The European Journal of Plant Science and Biotechnology ©2007 Global Science Books

Apricot Genetics and Biotechnology in Romania

Viorica Bălan[1*] • Valerica Tudor[2] • Elena Topor[3] • Mihaela Corneanu[4]

[1] University of Agronomic Sciences and Veterinary Medicine Bucharest, 59 Mărăşti Blvd., Romania
[2] Research and Development Station for Fruit-Tree Growing Băneasa, Bucharest, Romania
[3] Research and Development Station for Fruit-Tree Growing Constanţa, Romania
[4] University of Agricultural Sciences and Veterinary Medicine Timişoara, Romania

Corresponding author: * **balanviorica@yahoo.com**

ABSTRACT

The apricot genetic improvement programme performed in Romania between 1986-2006 included clearly formulated steps such as: wide species information, gene bank development based on worldwide exchange of the biological material, widened genetic variability through intra and interspecific hybrids, *in vitro* immature embryo research of interspecific hybrids from the *Prunus* genus, mutagenesis, genetic study of different valuable combinations in F_1, F_2, backcross generation, pollen grain study of various apricot phenotypes, molecular biology investigation, and tissue culture trials. Romania conserves a rich gene bank, including 655 apricot phenotypes originating from North America, Australia, Asia, and Europe. The genetic variability induced by conventional methods demonstrates that apricot-tree species still have genetic reserves for evolution. The reproductive barriers were overcome by the biotechnological methods applied after the hybridisation of ♀*Prunus armeniaca* × ♂*Prunus persica*, or ♀*Prunus persica* × ♂*Prunus armeniaca*, saving immature embryos often aborted in interspecific hybridisation due to nutritional non-compatibility. The genetic progress of the fruit quality characteristics resulted from backcross methods and physical mutagenesis by the mutagenic agent ^{60}Co 3000R. The electrophoretic investigation revealed peroxidase cryoresistance in the Comandor genitor. Strong shoots were obtained from MS culture medium supplied with 2.0 μM indole-3-butyric acid (IBA) + 2.0 μM benzylaminopurine (BAP) + 0.1 μM gibberellic acid (GA_3), using meristem tips as initial explants. Shoot elongation and caulogenesis were significantly improved in a medium prepared with depleted deuterium water instead of distilled water. Heterosis was independent of the culture medium composition. The 1983-2006 breeding programme validated the following varieties: 'Rareş', 'Valeria', 'Carmela', 'Viorica', 'Nicuşor', 'Adina', 'Alexandru', 'Bucovina', 'Siret', 'Atractiv', 'Dacia', 'Excelsior', 'Favorit', 'Comandor', 'Olimp', 'Tudor', 'Traian', 'Cristal', 'Danubiu', 'Auraş', 'Fortuna', 'Orizont', 'Amiral', 'Augustin'.

Keywords: *Armeniaca vulgaris*, genetic variability, heredity

CONTENTS

Received: 22 February, 2007. Accepted: 20 July, 2007.

Invited Review

INTRODUCTION

Background to apricot culture and research

Known since ancient times, the apricot tree has been appreciated and grown, without particular attention, on mountain slopes in the temperate areas of Central Asia and China.

Apricot-tree culture is favourable in the latitudes of 35° and 43° North, and heights of 700-1,500 m, with rainfalls under 500 mm/year, and lowest temperatures of -33°C in the cold areas. The continental climate records no temperature fluctuations. In Central Asia and Asia Minor, the apricot tree grows at altitudes of 1,000-2,500 m (Lilleland 1935, Loschnig and Passecker 1954).

Owing to its characteristics, the apricot tree is paramount in fruit-tree growing, and is renowned for the high food value of its fruit.

The apricot tree is particularly interesting from a fruit-tree growing viewpoint as it grows fast and yields fruit 3-5 years after planting; under favourable ecological conditions and adequate culture technologies, it can reach high yields each and every year (Bordeianu *et al*. 1967; Bălan 1991).

The studies performed on important European and American genetic apricot-tree collections, such as Yalta-Ukraine, Montpellier and Avignon-France, Bucharest and Constanța-Romania, Cacak-Yugoslavia, and Davis-USA, have emphasised a large range of phenotypes and genotypes originating from various geographic areas and recognizable, among others, by their ecological adaptability (Couranjou 1975; Bailey and Hough 1977; Layne 1980; Bălan 1991).

Many of the world cultivars come from local populations that are well adapted to their original places, although their pedigree is unknown. In his 1989 apricot-tree monography, F. Monastra reported that they held 15.7% of the total described cultivars (Strada *et al.* 1989).

All these apricot-tree phenotypes are a significant genetic inheritance of the entire world despite their impossibility of preservation in only one location and the requirements of registration and patenting which limit free access to genetic material of all the countries interested in developing apricot-tree growing.

Only 30 (23%) of the cultivars registered by the International Board for Plant Genetic Resources (IBPGR) are available in the commercial plantations of the main apricot-tree growing countries, i.e. France, Spain, Greece, Morocco (Audergon 1995).

Apricot culture and research in Romania

Romania has long been concerned with apricot-tree growing. In 1871, I. Henţescu published his work, "Pomology", providing recommendations for the growing of four apricot-tree varieties: ‘Ananas’, ‘Nancy’, ‘Muscatello’, ‘Violeta’ (the first two varieties still exist in the present fruit-tree collections).

By the end of the 19th century, there were several *ex-situ* apricot-tree collections in the nurseries of Bistriţa Pietroasele and Vişani; some varieties are still grown today in some orchards in the apricot-tree growing areas: ‘De Breda’, ‘Luiset’, ‘Rozal’, ‘Cea mai bună de Ungaria’/‘Best of Hungary’/.

In 1921, Nicola Krier created the first Romanian apricot-tree varieties, still sparsely grown: ‘Dulci de Vişani’ /‘Sweet of Vişani’/, ‘Târzii de Bucureşti’/‘Early of Bucharest’/ (Bordeianu *et al*. 1964).

After 1950, Nicolae Constantinescu and his collaborators, Vasile Cociu, Mircea Botez, Ecaterina Bumbac, set the basis of the first systematic research for the creation of apricot-tree varieties, implicitly concerned with the development of the genetic resources (Cociu 1981).

Vasile Cociu continued these studies on an international level between 1960-1980, his collaboration with Prof. Hough from Rutgers University being among the most memorable for the exchange of biological material and the development of the apricot-tree genetic resources.

After 1980, the activity was carried out even further by Viorica Bălan and her collaborators at SCDP Băneasa Bucureşti, and Elena Topor and her collaborators at SCDP Valul lui Traian Constanța–Dobrogea, reaching from 62 apricot-tree phenotypes in 1980 to 518 phenotypes in 1990 and 655 phenotypes in 2003 (Cociu 1990; Bălan *et al.* 1993, 2006; Cociu 2006).

The preservation of the genetic resources resulted in studies on the apricot-tree genetic variability with particular focus on adaptability and quality, as well as the transmission of such hereditary traits as: flowering period and fruit maturation, fruit shape, soluble dry matter content, vitamin C content, fruit acidity, skin and pulp colour, resistance to frost and diseases, as well as the substantiation of some genetic-based improvement strategies (Bălan 1993).

The improvement methods were diversified, resulting in complex hybridisation between the best hybrids F_1, SIB and backcross hybridisation. Thus, a very large genetic diversity was created, allowing gene combinations and recombinations according to the aims of the studies.

The improvement strategies were based on the objectives specific to every new phase, in close relation with the objectives set in the most important fruit-tree research centres in: France (Couranjou J, Audergon JM), Italy (Bassi D, Guerierro R), Greece (Karayannis I), Spain (Egea J, Burgos L and Dicenta F), Turkey (Gülcan R).

Summary of world apricot biotechnology advances

The *in vitro* micropropagation of the apricot can be an efficient method of obtaining healthy, pathogen-free – mainly to Sharka – uniform plantlets, in a controlled environment, as well as of *in vitro* conservation of the genetic resources. The review of apricot genetics and biotechnology in Romania presents the most significant results obtained by different Romanian research teams in comparison with other authors’ relevant works.

