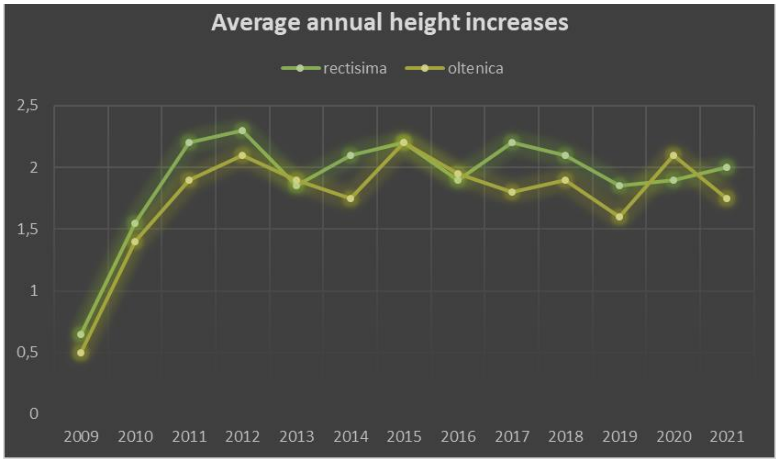

Fig. 2. Average annual height increases

The results obtained in Bârzeşti, regarding the average annual increase in height (fig.2) of the plants selected by acacia l of the two varieties tested, are consistent with those from the specialized literature which states that, in general, the vigor of the Oltenian variety is lower than that of the rectissima variety. Obviously, there are real differences between the two varieties at least from two points of view regarding the height of the plants:

- of the speed of growth in height of plants;
- of the dynamics of the average annual increases of this character.

According to the way of assessingthe selection criteria, it can be:

- ***Phenotypic selection***, based on the visible and eventually measurable manifestation, in the chosen individuals, of the favorable characteristics pursued by the breeder.
- ***Genotypic selection*** is based not only on the phenotypic aspect of the chosen individuals but also on the performance of the offspring of these individuals. In most forest species this type of selection is quite difficult to apply due to the long life periods of the respective species.

According to the direction in which the selection is oriented, this can be:

- ***Positive selection , in the***sense that only elected individuals, who have desired characteristics, are retained for the perpetuation of the population. This type of selection is specific to the improvement and production of seedlings.
- ***Negative selection*** occurs when all individuals who do not meet the characteristics desired by the breeder are eliminated from the population. This type of selection is commonly used in cultural works applied to stands of different ages.

According to the way in which the performances of the chosen individuals are traced, in the lineage, two fundamental types of selection are distinguished, namely:

- ***Individual selection*** involves assessing the lineage of each individual chosen and retaining those descendants in which all or most individuals have the characteristics desired by the breeder. The retained descendants will be multiplied (seminal or vegetative) and tested in comparative cultures (plantations) executed with the most accurate measurement of the characteristics pursued and the comparison of the population averages.
- ***Mass selection*** occurs when all the descendants of the chosen individuals are tested together, in the mixture, in terms of the characteristics pursued. Effectively, through mass selection, the initial population in which the selection was made is replaced by a new population, made up of the descendants of the most valuable individuals of the initial population.

Acacia, being a strictly alogam species, lends itself better to mass selection than to individual. Individual selection, by forcing the descendants of a single individual to pollinate each other, inevitably leads to the manifestation, to varying degrees, of the depression of inbreeding. Mass selection presents three distinct variants, depending on the number of choices made and the ways of grouping the seeds of the chosen individuals:

- *Simple mass selection with one choice*;
- *Repeated mass selection;*
- *Mass selection by groups of plants.*

Regardless of the variant, mass selection efficiently exploits the natural and/or artificial variability of tree populations with an obvious genotypic and phenotypic polymorphism. The efficiency of mass selection is expressed by the so-called genetic gain (CG) which, mathematically, is given by the relationship (Dudley and Moll, 1969):

CG = K.h2.i in which:

K is an index of the selection differential whose value is inversely proportional to the selection pressure;

h2 = heritability of the character pursued;

i = selection deviation calculated as follows;

I = the average character of the chosen elites: the average of character in the population under selection.