In 1989, G. Marino obtained plant regeneration in *P. armeniaca* and, by continuing his research, in 1993 he reported the importance of the carbon source on the multiplication rate, concluding that sorbitol (6.0%) gave better results than sucrose (3.0%). Balla and Vertesy (1999) studied the micropropagation of some Hungarian apricot genotypes, in order to obtain virus-free plants and noticed the importance of IAA (indole acetic acid) in the shoot elongation process. Remarkable results in apricot micropropagation were obtained by Pérez-Tornero *et al*. (1999, 2000), who successfully induced culture initiation starting from apical meristems, cultivated on the basal medium QL (Quoirin and Lepoivre 1977) or modified WPM (Lloyd and McCown 1981) of different phytohormone concentrations, obtaining the best results on the mediums supplied with BA (N^6-benzyladenine) (1.78-3.11 μM). They also noticed the frequent phenomenon of apical necrosis of the *in vitro* cultivated *Prunus*. In the same year, Pérez-Tornero *et al*. (2000b) communicated the effects of BA (2.22–2.66 μM) on improving caulogenesis and the stimulatory effects of IBA (indole-3-butyric acid) (29.53 μM) and NAA (α-naphthaleneacetic acid) (10.74 μM) on rhizogenesis. Pérez-Tornero *et al.* (2006) also studied the effect of the explant origin on the *in vitro* culture establishment in four cultivars, pointing out that even the axillary shoots were significantly more contaminated than the meristems, the time to produce elongated shoots was shorter and there were no differences in rooting ability between the shoots micropropagated from meristems and from axillary shoots. Koubouris and Vasilakakis (2006) studied the factors that affect the rapid proliferation and rooting in an apricot cultivar representative for Greece. In order to obtain healthy plants, they used Na-cefotaxime, an antibiotic, in the culture medium. To improve shoot induction, every two weeks they used subcultures in a medium supplemented with 2.2 μM BA + 5.71 μM IAA, and for the optimum root induction they used 19.6 μM IBA. Studying the acclimatisation phase of *Prunus* sp. rootstocks, Rogalski

et al. (2003) pointed out the significant effect of the IBA treatment, genotype and genotype x IBA concentration interaction, on the survival rate in *P. armeniaca* 'Capdeboscq'.

In Romania, research on the *in vitro* culture of the apricot developed in the last ten years, focusing on cultivar and hybrid micropropagation (Butic-Keul *et al*. 2004; Corneanu *et al*. 2006), interspecific (♀*P. armeniaca* x ♂*P. persicum*, ♀*P. persicum* x ♂*P. armeniaca*) immature embryo germination (Bălan *et al*. 1999), and rootstock micropropagation (Popa *et al*. 2005). Different culture mediums and phytohormone balances, the effects of some unconventional bioactive substances (deuterium-depleted water, magnetic fluids) were tested in order to increase micropropagation or rooting rate.

Deuterium-depleted water (DDW) is defined as having the deuterium content under 80 ppm, which, compared with natural water, has 144 ppm. Recent research points out that there is a correlation between the deuterium content in water and DNA degradation. Cell ageing is connected to the gradual accumulation of errors in DNA or the dysfunctional DNA repairing mechanisms (Goodall 2003). In *Robinia pseudoacacia* var. *oltenica*, the DDW concentration in the culture medium had a significant effect on the shoot elongation, as well as on the organogenesis processes (Corneanu *et al*. 2006). Similar results were obtained by Butnaru *et al*. (2001, 2004) in *Chrysanthemum indicum* and Radovet-Salinski *et al*. (2004) in *Coleus blumei*.

Magnetic fluids (MF) are ultrastable colloidal suspensions of ferro- and ferrimagnetic particles in different liquids (water, petroleum, oleic acid, vitamins, a.o.). They were initially used in physics and technics (aerospatial industry) and, after the year 1990, they were tested in biology and medicine. The stimulative effect of magnetic fluids on the development and almost on the *in vitro* rooting process was reported by Corneanu *et al*. (2000, 2004, 2006), Butnaru *et al*. (1999) and Minea *et al*. (2003) in many species of horticultural interest and, in the last years, also in woody species (*Robinia pseudoacacia*, *Prunus avium*).

This review is structured into two distinct sections: genetics of apricot tree in Romania and biotechnology of apricot tree in Romania.

GENETICS OF APRICOT TREES IN ROMANIA

This section presents the research methods employed by the authors of this review, as well as the results obtained from the studies conducted by the corresponding author and the interdisciplinary team, between 1980 and 2006, in accordance with the internationally acknowledged scientists and specialist literature in the field of apricot genetics

The apricot genetics and breeding programme in Romania included: cytogenetics, wide information on the species, adaptability, genetic, physiological and biochemical characteristics and traits, productivity, resistance to stable diseases, initial genetic variability, preservation of genetic resources, selection of genitors, widening genetic variability through intra- and interspecificities, mutagenesis, cryoprotein studies and embryo collection, genetic studies on heredity types and the genetic mechanisms referring to cytoplasmic heredity, genetic transgression, heterosis effect, dominance of some characteristics, segregation in F_1, F_2 progenies, backcross and V_2 mutants, study on microcultures and competitive cultures of the most valuable apricot elites, and the validation as varieties of the apricot trees that corresponded to the breeding objectives.

Biological material for the study of initial genetic variability, preservation of genetic resources, selection of genitors

Devoted to the principle of evolution and preservation of biodiversity, Romania conserves a rich gene bank in the main areas: The Research Station for fruit tree growing Băneasa-Bucharest, with 655 phenotypes, and The Research Station for fruit tree growing Constanța with 471 phenotypes.

The apricot-tree phenotypes preserved derive from the following geographic areas: North America (New Jersey-65, Canada-58, California-74), Australia-6, Asia (China-23, Middle Asia-2, Armenia-2, Iran-2), Europe (Romania-257, France-25, Germany-4, Yugoslavia-10, Greece-3, The Czech Republic and Slovenia-14, CSI-3, Italy-32, Ukraine-10, Macedonia-52, Spain-2, Holland-2, Hungary-12, the Republic of Moldova-5, Bulgaria-2).

Biological material for the study of induced variability and various genetic mechanisms

The biological material for the study of induced variability and various genetic mechanisms, and for the selection of new phenotypes was obtained from intra- and interspecific hybridisation, auto-fecundation, backcrossing, physical and chemical mutagenesis, and *in vitro* cultures.

Hybridisation resulted in 9,000 intraspecific and 1,100 interspecific hybrids.

The genitors used were: 'Comandor' standard, V2- 56 'Comandor', 'Excelsior', 'Dacia', 'Sirena', 'Selena', 'Olimp', 'Sulina', 'Litoral', 77.3.52BV, 'Valeria', 'Rareş', 'Carmela', 'Viorica', 'Favorit', 'Mamaia', 'Roşii de Băneasa', 'Red of Băneasa', 'Sirena', 'Sulina', 'Patriarca temprano', 'Early Orange', 'Goldrich', 'Harcot', 'HW 407', 'Skaha', 'Sungold', 'Sunglo', 'Vivagold', 630203, 'Wenatchee', 'Blenryl', 'Harogem', 'Sundrop', 'Stella', 'Riland', 'Kinred', NJA 58, NJA 25, 'Goldrich', 'Ksongady Magyar Kayszi', 'Salah', B12/6, NJA13, 'Farmingdale', NJA 20, 'Steaua Roşie', 'Red Star', 'Cais trandafiriu', 'Rosy Apricot-tree', Marculesti 19, B 28/2, CR 2-63, 'ReUmberto' F_2, 83.15.23 BI The auto-fecundation of the phenotypes 'Comandor', 'Olimp', 'Selena', 'Sulina', 'Litoral' resulted in 15-82 C_1 descendant. Within hybrid families, 15-230 descendants F_2 were obtained. Backcrossing resulted in 120 descendants. Physical mutagenesis used the mutagenic agent $^{60}C_O$3000R, and resulted in 140 V_2 'Comandor' mutants. Chemical mutagenesis used the mutagenic agent hydroxyl amine, and resulted in 20 M_1 'Olimp' individuals. 1100 hybrids resulted from the *in vitro* saving of immature embryos.

Statistical data processing

The data resulted from the studies conducted below were statistically processed for the following characteristics: tree height, crown height, crown diameter on the row and perpendicular to the row, trunk diameter on the row and perpendicular to the row, trunk-section surface, the ramification angle of the mother branches, the length and number of the annual shootlets per one metre of mother branch, the number of foreseen shootlets per fruit tree, the length of the two-year old branches per one metre of mother branch, fruit cluster formation, leaf surface per offshoot, respiration and photosynthesis intensity, the attack degree of some specific diseases, the free and bound water content, the carbon hydrates content of one-year old shootlets (both in the dormant and vegetative stages), the percentage of damaged and dead buds, the biometric elements of the fruit, the soluble dry matter content, the vitamin C content.

As the studied quantitative characteristics were expected to have the highest phenotypical value, sampling (average samples) was performed on more than 10 and less than 50 individuals from each tested population. Research in the quantitative genetics and statistical analysis of fruit trees in the US (West Lafayette), cherry tree in California, apricot tree in France and Romania, peach tree in France, genetically resistant plants in France and Romania, and horticultural plants in Romania, had previously reported that this type of sampling was sufficient to provide objective proof: Crăciun (1981), Lapins (1983), Hansche *et al*. (1975), Ceapoiu (1968,1980), Couranjou (1975, 1989), Monet (1967, 1977), Monet and Bastard (1971, 1982), Pena (1986), Cociu and

Oprea (1989), Bălan (1991); Bălan *et al*. (2006).

The measurement tools and devices were unchanged for all the sampled individuals and samples.

To analyse the variability of the studied traits and characteristics, it was agreed, according to the genetic experimental techniques, that the *s%* value of 0-10 refers to low variability, the interval 10-20 refers to average variability, and values over 20 refer to high variability. Environmental variance (V_E), calculated according to the Nokorinthop formula, was used to emphasise the influence of the environment on the phenotype.

$V_E = 1/3(s^2P_1 + s^2P_2 + s^2F_1)$ is the average between the parents and the generation F_1.

Genetic variance is the genotype variance, and was calculated according to the formula:

$V_G = V_P - V_E$, where V_P is total variance, or the F_2 variance.

Heritability was calculated according to the formula $h^2 = V_E/V_P$.

The difference between the parental arithmetic means and the arithmetic means of the descendants F_1, F_2, C_1, V_2 and M_1 was calculated.

Genetic studies conducted on apricot in Romania

Apricot-tree cytogenetics

The chromosomal set known until the present is 2n = 16 (Darlington 1945; Bălan 1991). **Fig. 1** shows the chromosomal set present in the mitotic metaphase of active apricot-tree rootlets of *Armeniaca vulgaris*, hybrid '88.4.11 BI'.

The meiotic divisions observed in several apricot-tree varieties and hybrids showed no anomaly, which reflects the safe descendant transmission of some parental traits, i.e. their genetic continuity. **Fig. 2** shows that the meiotic divisions (diakinesis to prophase 1, metaphase 1, anaphase 1, telophase 1 and metaphase 2, anatelophase 2) were normal in the descendant hybrid '88.4.11 BI'. The display of chromosomes followed the Salesses method (1988).

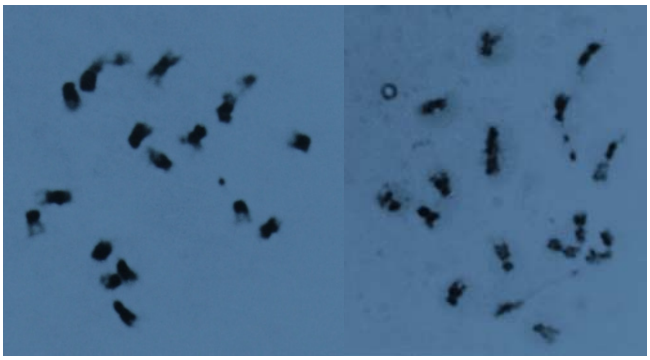

Fig. 1 Chromosomes in mitotic metaphase in apricot.

Initial and induced variability, heredity type and genetic mechanisms of descendant trait transmission

The research methods and results refer to the initial and induced variability, the heredity type and the genetic mechanisms of descendant trait transmission: vegetative growth, morphological characteristics, certain physiological characteristics, frost resistance and wintering, behaviour under the main pathogen attacks – as elements of apricot-tree adaptability in the studied areas, production traits and fruit quality.

Variability of vegetative growth

The methods included in this sub-section had been previously established and used by the authors: Crăciun et al (1978), Cociu (1969), Couranjou (1975), McLean and Rasmussen (1980), Renaud (1980), Bassi (1990), Bassi *et al*. (1995), Bălan (1991), Dejampour and Zeinalabedini (2006).

The following characteristics were recorded in the collection-preserved material, parents, hybrid descendants, CI crossbred descendants, backcross descendants, V_2 and M_1 mutants, both in the juvenile and maturity stages: tree height, crown height, crown diametre on the row, crown diameter perpendicular to the row, trunk diameter perpendicular to the row, trunk diameter on the row, trunk cross-section surface.

Tree height, crown height, crown diameter and crown volume

The traits – tree height, crown height, and crown diameter on the row and perpendicular to the row – were calculated with respect to their heritability.

The crown volume is characteristic for each phenotype, as the result of crown diameter and its height, calculated under conditions of free crown growth..The crown volume, measured in m^3, was calculated based on the Sarger formula: $V = ½(D+d) \times H \times 0.416$, where D = crown diameter on the row, d = crown diameter perpendicular to the row, and H = crown height. Calculations also included the initial and induced variability of the crown volume, and the correlation between its components; genetic analysis was performed on the crown shape, as well as the assessment of descendant selection of the apricot-trees that had a low crown volume in their juvenile phase and were likely to maintain it during their entire life.

The trunk diameters on the row and perpendicular to the

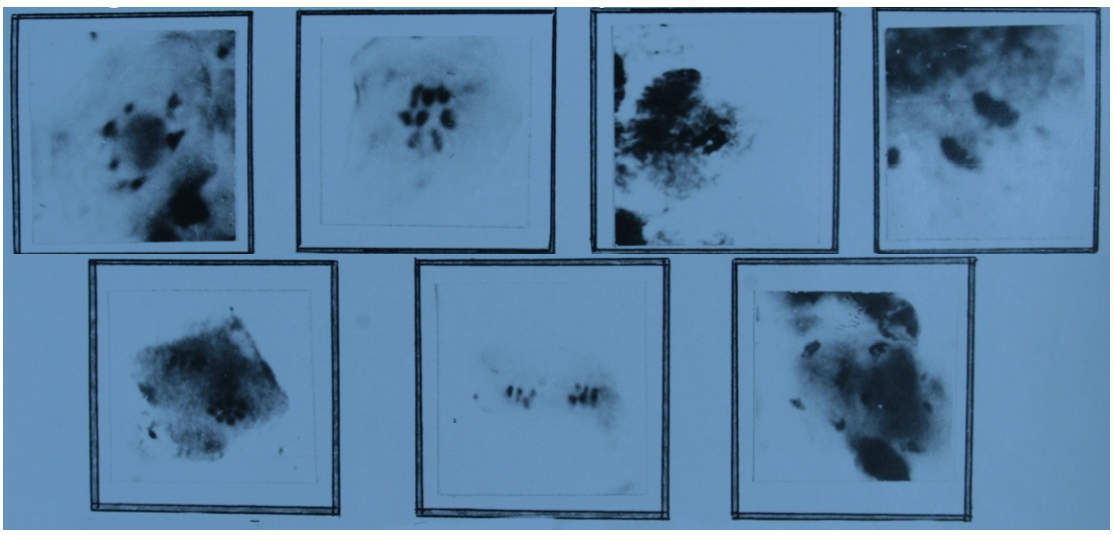

Fig. 2 Meiotic divisions in hybrid descendant 88.4.11.BI. Diakinesis to prophase 1, metaphase 1, anaphase 1, telophase 1 (top); Metaphase 2, anaphase 2, anatelophase 2 (bottom).

Table 1 Heritability of tree height in apricot tree.

Hybrid family	No. of descendants	V_P M	V_E m/%	V_G m/%	H^2
Comandor × Excelsior	15	1.91	1.01/53	0.91/47	0.48
Excelsior × Comandor	18	2.05	1.06/52	0.99/48	0.48
Comandor × Dacia	22	3.43	1.73/51	1.70/49	0.49
Comandor × 77.3.52BV	12	1.66	0.94/57	0.72/43	0.43
Excelsior × Goldrich	50	1.91	1.0/53	0.91/47	0.48

row, measured in cm, were calculated in all fruit-trees, 50 cm above the soil surface.

The trunk-section surface was calculated using the following formula: $\pi \times 1/4(D+d)^2$ The growth rate of the trunk surface, i.e. the trunk thickness as a component of the fruit-tree vigour, was a selection criterion for the low-vigour phenotypes, together with the crown volume.

The following studies were conducted by Viorica Bălan, Elena Topor, Valerica Tudor and collaborators (1986-2006). They resulted in collection-preserved phenotypes in which the tree height varied between 3.0 m in the elite 77.3.52. BV-Romania, and 5.6 m in the following varieties: 'Cea mai bună de Ungaria'/'Best of Hungary'/-Hungary, 'Sulina'-Romania, and 'Sungold'-America. The amplitude of variation was 2.6 m, whereas the average height of all phenotypes was 4.8 m. 6% of the phenotypes were shorter than the average of all the preserved phenotypes. In the maturity period (seven years after planting), the amplitudine of the initial variation in tree height allowed the selection of short genitors which were employed for the genetic study of this trait. The height variability of the hybrid descendants belonging to ♀Excelsior × ♂Goldrich, ♀Excelsior × ♂Comandor, ♀Comandor × ♂Dacia, ♀Comandor × ♂77.3.52 BV was average, as the variability coefficient s% varied between limits (10.6-12.2) during the intense growth of the descendants, i.e. between years 2 and 4 when fruition started. The variation limits of the tree height in the fourth year of growth were 1.90 m in the descendant 83.8.16 BI (parents: ♀Comandor and ♂Dacia), and 2.15 m in the descendant 83.4.3 BI (parents: ♀Comandor and ♂ 77.3.52 BV). In the phenotypical illustration of the tree height, out of the total variance V_P, genetic variance V_G was between 43% and 49%, while environmental variance V_E was somewhat higher (between 51% and 57%). The heritability h^2 of the tree height varied between 0.43 and 0.49, which reflects the percentage of hybrid descendants inheriting the height of their genitors (**Table 1**). 30-50% were short-height hybrid descendants, and the maintenance of this trait during their ontogenetic evolution of growth and development (years 2-8), and the high value of the genetic variance V_G allowed the phenotype-based selection of apricot-tree elites that were shorter than their parents. On average, the hybrid generation was distinctly taller than the parents. Cytoplasmic heredity was identified in the tree height trait where the 'Excelsior' variety was used as maternal genitor. In the crossbred descendants C_1, the tree height variability was low in 'Sirena' C_1 (s% = 6.32) and 'Selena' C_1 (s% = 6.53), and average in 'Sulina' C_1 (s% = 12.26) and 'Litoral' C_1 (s% = 17.44). At a similar age, the crossbred descendants were shorter than the hybrid descendants, with the following limits: 0.40-1.45 m in year 2 compared with 1.20-1.90 m in the hybrid descendants, and 0.75-1.50 m in year 3 compared with 1.60-2.50 m in the same descendants. At a similar age (year 4), the average height of the mutants V_2 'Comandor' ($\bar{x}$ = 2.3 m) and M_1 'Olimp' ($\bar{x}$ = 2.55 m) was very significantly distinct from the standard phenotypes 'Comandor' ($\bar{x}$ = 3.7 m) and 'Olimp' ($\bar{x}$ = 3.80 m). Crossbreeding, physical (^{60}Co) and chemical (hydroxylamine) mutagenesis resulted in descendants shorter than their common ancestor, either 'Comandor' or 'Olimp'. There were insignificant differences in the average between the crossbred descendants C_1 'Comandor' and V_2 'Comandor', as well as between C_1 'Olimp' and M_1 'Olimp'.