In acacia, the positive mass selection, applied to free fertilized plus trees (fig.3) or to trees plus artificially pollinated, is followed by negative mass selection applied in the form of thinings (eliminations) in the populations of seedlings resulting from seeds. The plantations thus obtained may be used as seed producers necessary for the production of forest saplings intended for afeding. Depending on the effects on the genetic structure of the populations, the following types of mass selection are distinguished:

Stabilizing selection involves the elimination of extreme variations and the maintenance of genotypes with the highest representativeness in the population, which have the greatest capacity for adaptation and survival.

Directional selection favors the group of extreme genotypes (plus variants or minus variants) which leads to the displacement of the average population towards the favored group.

Fig 3. Trees Plus, Săcuieni Forest District, Bihor County.

Disruptive selection favors one or two optimal phenotypes over intermediate ones. Gradually, the population splits into subpopulation, some very close to the optimal, others very close to the minimum.

In forest species, including acacia, mass selection, positive and negative, also takes place in the form of cultural selection. The works of care for the acacias by applying cleanings and thins along with favoring the development of some trees from the most typical and vigorous drajons are, in fact, forms of mass selection. The mass selection, at the acacia, beyond its value in the improvement of this species, has an equally high value in the realization of the stands (orcharges) seed sources. In Romania, the identification of the seed source stands or the creation of new stands of this kind, started after 1960, reaching that, after a few years, to have about 65,000 ha of such stands (Bumbu and Catrina, 1982).

Clonal selection involves the multiplication of valuable individuals, chosen in the selection process, by organs of vegetative propagation (cuttings, drajons, altoaie, etc.). The resulting clones are tested in comparative crops, the most valuable being used in the establishment of seed-producing stands (plantations). In acacia this type of selection is very common due, first of all, to the ease with which this species can multiply vegetatively. At the level of all forest species, the application of clonal selection has led to so-called clonal forestry. (Libby and Ahuja (1993), Enescu (2002), Savatti and Savatti Jr. (2005) analyzed, in detail, the characteristics of clonale forestry, the benefits and disadvantages of this type of forestry, mentioning the fact that, in species such as acacia, where vegetative propagation is easy to achieve, at moderate costs, the benefits are much higher than the disadvantages.

The assisted selection of molecular markers allows the acceleration and efficiency of the selection process by diminishing its probabilistic character (GALLAIS, 1990). In principle, this type of selection involves the "binding" of a phenotypic character to a certain molecular marker, easy to highlight, at any age of the plant, by analyzing proteins, enzymes, DNA, RNA, etc. For forest trees this aspect is vital if one takes into account the very long time required to carry out genetic analysis using conventional methods. In addition, for the trees where it is possible to obtain intraspecific hybrids, the selection assisted by markers allows the choice of the combinations with the best chances to exteriorize a positive trans-heteroside of wood production and wood quality. It is also not to be neglected that, unlike conventional selection, whose efficiency is directly proportional to the size of heritability (h2), the selection assisted by markers allows significant genetic gains in characters with small and very small heritability (Baptism, 1994).

Discussing the selection methods applicable in the improvement of acacia does not mean that all these methods have been and are used with the same frequency. In this respect, we consider that the presentation of a few examples can be edifying. As a rule, clonal, individual or mass selection was applied, depending on the characteristics that had to be phenotypically exteriorized by the new cultivar (Bongarten,1992; DeGomez, 2011). A number of over 30 monoclonal and multiclonal cultivations were homologated and launched into culture during that period. Subsequently, nrcs (National Resources Conservation Service, USDA) concentrated acacia breeding in four universities located in areas with great extent of these species: Georgia, Michigan, Kentucky and Maryland, for the common acacia, red acacia and viscous acacia, and Arizona, for the Mexican acacia.