In the collection-preserved phenotypes, the crown heights varied between 2.4 and 4.8 m, the large diameter of the crown between 3.2 and 5.5 m, and the crown volume between 2.3 and 5.7 m^3. In Romania, the shortest height (2.4 m) and width (3.2 m) of the crown was recorded in 77.3.52 BV. Also, narrow widths of the crowns were recorded in the following phenotypes: 'Dacia' (3.5 m) in Romania, 'Don Gaetano' (4.2 m) in Spain, and 'Canada 60012' (4.2 m), 'CR-2-63' (4.0 m), 'Manitoba' (4.2 m), 'Vivagold' (3.9 m), and 'Canada 6001' (4.2 m) in the US. In the hybrid descendants, the variations in crown height were low (s% = 9.61) in the ♀Comandor × ♂Excelsior family, or moderate (s% = 14-16.5) in the other hybrid families. In year 4, the crown height reached up to 2.3 m in 50-85% of descendants of the studied hybrid families, excepting those of the ♀Comandor × ♂77.3.52 BV family in which only 10% had this height while the rest were taller than 2.3 m. The crown volume ranged between narrow and average (10.8%) in the ♀Comandor × ♂Excelsior family, and large in the other families. Cytoplasmic heredity occurred for crown size and volume even if 'Excelsior' was the maternal genitor. The genetic variance V_G for crown height, large crown diametre, and narrow crown diametre was lower than the environmental variance V_E in all the hybrid families under study, i.e. between 28% and 48% of the total variance. The improvement value of crown height, large crown diameter, and narrow crown diameter was foreseen in 21-47% of cases, as heritability varied between 0.27-0.47 for crown height, 0.21-0.40 for large crown diameter, and 0.25-0.33 for narrow crown diameter. In the crossbred descendants C_1, the smallest crown size and volume were recorded in 'Sirena' C_1 while the highest were recorded in 'Olimp' C_1. The variation in crown height was low in 'Selena' C_1 (s% - 8.26), very high in 'Olimp' C_1 (s% = 98.4), and average in the following descendants: 'Sirena' C_1 (s% = 18.8), 'Comandor' C_1 (s% = 17.6), 'Litoral' C_1 (s% = 17.6).The large diameter of the crown recorded low variations in 'Selena' C_1 (s% = 6.45), and very high variations in 'Sirena' C_1 (s% = 34.4) and 'Sulina' C_1 (s% = 38.18). The narrow diameter of the crown showed high variability, as the variability coefficient s% was 25.2 in 'Sirena' C_1, and 45% in 'Comandor' C_1. For the narrow crown diametre, distinctly significant differences were determined between the mean of the crossbred descendants 'Olimp' C_1 and 'Sulina' C_1, and the standard phenotypes 'Olimp' and 'Sulina'. For the crown volume, the differences were distinctly significant between the crossbred phenotype 'Olimp' and the standard phenotype 'Olimp', and very distinctly significant between the crossbred descendants C_1 and the standard phenotypes 'Sirena', 'Selena', 'Comandor' and 'Litoral'. There was a large variation range in crown size and volume in the mutants V_2 'Comandor' and M_1 'Olimp'. In the relation between the standard phenotype 'Comandor' and the mutant phenotype V_2 'Comandor', there were distinctly significant differences between the average crown heights, and very distinctly significant differences between the small diameters and volumes of the crown. The significant differences of the average crown size and volume between the standard phenotypes 'Comandor' and 'Olimp', and the crossbred phenotypes C_1 'Comandor' and 'Olimp', as well as between the same standard phenotypes and the mutant phenotypes V_2 'Comandor' and M_1 'Olimp', proved the efficient crossbreeding and physical and chemical mutagenesis methods, resulting in the creation of new low-vigour phenotypes. The multiple regressions of the simultaneous influence on the

Table 2 Partial correlations between the crown height, large crown diametre, narrow crown diametre, and crown volume in the hybrid and crossbred descendants C_1 of apricot tree

Grade-2 correlations	Partial correlation coefficients (*r*)	Correlation signification highest *r*
rxyzw (H × D)	-0.97	000
rxzyw (H × d)	-0.81	0
rgzxw (D and d)	-1.10	000
rxwzy (H and V)	0.81	X
rywzx (D and V)	0.27	
rzwxy (d and V)	0.11	

x = crown height (H); y = large diametre of crown (D); z = narrow diametre of crown (d); w = crown volume (v) r (highest) 5% = 0.75; 1% = 0.87; 0.1% = 0.95.

three crown sizes of the hybrid, crossbred and mutant descendants emphasise the existence of a significant positive correlation between the crown height and the crown volume $r = 0.81$, and an insignificant correlation between the large diameter and the crown volume $r = 0.27$, and between the narrow diameter and the crown volume $r = 0.11$. A very significant negative correlation was evident between the crown height (H) and its large diametre (D), and the large crown diameter (D) and the narrow diameter (d) (**Table 2**).

Conclusions reveal that:

- For the height characteristics, VG=1/2VP (genetic variance represents ½ of total variance) the methods employed were: controlled hybridisation, inbreed by cross breeding, and mutations by physical and chemical gene mutation.

- For the crown shape characteristics, genetic recombination was involved by controlled hybridisation.

Genetic analysis of crown shape

The dialelic hybridisation between the oval-shaped and flat-shaped crown phenotypes resulted in descendants with three types of crown shape: oval, flat, and round. The analysis of the crown shape frequency in the hybrid descendants F_1 pointed that no segregation rapport can be established for this trait; consequently, the occurring non-parental flat shape was not the result of new gene combinations but of genetic recombinations. Thus, determinations regarding the recombination probability (p), the gametes (Os, as, Oa, ss) probability, phenotype frequency and, in the end, total crossingovers and non crossingovers were performed on the descendants from the following hybrid families: ♀Excelsior (oval) × ♂Goldrich (flat), ♀Excelsior (oval) × ♂Comandor (flat), ♀Comandor (flat) × ♂Excelsior (oval), ♀Comandor (flat) × ♂Dacia (oval) ♀Comandor (flat) × ♂77.3.52 BV (oval) (**Table 3**). The analysis of the above data shows that the non crossover-determined parental phenotypes can occur with a frequency between 87% (♀Excelsior × ♂Comandor) and 97% (♀Excelsior × ♂Goldrich and ♀Comandor × ♂Dacia). The frequency of the non crossover-determined non-parental phenotypes can range from 3% (♀Excelsior × ♂Goldrich and ♀Comandor × ♂Dacia) to 13% (♀Excelsior × ♂Comandor).

Trunk diametre and trunk section surface

The trunk diametres on the row and perpendicular to the row, measured in cms, were calculated in all fruit-trees, 50 cm above the soil surface.

The trunk-section surface was calculated by using the follwing formula: $\pi \times 1/4(D+d)^2$ The growth rate of the trunk surface, i.e. trunk thickness as a component of the fruit-tree vigour, was a selection criterion for the low-vigour phenotypes, together with the crown volume

The results revealed that, in the collection-preserved phenotypes, the variation amplitude of the trunk section surface was higher in the Romanian varieties, compared with varieties from USA, Italy, France, Spain, and Asia Minor. The selection 77.3.52 BV recorded the smallest surface of the trunk section (69.4 cm^2) whereas the Romanian variety 'Litoral' had the largest surface (147.3 cm^2). The frequency polygon of the trunk surface variation represents a plurimodal distribution with a slightly negative asymmetry, which points to the heterogeneity of the biological material under study. In the four-year old hybrid descendants, the trunk section surface varied between 10.20-55.37 cm^2. The variation range was average for the trunks of the hybrid descendants of ♀Excelsior × ♂Comandor (s% = 10.7), and ♀Comandor × ♂Excelsior (s% = 15), and high in the descendants of ♀Excelsior × ♂Goldrich (s% = 29.09), ♀Comandor × ♂77.3.52 BV (s% = 33.9), and ♀Comandor × ♂Dacia (s% = 39.3). The configuration of the diagram and the regression line pointed that there was no actual correlation between the surface of the trunk section and the crown volume, as the correlation coefficient was $r = 0.58$. The crossbred descendants were characterised by significant differences in the average surface of the trunk cross-section compared with their ancestors: 'Sirena', 'Selena', 'Olimp', 'Sulina', 'Comandor', 'Litoral'. The trunk section surface of the phenotype C_1 'Comandor' was significantly different

Table 3 Genetic analysis of crown shape. (Viorica Bălan)

Hybrid family	Oval %	Round %	Flat %	p	Gametes (Os, as Oa, ss) probability	Phenotype frequency (Os, Oa, as, ss) %	Total cross overs %	Total non cross overs %
♀Excelsior oval × ♂Goldrich flat	77	19	4	0.04	Os/0.48 as/0.48 Oa/0.02 ss/0.02	Os/73 as/24 Oa/2 ss/1	3	97
♀Excelsior oval × ♂Comandor flat	28	56	16	0.16	Os/0.42 as/0.42 Oa/0.08 ss/0.08	Os/66 as/21 Oa/8.6 ss/4.4	13	87
♀Comandor flat × ♂Excelsior oval	50	40	10	0.1	Os/0.45 as/0.45 Oa/0.05 ss/0.05	Os/69 as/22 Oa/5 ss/4	9	91
♀Comandor flat × ♂Dacia oval	50	45.5	4.5	0.04	Os/0.48 as/0.48 Oa/0.02 ss/0.02	Os/73 as/24 Oa/2 ss/1	3	97
♀Comandor flat × ♂77.3.52 BV oval	71.4	14.3	14.3	0.14	Os/0.43 as/0.43 Oa/0.07 ss/0.07	Os/67.5 as/21.6 Oa/7.5 ss/3.4	11	89

from V_2 'Comandor', i.e. it had lower vigour.

In conclusion, physical gene mutation and crossbreeding, induced inbreed and mutation were involved for fruit-tree vigour (crown shape and size, trunk-section surface).

Variability of some morphological characteristics

In this sub-chapter, we included methods that had been previously used by the authors: Decourtye (1967), Couranjou (1975), Bailey and Hough (1977), Barlow (1980), Hansche and Beres (1980), Sjujka-Lacza (1985), Bassi (1990), Bălan (1991), Bassi *et al*. (1995), Bălan (1999), Audergon *et al*. (2006), Bassi and Audergon (2006), Costes *et al*. (2006), Legave *et al*. (2006).

The research conducted by Viorica Bălan and collaborators in Romania is in accordance with the above-mentioned literature.

The morphological characteristics that may provide new phenotypes of higher values were studied with the aim of contributing to further practical and scientific information necessary to create new apricot-tree varieties that use solar energy more efficiently in order to obtain high top-quality yields and better adaptability to weather conditions.

The morphological characteristics studied by Viorica Bălan and collaborators were: the ramification angle of the mother branches, the length and number of the annual shootlets per one metre of mother branch, the number of foreseen shootlets per fruit-tree, the length of the two-year old branches per one metre of mother branch, fruit cluster formation, leaf surface per offshoot. Measurements were performed on groups of three fruit-trees belonging to each phenotype preserved in the collection, and on each individual and family in the case of the hybrid, mutant, C_1, F_2, and backcross populations.

The ramification angle of mother branches recorded high variations in the hybrid descendants, as the variability coefficient s% varied between 25.9% in the ♀Comandor × ♂77.3.52 BV family, and 57.5% in the ♀Excelsior × ♂Goldrich family. The adequate insertion angle of the mother branches (40-50°) was recorded in 25% of the ♀Excelsior × ♂Goldrich descendants, 35% of the ♀Comandor × ♂Dacia descendants, and in 40% of the ♀Comandor × ♂77.3.52 BV descendants.

The number of annual shootlets per one metre of mother branch varied widely in the hybrid descendants, the variation classes ranging from 10-95 in the first crown level, 12-99 in the second, and 12-108 in the third. Compared with the genitors, some of the descendants recorded less shootlets grown on one metre of mother branch, e.g. ♀Excelsior × ♂Goldrich and ♀Excelsior × ♂Comandor, while others had the same number as their genitors, e.g. in 40% of ♀Comandor × ♂Excelsior and in 15% of ♀Comandor × ♂77.3.52.BV; however, no descendant had more shootlets per one meter of mother branch. The length of the annual shootlets per one metre recorded average variations, as illustrated by the lowest limits of the variability coefficient, s% = 14 in the ♀Comandor × ♂77.3.52.BV descendants, and s% = 33 in the ♀Excelsior × ♂Comandor descendants. The number of foreseen shootlets (shootlet/shootlet) varied within 1-35 (in ♀Comandor × ♂Dacia) and 1-22 (in ♀Comandor × ♂77.3.52.BV). The induced variability of the foreseen shootles number varied widely, irrespective of the level: lowest in the F_1 ♀Excelsior × ♂Comandor descendants (s% = 39), medium in the F_1 ♀Comandor × ♂Dacia descendants (s% = 31), or highest, in the F_1 ♀Excelsior × ♂Dacia descendants (s% = 39).

The flowering branches per one metre of mother branch recorded wide variations in number and length, both within the same family and between families. The variation classes for the number of flowering branches per one metre of mother branch ranged between 1 and 50, while the branch length was between 1 and 60 cm. The descendant transmission of the flowering branch type was studied, pointing to the transgressive heredity of the characteristic, which allowed the identification of some spur-branched hybrids F_1 (3-6 cm), particularly in the ♀Excelsior × ♂Goldrich and ♀Excelsior × ♂Comandor families. The cytoplasmic heredity pf the maternal genitor 'Excelsior' was also emphasised for the descendant transmission of the flowering branch type.

The distance of the fruting branch insertion on the multiannual branches varied between 1 and 50. The heredity of the branch framework was transgressive, as the distance between the fruiting branches was either longer or shorter in the descendants, compared with their parents. The standard distance between the branches was considered to be 5-10 cm.

The leaf surface per offshoot unit varied within 15-40 cm^2 in the hybrid descendants, whereas the variability coefficient ranged between 26.7 in the F_1 ♀Excelsior × ♂Goldrich descendants and 34.8 in the F_1 ♀Comandor × ♂Excelsior descendants.

The conclusions of this study reveal that:

- Very distinctly significant differences of the average leaf surface were recorded between the 'Excelsior' and 'Goldrich' parents, as well as between these parents and their F_1 descendants.
- Similar to the parents, the angle between the leaves and the horizontal line in the descendants F_1 of the 'Excelsior', 'Goldrich', 'Dacia', 77.3.52BV phenotypes was either 30-45° or 60-90°, without exceeding 90°, which proved optimum for the best capture of solar energy.
- The 'Excelsior' phenotype showed its cytoplasmic heredity in the descendant transmission of the leaf surface trait.
- Genetic transgresion and cytoplasmic heredity were involved by controlled hybridisation in the May-bunch and spur-form fruit branches.

Apricot-tree adaptability

Flowering time, fruit maturity, and photosynthesis-respiration

The methods included in this sub-chapter followed the specific methods for this field, presented in specialist literature, such as: Couranjou (1975), Kuebemen *et al*. (1979), Hansen and Ryngo(1979), (Bailey *et al*. (1983), Chang (1984), Suranyi (1985), Dorobanțu *et al*. (1986), Cociu at al (1985), Loukas and Pontikis (1985), Audergon *et al*. (1988), Manganaris (1989), Bassi (1990, 1999), Bălan (1991), Badenes *et al*. (2006), Burgos (1995), Geuna et al (2006), Muleo *et al*. (2006), Paydas *et al*. (2006), Poessel *et al*. (2006), Struss *et al*. (2006), Topor and Burtoiu (2006).

Adaptability is the capacity of the body to provide normal functioning of the vital and reproductible processes under the action of the weather factors. In order to emphasise the adaptability level of the apricot-tree phenotypes, observations and determinations were performed at the beginning and end of both the flowering and fruit maturation phases, in order to measure: the intensity of respiration and photosynthesis, the two simultaneous and opposed metabolic chains, the behaviour under conditions of frost and wintering, and the attack of some specific diseases.