The improvement methods used were diversified (the selection of the half-sib and full-sib families, the selection of artificially induced mutations and polyploids, the exploitation by selection of somali variability, the transfer of genes mediated by biological, physical and chemical vectors), the results materializing in an impressive number of new cultivation (over 70), not only at Robinia pseudoacacia but also at the other three species of acacia related to the common acacia: R. hispida (Wandel, 1989), R viscosa (Isley and Peabody, 1984) , R. neomexicana (Isley and Peabody, 1984).

In Hungary, the first acacia improvement programme was initiated in 1960 and had as its main objective the selection of new clones with higher characteristics in terms of quantity and quality of production of industrially usable wood (Rédei et al.,2008). In several plantations, previously obtained from seed, three groups of individuals have been identified with these characteristics, in each group being nominated trees plus, resulting in a total of 40 such trees (Keresztesi, 2013). Vegetative material from these trees was used for their multiplication by grafting, the clones obtained being tested, in comparative cultures, at the Gödölfi resort.

At the age of exploitation, five of the most productive clones were homologated as new cultivation under the names: Jászkisári, Kiscsalai, Nyirsági, Űllöi and Szajki (Keresztesi, 1994). Because, in Hungary, the areas with optimal pedoclimatic conditions for the acacia culture are quite limited, the acacia has come to occupy large areas in areas with suboptimal conditions.

The production of wood and its quality, in those areas, is far below what the new acacia clones produced in the areas of maximum favorability, therefore, the next improvement program, at the acacia, had as main objective the selection of new productive clones, with quality wood and which are able to tolerate changes in ecological conditions. The result of this new selection cycle resulted in 12 new clones, recommended for approval and introduction into culture (Rédei et al., 2002).

The acacia improvement programs, in the following stages (1983; 1996), used as initial material for selection inter and intraspecific hybrids, populations obtained from cuttings irradiated with Co60, 136 polyploid forms. The comparative orientation cultures (6-10 years), with the best half-sib and full-sib families, with mutants and/or tetraploid forms were organized in eight forest districts, with different pedoclimatic conditions, on a total area of 120 ha. The comparative long-term competition cultures (15-20 years) occupied over 300 ha and were organized in three research stations placed in totally different areas in terms of the degree of favorability for the acacia culture.

The results of these programmes resulted in the homologation of seven new acacia cultivation (until 1996) and the submission of homologation proposals for five other valuable new clones (after 1996) (OSVÁTH-BUJTÁS and RÉDEI, 2007). Unfortunately, in the specialized literature in Romania there is little data on the improvement programs carried out at the acacia tree and their results.

The results of short-term programs (1972-1975) were published by BÎRLĂNESCU et al. (1977) and, fortunately, the authors also refer to the results of previous periods, without delimiting these periods in time. One thing is certain about these programmes: they were part of a National Programme on forest conservation and development between 1976 and 2010. According to the authors quoted, in the period before 1972, some notable results were obtained in our country in the improvement of the acacia tree, among which they mention:

- identification and selection of 29 plus trees that have been vegetatively multiplied, the respective clones being used in the creation of the first 15 ha of acacia plantations
- identification of a new variety of acacia for the flora of Romania, R. pseudoacacia, var. oltenica, differentiated both morphologically and productively from the common acacia;
- the creation of 11 intraspecific acacia hybrids in which var. oltenica was one of the parental forms;
- selection of acacia forms of beekeeping interest.