Flowering and fruit maturation. The temperature necessary for the optimum fruition phenophases was calculated by summing up the active temperatures over the biological threshold (+6.5°C). It was considered that flowering began when 10% of the flowers bloomed, and ended when 90% of the flowers senesced, whereas fruit maturation was recorded when 90% of the fruit had ripened. Determinations referred to the amplitude of variability, the heredity of flowering, and the maturation of the fruit.

Respiration and photosynthesis intensity were determined in the phenotypes selected as genitors and the hybrid descendants in 100 g plant material/hour, in two important periods of time: 15 May-15 June, the time of the most intense physiological processes; and 15-29 September, when these processes slowed down.

The intensity of photosynthesis was determined by the

Ivanov-Kosovici method based on the determination of the cabon dioxide amount absorbed by the plants during photosynthesis, given a certain air volume. The CO_2 amount was calculated according to the following formula: if = [(a-b) × f × 0.9 × 60]/(g × t). The intensity of respiration was determined by the Boysen-Jensen formula based on the amount of CO_2 released through respiration by the plant material. The variation amplitude of these physiological characteristics was determined in the parental phenotypes and their hybrid descendants.

In this field, the results obtained by Viorica Bălan and collaborators in Romania showed that controlled hybridisation resulted in descendants F_1 that exceeded the variation limits of the parental phenotypes, reflecting the transgressive heredity of the flowering trait. The differences between the descendants F_1 resulted from the same parents (alternatively used as mother and father), which pointed to the cytoplasmic heredity of the standard phenotypes 'Comandor' and 'Excelsior'. The heredity of fruit maturation was illustrated by three cases: transgressive (7%) to very early (5-25 June), in the combination of ♀late maturation × ♂semi-early maturation in ♀Comandor × ♂Dacia; dominant for the early maturation of the father genitor, in the combination of ♀late maturation (August) × ♂very early maturation (June) in ♀Comandor × ♂77.3.52 BV; and intermediary, in the combination of ♀average maturation × ♂late maturation in ♀Comandor × ♂Excelsior and ♀Excelsior × ♂Comandor.

The photosynthesis-respiration balance, both during the intensive growth of the shootlets and fruit, 15 May-15 June, and during the inactive phase (quiescence), pointed to the normal metabolism of the accumulated organic matter available for the vital activities, which reflected the physiological adaptation of the phenotypes selected as genitors, as well as their descendants, in the areas under study, i.e. the Romanian Plain and Dobrogea.

The results led to the following conclusions:

- Genetic transgressions and cytoplasmic heredity were involved for the blooming time of apricot F_1 descendants.
- For fruit maturation, genetic transgressions, dominant and intermediary heredity was involved by controlled hybridisation and induced gene mutations by physical mutagenesis.

Behaviour under conditions of frost and wintering

These traits were analysed according to the methods employed by: Hatch and Walker (1969), Hansche *et al*. (1972), Richardson *et al*. (1974), Erez *et al*. (1979), Raming (1980), Gilreath and Bouchanam (1981), Giulivo *et al*. (1983), Guerriero *et al*. (1985), Bălan and Ivaşcu (1989), Guerriero *et al*. (2006), Pedryc *et al*. (2006), Rodrigo *et al*. (2006), Ruiz *et al*. (2006).

There are numerous elements illustrating the resistance or susceptibility of the collection-preserved apricot-tree phenotypes, genitors and descendants in relation to low winter temperatures and fluctuating temperatures recorded at the end of winter and in spring time. Out of these elements, the determinations referred to: the free and bound water content and the carbon hydrate content, both in the dormant and vegetation stages, cryosusceptibility of malate dehydrogenase and peroxydase in the buds that were naturally exposed to frost during winter, and the percentage of dead flower buds.

Initial and induced variabilities, the heredity and genetic mechanisms of this characteristic were emphasised.

The carbon hydrate content of one-year old shootlets, both in the dormant and vegetation stages, was based on the extraction of sugars by ethylic alcohol and perchloric acid, respectively, under established conditions; the sugars were subsequently treated with anthrone (a tricyclic aromatic hydrocarbon). The starch extract was measured by photocolorimetry.

The cryosusceptibility of malate dehydrogenase and the peroxidase isosimic spectrums were analysed by using phenotype buds that had been naturally exposed to frost (-16°C) and temperature fluctuations (-6°C +16°C).

Acellular homogenates were prepared by manual grinding with quartz sand in 1 Nm Tris- dithiothreitol buffer to protect enzymatic activity. The supernatants centrifugated with 2.6 mg/ml total protein were extracted by vertical discontinuous electrophoresis on polyacrylamide gels. The enzymatic activities were emphasised by the formazan reaction for malate dehydrogenase using nitrotetrazolin-blue and oxidized nicotin aminodimelcatide (NAD) while a buffer mixture of benzenidyn 1 mg/ml and perchydrol 0.03% was used for peroxidase.

The results revealed that the starch content of the annual shootlets varied widely, as the variation coefficient s% ranged between 21.7 in the F_1 ♀Comandor × ♂Excelsior descendants, and 78.9 in the F_1 ♀Comandor × ♂77.3.52BV descendants in their dormant stage, and between 45.5 and 60.7 in their vegetation period. The variation limits of the starch amount were recorded in December-February, between 0.17-4.32 mg/100 g dry matter in the F_1 ♀Comandor × ♂Dacia descendants, and 0.30-6.0 in the F_1 ♀Comandor × ♂77.3.52.BV descendants, whereas in April-May the variations were 0.30-1.45 mg/100 g in the former, and 0.39-6.10 in the latter. The soluble carbon hydrate content varied widely, recording higher values than starch, i.e. 1.35-13.85 mg glucose/100 g dry matter, compared with 0.17-4.32 mg starch/100 g in the F_1 ♀Comandor × ♂Dacia descendants in December-February, and 4.36-11.95 mg glucose/100 g, compared with 0.30-1.45 mg starch/100 g in April-May. The correlation between the starch-carbon hydrate rapport and the frost resistance of the flowering buds was observed in the F_1 ♀Excelsior × ♂Goldrich descendants, where 8% recorded losses of only 20-30%, while the starch amount was 1.54 mg/100 g higher than the amount of soluble carbon hydrates. The bound water content was higher in the hybrid descendants F_1 than in their parents, e.g. 0.4-5.5 mg/100 g dry matter in the descendants F_1 of ♀Comandor × ♂Dacia, 0.3-3.50 mg/100 g in the genitor ♀Comandor, and 0.26-4.1 mg/100 g in the genitor ♂Dacia. The heterosis of the bound water content was determined in the descendants F_1, compared with their parents. The free water content of the descendants F_1 recorded low or average variations, both in the dormant stage and the vegetation period.

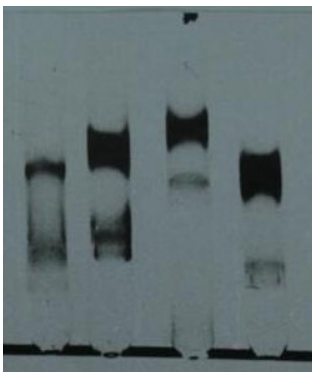

Fig. 3 Cryosusceptibility of cytoplasmic and mitochondrial dehydrogenase in genitor Comandor. Isosimic spectrums indicating decreasing activity in mitochondrial and cytoplasmic malate dehydrogenase.

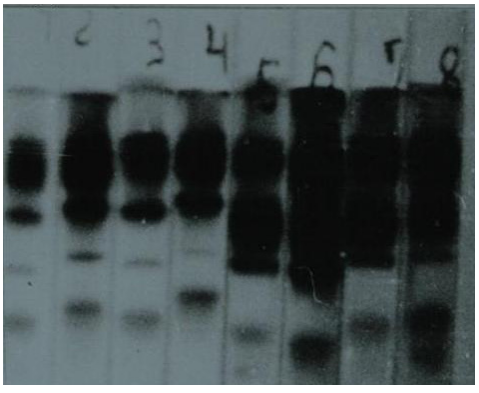

Fig. 4 Peroxidase cryoresistance in genitor Comandor. Isosimic spectrums indicating peroxidase activation.

The free water-bound water balance varied inversely, as the bound water level was higher than the free water level in the dormant stage, and lower in the vegetation period. The cytoplasmic and mitochondrial malate dehydrogenase had evident lower activity in the dead buds, compared with the living buds, in the genitors 'Comandor' and 77.3.52 BV, which emphasised their cryosusceptibility (**Fig. 3**). However, peroxidase manifested cryoresistance (**Fig. 4**), as the peroxidasic isosimic spectrum indicated no differences reflecting cryoinactivation, both in the living and the dead buds. Peroxidase cryoresistance and malate dehydrogenase cryosusceptibility were employed as control indicators for cryoresistance variation in the descendants F_1.

The conclusions resulted from the research data refer to the folowing:

- Heterosis of the content in carbon hydrates, free water and bound water present in the early shoots can be expected in descendants F_1.
- Transgressive heredity was revealed for the frost resistance traits of descendants F_1.
- There was a correlation between the peroxidase cryoresistance of the genitors and the frost resistance of descendants F_1.

Death of flower buds

Frost resistance of the flower buds is a biological characteristic influenced by such factors as: absolute temperature, temperature evolution from the end of the winter dormant stage to the flowering stage, and the physiological condition of the fruit-tree.

Specialist literature (Hatch and Walker 1969; Couvillon and Hendershott 1974; Erez and Lavee 1971; Spiegel-Roy and Alston 1979; Snir 1983; Paunovic and Plazinic 1976, 1983; Paunovic *et al*. 1983, 1985; Paunovic 1986; Scalabrelli and Couvillon 1985; Guerriero *et al*. 2006; Szalay *et al*. 2006) and personal research (Bălan and Ivaşcu 1989, 1995) show that sometimes the flower buds belonging to the same phenotype resist up to -25°C, while some other times they can die at -10°C.

The measurement of the damage caused to the flowering buds started in mid-January, after the temperatures decreased below -15°C, then followed in February-March, when temperatures fluctuated from (+) to (-), sometimes between +16°C and -16°C.

The percentage of damaged buds was determined, and the evaluation of resistance was based on marks ranging from 1 to 5 (Bălan 1991), as follows: 1 = highly resistant phenotypes (0-20% damaged buds), 2 = resistant phenotypes (20-25% damaged buds), 3 = slighly resistant phenotypes (51-70% damaged buds), 4 = sensitive phenotypes (71-80% damaged buds), 5 = highly sensitive phenotypes (81-90% damaged buds).

The results obtained by Viorica Bălan and collaborators emphasise that the flowering buds resistance to frost and wintering (-18°C) and to the temperature fluctuations recorded in February and March (-16°C to +16°C) was transgressively transmitted in descendance, as illustrated not only by the more resistant, but also by 10-25% more susceptible descendants than the genitors, e.g. in ♀Comandor × ♂Excelsior, ♀Excelsior × ♂Goldrich.

In conclusion, heterosis was found for the resistance of fruit buds F_1 to low winter temperatures (-18°C).

Behaviour under the attack of the main diseases

Research on the stable resistant diseases of the apricot tree is specific to various growing areas, as mentioned in specialist literature: Rishbeth (1964), Mănescu *et al*. (1975), Vanderzwet *et al*. (1975), Carter and Moller (1977), Klement (1977), Garrett (1979), Mircetich (1981), Ceapoiu and Negulescu (1983), Okie (1983), Rozsnyay (1983), Bălan *et al*. (1985), Morvan *et al*. (1985), Niyujto *et al*. (1985), Reffatti (1985), El-Kady *et al*. (1986), Baicu and Săvescu (1986), Nemeth (1986), Dosba *et al*. (1988), Morvan (1988), Karayannis (1988), Bălan *et al*. (1989), Crăciun and Crăciun (1989), Bassi (1990), Ionică *et al*. (1990), Bălan *et al*. (1995), Bălan and Stoian (1995), Bassi (1999), Bălan *et al*. (1999), Dicenta *et al*. (1999, 2006), Egea *et al*. (1999), Şesan and Oprea (1999), Karayannis *et al*. (2006), Krska *et al*. (2006), Nicotra *et al*. (2006), Oztűrk *et al*. (2006), Romero *et al*. (2006), Trandafirescu and Teodorescu (2006).

Although literature mentions several apricot-damaging fungi, the most frequent in Romania are: *Monilinia laxa* (Aderh *et* Ruhl) *Honey*, *Stigmina carpophila* (lev) M. B. Ellis, and *Cytospora cincta* Sacc. producing important damage to all the apricot-tree growing areas .

Between 1982 and 2006, a team coordinated by Viorica Bălan conducted a research programme with respect to the genetics of resistance to stable diseases, aiming to create some phenotypes that are genetically resistant to high-frequency pathogen attack.

The particularity of this programme consisted in the absence of resistant genitors belonging to the wild species, spontaneous populations, or cultivated forms.

Therefore, the programme was started by providing natural infection conditions, i.e. plant treatments were stopped for three consecutive years. The selection lot consisted of 1600 F_1 descendants belonging to 64 combinations resulting from dialelic hybridisations of ancestral Romanian biotypes, complex hybridisation, backcrossing, hybridisation between geographically distant fruit trees, crossbreeding. Under strong infection conditions, selection was performed on the phenotypes resistant to the attack of the following pathogens: *Monilinia laxa* (Aderh *et* Ruhl) *Honey*, *Stigmina carpophila* (Lev) M. B. Ellis, and *Cytospora cincta* Sacc., mycoplasmas, bacteriosis, *Pseudomonas siringae* p.v. *siringae* van Hall, and viral diseases, particularly *Plum-pox*.

The selected phenotypes were vegetatively multiplied (20 trees from each phenotype), and then introduced into protected areas and screened by artificial inoculation.

Moreover, three apricot-trees from each collection-preserved phenotype, as well as each individual from the mutant, crossbred C_1 and F_2, and backcross populations, were artificially inoculated with the fungi *Monilinia laxa* and *Cytospora cincta* under orchard conditions, with minimum treatment applied to the collection and no other phytosanitary treatment. The phenotype variability of the reaction to pathogen attack was determined, and the resistant phenotypes were selected as genitors.

Dialelic hybridisation was performed between the phenotypes selected as resistant genitors, as well as between the resistant genitors and top-quality genitors. Determinations were performed on the descendants: induced genetic variability, genetic mechanisms, and the heredity types of resistance to stable diseases.

The attack produced by *Monilinia laxa* was observed on the branches after flowering, and the observations included the percentage of damaged branches out of 100 (F%) and the intensity (I%) of the disease on each branch, according to the assessment scale of 0-4 (Săvulescu and Săvulescu 1959). The degree of the attack was calculated according to the following formula: $GA = (F \times I)/100$. Artificial inoculation was made by the virulent ML_{27} strain of *Monilinia laxa* by spraying the sack-covered flowers with a spore suspension in sterile distilled water (concentration 10^6 spores/ml).

The attack produced by the fungus *Cytospora cincta* was evaluated according to the drying level of the branches that had been artificially inoculated with fragments of fungus colonies by using two virulent strains: C_{36} and C_{41} grown on a CGA. medium. The inoculum was applied to scalpel-cut wounds made in October, and the evaluation of resistance to the action of the fungus was made by measuring the necrosis length starting from the infection point, as follows: 0-3 cm-resistant (R), 3.5-18 cm-medium resistant (MR), over 18 cm-susceptible (S) (Rozsnyai 1977).

The attack produced by the fungus *Stigmina carpophila* on leaves and fruit was determined by observing the frequency of the damaged organs out of a total of 100, and the attack intensity for each damaged organ by using the scale

of 0-6 (Baicu and Săvescu 1986). The degree of the attack was subsequently calculated according to the folowing formula: GA = (FxI)/100, where F = attack frequency and I = attack intensity.

The biological material was also tested for infection with such pathogens as *Apricot chlorotic leaf roll*, *Plum pox* (Sharka) and *Pseudomonas siringae* p.v. *siringae* van Hall; as the biotic factors were involved in apricot-tree damage, especially in complex actions together with micoses.

Micoplasmic infections were observed by optical microscopy, using the Diens method. Resistance to the attack of the bacterium *Pseudomonas siringae* p.v. *siringae* van Hall. was tested *in vitro*. Ten shootlets were sampled from each fruit tree belonging to a phenotype, as well as from each descendant, and subsequently inoculated with bacterial *Pseudomonas* suspension, a mixture of three strains: syringomicin-producing T_{96}, strong ice-nucleating T_{1328}, and medium syringomicin-producing and medium ice-nucleating T_{1318} of 10°UFC titre.

To evaluate the attack of the virus *Plum pox*, samples of 150 leaves and 25 fruit were collected from each tree under study, and determinations were made for the intensity of the attack, the frequency of the attack, and the degree of the attack was calculated. For a better interpretation of the results, the entire biological material was subject to screening according to the degree of the attack and the results of the ELISA test. The frequency of the Sharka attack was calculated by using the formula f% = (n × 100)/N, where n = the number of attacked leaves or fruit, and N = the number of observed leaves and fruit. The intensity of the Sharka attack was calculated in order to analyse the spreading degree of the attack as the ratio between the area of the attacked leaves or fruit and the total area of the observed organs. The interpretation of the results was based on the scale of 0 to 6 classes equivalent to some percentage of the attack intensity (attack surface%/attack intensity class): (1-3)/1, (4-10)/2, (11-25)/3, (26-50)/4, (51-75)/5, (76-100)/6. The relative expression of the intensity of the *Plum pox* attack was calculated by the formula I = [F(i × f)]/n, where F = attack frequency, i = class or percentage of the attacked area, f = number of attacked cases within the same class, and n = total number of attacked cases. The degree of the attack (GA%) illustrated the seriousness of the attack, and was determined according to the relation: GA% = (F × I)/100.