The lack of large-scale provenance studies was compensated, in our country, by studies of behavior of acacia stands in different resorts. In this regard, it is worth mentioning the 16 experimental blocks with acacia stands of different ages installed by ICEF in 1955; 1956, in six forest districts: Ianca, Săcuieni, Calafat, Lehliu, Miteeni and Craiova. The observations and measurements made with a periodicity of three years, in these experimental blocks, allowed the formulation of some interesting conclusions regarding the increases in height, in basic diameter and the peaks of the increases (Armăşescu et al., 1969). It was found that, at the same age of the stand, the respective characters varied significantly from one resort to another, which reveals the importance of the environment and interaction, ***genotype* × *the environment*** in the phenotypic manifestation of the respective characters.

In recent years, in most countries with large acacia areas (China, USA, Hungary), the study in comparative cultures of the provenances of different origins is increasingly used to highlight clones / families with superior characteristics for one or more improvement objectives. We mention, in this respect, the studies of interfamilial variability of the intensity of photosynthesis and the growth of trees made in the USA (Mebrahtu and Hanover, 1989), the regional comparative crops in China with acacia clones for fodder (Zhang et al., 2013) and those from Canada and Hungary, for determining the variability of the quality of wood at the different acacia origins (Stringer, 1992; Rédei, 2008).

Probably one of the most interesting studies of origin is the one reported by Liesebach et al, (2004) in which, at the Institute of Genetics and Improvement of Forest Trees in Germany, 18 seminal descendants (families) of acacia, coming from the USA, Germany, Slovakia and Hungary, were characterized with the help of enzymatic markers.

The results were surprising by the way they differentiated these origins: a high variability, at the enzymatic level, was reported within the six populations from Hungary, combined with a very low interpopulation genetic variability. On the contrary, the eight German populations showed a low intra-population genetic variability at the enzymatic level, while the interpopulation variability showed very high values.

The authors conclude that, for Europe, a general valid model of evolution of variability cannot be given at the acacia tree, because it certainly depended, in each country, on the way of multiplication predominantly used in obtaining seedlings for af afedations made with this species.

The analysis of these results indicates that, in the early period of the acacia improvement in Romania, it was started, as in the USA and Hungary, with the clonal individual selection, which implied the identification of plus trees in the stands with an obvious variability of the traced characteristics, their vegetative multiplication followed by the testing of clones in plantings specially established for this purpose to obtain the seed source stands. Also from the work of the authors quoted above we learn that, in the period before 1972, intraspecific hybrids had already been obtained in which, certainly, the selection was applied in the descendants of F1 falf-sib and full-sib followed by the vegetative multiplication of elites and the testing of clones in comparative cultures.

According to the data presented by Enescu (1975), by 1960, 79 plus trees had been identified, whose clonal descendants were tested in comparative cultures at the Experimental Station Craiova. According to the same author, in our country, the first artificial hybridizations, at the acacia, were made by Bîrlănescu et al. in 1969, and the first works of artificial induction of polyploidy, through treatments with colchicine and/or with physical mutagenic agents, were carried out by Leandru et al., in 1971. The most significant results, from the point of view of acacia improvement, of the short-term program 1972-1975, reported by Bârlănescu et al. in 1977, are:

- Identifying and choosing new plus trees, which increased the number of plus trees introduced as clones, in plantations, to 66 of which 59 were clones obtained in our country.
- The choice of 50 new clones of beekeeping interest, which were to be tested alongside similar clones from Hungary and Bulgaria.
- Performing the first tests with clones from half-sib (maternal) descendants that proved that, due to hybrid vigor, as early as the age of 4-5 years, the clones of hybrid offspring significantly exceeded the control (common acacia).

In the current conditions, wooden resources must be well preserved. In rural areas, for the afforestation of degraded lands, acacia would be a solution to cover the needs of the population with firewood, along with other environmental advantages. In this regard, European funds can be accessed or the relationship between the citizen and the public institution can be encouraged at the level of the administrative decision. In certain situations, environmental protection in the name of the proper functioning of the community justifies restrictions on the exercise of certain rights, such as that relating to the protection of property. (Timofte et al.,2010)

In Romania, very little research has been done related to the genetic determinism of these characteristics on which the productivity of the acacia depends, to the greatest extent. A special mention deserves the phd thesis elaborated by Ciuvăţ (2013) which, based on the analysis of a large number of acacia stands, aged 1-4 years, from south-western Oltenia, elaborates allometric equations for the estimation of the total biomass and its components according to the biometric characteristics of the measured copies. Beyond the value of these data for the needs of the respective doctoral thesis, they could constitute a good database for calculating the heritability of the respective characters characteristic of the respective populations or as a resultant of the individual measurements.

CONCLUSIONS

Unfortunately, so far, in the literature I have not found any paper that attests to an oligogenoic genetic determinism for any of the elements of productivity or quality, in acacia. The small number (1-3)/large number (11-23) of leaflets in the leaf seems to be determined by a single major gene, and this finding can, indirectly, serve to improve productivity. If the parental forms had as a genetic marker the large/small number of leaflets in the leaf, the hybrid individuals can be easily identified and then processed by selecting the hybrids with the highest level of trans-heterosis.

If it is accepted that var. *rectissima* would be more correct to be called ***cultivar*** and not ***variety***, we do not see why the same rule would not apply inthe taxonomic framing of var. *oltenica*, given that it was originally extracted as a subpopulation of lime. *rectissima.*

Regardless of the taxonomic category in which *var. oltenica* is or will be classified, we consider that it has superior productivity and quality characteristics, very similar to those of lime. *retissima* and a good adaptability to the pedoclimatic conditions of the premontane area in the south-west of the Apuseni Mountains. Based on these considerations, we recommend the extension of the Oltenian variety into *culture, along with the rectissima variety* in the above-mentioned area.

REFERENCES

1. Armăşescu, S., A. Ţabrea, I. Decei, E. Bîrlănescu, 1969, Research on the increase of the production and quality of acacia stands, In:Research on the acacia culture (Robinia pseudoacacia L.), Ed.Agro-sillvică, Bucharest.
2. Bîrlănescu, E., A. Costea, T. Ivanschi, S. Tănăsescu, 1969, Studies on acacia assortments in relation to the types of crops and production cycles. In: Research on acacia culture (Robinia pseudoacacia L.) Ed. Agrosilvică, Bucharest.
3. Bîrlănescu, E., M. Diaconu, A. Costea, I. Cojocaru, 1977, Cercetări privind ameliora acaciaului (Robinia pseudoacacia, L.). ICAS Anelele, vol. 34(1), 41-54.
4. Bongarten, B., 1992, Genetic variation of black locust within its native range. In: Proc. Intl. Conf. On Black Locust Biology, Culture and Utilization, East Lansing, Mich, 1991,78-97
5. Botez, C., M. Ardelean, M. Savatti, 1994, New guidelines of fundamental and applicative research in genetics and plant improvement. USAMV-CN Bulletin, A-H, 48, 5-11
6. Bumbu, Gh. and I. Catrina, 1982, Guidelines and results of the scientific research from the period 1976-1980 regarding the increase of the productivity and usefulness of forests. Forest Review, 6, 5-14.
7. Ciuvăţ A.L, 2013, Biomass production and carbon storage in young acacia stands *(Robinia pseudoacacia* L.) in southern Romania, PhD thesis, "Transylvania" University of Brasov, Department of Forestry.
8. DeGomez, T. and M.R. Wagner., 2011, Culture and use of black locust, Copmprehensive Crop Reports, www.horttech/ashspublications.org.
9. Doniţă, N., 1999, Dendrologie – Course notes, University of Oradea.
10. Drăcea, M., 1926/1928, Contributions to the knowledge of the Robinia Rumaenia with special consideration of their culture on sandy soils in the Oltenia, Ed. Stereotipia, Bucureşti.
11. Drăcea, M., 2008, Contributions to the knowledge of acacia in Romania, with special regard to its culture on the sandy soils of Oltenia. Ed. Silvică, ICAS, Bucharest.
12. Dudley, J.W. and R.H. Moll, 1969, Interpretation and use of estimatesof heritabi-lity and genetic variances in plant breeding. Crop Sci., 9;257-262
13. Enescu, V.,1975, Amelioration of the main forest species, The special part, Ceres Ed., Bucharest. ENESCU, V., 1985, Ecological Genetics, Ceres Ed., Bucharest

14. Enescu, V., 2002, Sustainable Forestry, Agris Ed., Bucharest.
15. Gallais, A., 1990, Selection Theory in Plant Breeding. Ed. Masson, Paris
16. Isley, D. And F.J. Peabody., 1984, Robinia (Leguminosae; Papilionoidea), Castanea, 49: 1877-202.
17. Keresztesi, B., 1994, Forest tree improvement in Hungary, Unasylva, 88, 33-38 98 Acacia culture
18. Keresztesi, B., 2013, The Black Locust, FAO Corporate Document Depository, www.fao.org/doc.
19. Libby, W.J. and M.R. Ahuja., 1993, The genetic of clones. In: Clonal Forestry I.. Springer-Verlag, Berlin.
20. Liesebach Heike, M.S. Yang, V. Schneck., 2004, Genetic diversity and differentiation in a black locust (Robinia pseudoacacia L.) progeny test. Forest Genetics, 11(2): 151-161.
21. Mebrahtu, T. and J.W. Hanover., 1989, Heritability and Expected Gain Esimates for Traits of Black Locust in Michigan, Silvae Genetica, 38, 3-4, 125 -130
22. Németh, R. And S. Molnár., 2005, Utilization of walnut (Juglans), black locust (Robinia) and ash (Fraxinus) on the bases of Hungarian Experiences, COST Action E 42, Growing Valuable Broadleaf Tree Species, Thessaloniki, Greece.
23. Osvath-Bujtás, Z. and K. Rédei., 2007, Akac variety guide, Agroinform Publishing House, Budapest.
24. Rédei, K., Z. Osvath-Bujtás, I. Balla., 2002, Clonal approaches to growing black locust (Robinia pseudoacacia) in Hungari; a review. Forestry,75(5): 548-552
25. Rédei, K., Z. Osvath-Bujtás, Irina Veperdi.,2008, Black Locust (Robinia pseudoacacia L.) Improvement in Hungary: a Review. Acta Silv. Lign. Hung., 4:127-132
26. Savatti, M. și M. Savatti jr., 2005, Amelioralor arborilor forestieri, Ed. AcademicPres, Cluj-Napoca. STĂNESCU, V., 1983, Genetics and improvement of forest species, Ed. Did. and Ped., Bucharest.
27. Stănescu, V., N. Şofletea, Oana Popescu, 1997, Flora forestieră lemnoasă a României. Ed. Ceres., Bucharest.
28. Stringer, J.W., 1992, Wood properties of black locust (Robinia pseudoacacia L.): physical, mechanical and quantitative chemical variability. In J.W. Hanover, K. Miller and S. Plesco, Eds., Proceedings of International Conference on Black Locust: Biology, Culture and Utilization, 197– 207.
29. Timofte C.S., Timofte A.I., 2010, Aspects Regarding the Correlation Between Environmental Protection and Human Rights. Analele Universităţii din Oradea, Fascicula Protecţia Mediului, ISSN 1224-6255, , pg.807-810
30. Zhang, G., S. Zhang, Y. Sun, L. Li, H. Xin, C. Yuan, 2013, Regional trial of superior clones for fodder in Robinia pseudoacacia L., http://118.145.16.238.81 zk/EN abstract, 35(5): 8-14.
31. Wandel, W.N., 1989, Handbook od lanscape cultivars, Easr Prairie Pub. Co. Ill, USA.
32. Wright, J.W., 1963, Genetic Aspects of Forest Tree Improvement. In: Forest and Forest Product Studies, FAO, Roma.