The results show that the consecutive three-year absence of treatments and the conditions provided by the Bucharest area, where *Monilinia laxa* Aderh *et*. Ruhl Honey and *Stigmina carpophila* M. B. Ellisse may produce over 70-80% damage, created favourable conditions for screening. Thus, out of 1600 descendants of 64 genomic families resulted from dialelic breeding between geographically distant partners, complex hybridisation, and backcrossing, only 13 descendants of nine genomic families were selected according to their field resistance to the two pathogens. The degree of attack (DA%) of the 13 descendants was limited to 2.5-7.5 in *Monilinia laxa*, and 1.8-7.5 in *Stigmina carpophila*. 'Marculesti 19' was the maternal genitor in three of the nine genomic families, and 'Re Umberto' was the maternal genitor in five families and the paternal genitor in one of the selected families. The selected elites were retested by artificial inoculation under glasshouse conditions, and no difference was observed, compared with their behaviour under natural infection conditions. The selection 83.15.23 (♀Re Umberto × ♂Timpurii de Chişinău/Early of Chişinău) was also resistant to inoculation based on fragments of *Cytospora cincta* colonies whereas selections 83.29.4 B1 and 83.29.3 B1 (♀Mr.19 × ♂CR5-180) showed average resistance. The selection 83.29.4B1 was highly resistant to pathogens and temperature fluctuations, and produced top-quality fruit; therefore, it was homologated in 1984 under the name of 'Dacia', and was protected by a patent. The phenotypes that resisted the attack of stable pathogens were the basis for the genetic study of resistance to diseases, as well as genitors in the genetic breeding programme for apricot trees. The study of the F_1 descendants resultant from ♀resistant ('Dacia', 83.15.23B1, 77.3.52 BV) × ♂intermediary ('Comandor', 'Excelsior', 'Goldrich') showed high variability to the attack of the pathogens under study. The transgressive heredity of the reaction to the pathogenic action of the fungus *Stigmina carpophila* was determined in the following descendants F1: ♀Comandor × ♂Excelsior, ♀Excelsior × ♂Goldrich, ♀Excelsior × ♂Comandor, ♀Comandor × ♂Excelsior, ♀Early Orange × ♂Don Gaetano. The hybrid descendants F_1 ♀Excelsior × ♂Goldrich, ♀Comandor × ♂Dacia, of the ♀susceptible × ♂resistant type, and ♀Comandor × ♂77.3.52.BV of the ♀susceptible × ♂average resistant type, reacted to *Cytospora cincta* Sacc., manifested heterosis under conditions of inoculation with the virulent strains C_{36} and C_{41}. The $^{60}C_O$ physical mutagenesis, in a rate of 3000R, induced resistance to the fungus *Stigmina carpophila* in 33% of the total mutants V_2 Comandor.

The conclusions of the above results indicate that:

- Intermediate resistance to *Monilinia laxa* was involved by controlled hybridisation and physical gene mutation.
- Genetic transgression was induced by controlled hybridisation for resistance to *Stigmina carpophila*.
- Heterosis of *Cytospora cincta* resistance was induced by controlled hybridisation (VG>VP). Induced gene mutation was found for *Cytospora cincta* resistance and for the biochemical traits quality.
- Resistance to Sharka was analysed, resulting in the selection of resistant genitors, i.e. 'Stella', 'Early Orange', and NJA 42.

Yield characteristics

Yield level and regularity

Literature emphasises that apricot yield is still deficitary worldwide; therefore, yield characteristics are an important objective in the research programmes of the developing countries: Sansavini *et al*. (1974, 1988), Moore (1979), Friundlund (1979), Lespinasse *et al*. (1985), Crăciun (1987), Bălan (1991), Smith and Mollendorf (1999), Bertazzoli and Rivaroli (2006), Brunton *et al*. (2006), Ghelfi and Lucchi (2006), Mittermayer (2006), Olgun and Adanacioglu (2006), Albuquerque *et al*. (2006).

In Romania, Viorica Bălan and the research team analysed the fruit yield as a biological characteristic and, at the same time, as an indicator for the behaviour of the varieties under the given environmental conditions. Early fruiting, i.e. the fruiting time of the studied variants, was recorded for each tree belonging to the collection-preserved phenotypes, as well as for each descendant, and was genetically analysed.

High yields, i.e. marked 3 on a scale of 1-3, were recorded in 10-30% descendants F_1 of the following families: ♀Excelsior × ♂Goldrich, ♀Excelsior × ♂Comandor, ♀Comandor × ♂77.3.52.BV, ♀Comandor × ♂Dacia, ♀Olimp × ♂$CR_{2\text{-}65}$. 30% mutants V_2 'Comandor' were similar to the standard phenotype 'Comandor'.

Fruit quality

The complex physical and chemical characteristics of the apricots, such as the biometric elements and the biochemical components of quality, have been an important field of research for numerous specialists worldwide, among which: Couranjou (1975), Giulivo *et al*. (1983), Guerrriero (1984), Cociu and Hough (1985), Margarian *et al*. (1986), Mehlenbacker and Hough (1986), Hansche(1986), Bassi (1990, 1999), Bassi and Negri (1991), Bălan (1995), Guerriero *et al*. (1995), Bălan *et al*. (1999), Bassi and Audergon (2006), Bălan *et al*. (2006a, 2006b), Benedikova (2006), Bureau *et al*. (2006), Ham (2006), Lachkar and Mlika (2006), Mencarelli *et al*. (2006), Pennone and Abbate (2006), Petrişor *et al*. (2006), Tzoneva and Tzonev (1999), Wang and Liu (2006).

The biometric elements and biochemical components of the fruit quality were determined for each individual studied,

and the data were statistically processed and analysed for: initial variability and the variability induced by hybridisation, crossbreeding, mutagenesis, F_2, backcrossing; the genetic mechanisms, and the heredity of the quality traits and characteristics; phenotypical correlations of some features referring to the fruit quality. A number of 30 fruit were sampled from each variant in order to determine its physical characteristics, and 2-3 kg were collected for the biochemical determination of the quality. The basic colour of the skin was evaluated by using the apricot-tree colour code devised by Ctifl France (Centre technique interprofessionnel des fruits et légumes) and adopted by the Romanian specialists.

Height (H), dorso-ventral diametre (D), and lateral diameter (d) were measured by the vernier caliper. The data obtained were statistically interpreted to emphasise variability and to calculate the shape index $I.F = H^2/D \times d$, When the index was higher than 1.0, the fruit was elongated whereas, when lower than 1.0, the fruit was either round or flat round. The average weight of the fruit was determined on 30 fruit sampled from each variant, and the results were statistically processed to obtain the initial and induced variabilities, and the descendant transmission of the respective trait. The pulp/stone ratio was determined by weighing the latter separately and relating the value to the total fruit weight, which resulted in pulp productivity.

The soluble dry matter content provided an overview of the content in carbon hydrates, organic acids, and mineral salts, determined by the Zeiss scaled refractometre. To avoid determination errors, fruit were sampled from all the variants after reaching the consumption maturity, the gathering time being based on the colour code and the Hunter lab measurements, originally correlated with the penetrometre-based determinations. The reducing sugar content was achieved by the Fehling-Soxhlet method, i.e. the polysugars and protein removal without converting saccharose into glucose and fructose. Vitamin C ascorbic acid, considered one of the most important vitamins for its catalytic functions and direct intervention in metabolism, was determined by the Thillmans method modified by 2-6 dichlorinephenolindophenol. Titre was established by using ascorbic acid. Measurement was made in mg% of 100g fresh matter by the following formula: ascorbic acid (vitamin C) = (V × F × 1000 m)/m × mp. The mean of the three determinations performed for each sample was statistically processed in order to analyse the genetic variability and heredity of this important biochemical component of apricot quality.

The results point out that,genetic variability was induced for the following fruit quality traits: average fruit weight (g) in the backcross descendants ♀Comandor × ♂F_1 ('Excelsior' × 'Comandor') s% = 25.42, and F_2 'Olimp' s% = 21.80; titratable acidity-malic acid (g%) in the mutants V_2 'Comandor' s% = 29 and F_2 'Olimp' s% = 20.11; soluble dry matter (DM%) s% = 24.02, titratable acidity-malic acid (g%) s% = 46.06, ascorbic acid-vitamin C (mg.%) s% = 26.60 in the F_1 ♀Olimp × ♂NJA19 descendants.

The alternative use of the variety 'Comandor' as maternal and paternal genitor, in combination with the variety 'Excelsior', resulted in low variability in the former case, and average variability in the latter, which points to the cytoplasmic heredity of both partners. The study of the genetic progress achieved in the descendants F_1, F_2, backcross, mutants V_2, pointed to the statistically assured increase in the fruit quality traits, compared with one or both parents in the following cases (**Table 4**): a) soluble dry matter in the backcross generation ♀Comandor × ♂F_1 ('Excelsior' × 'Comandor'), mutants V_2 'Comandor', and descendants F_1 ♀Olimp × ♂NJA_{19}; b) ascorbic acid-vitamin C in the descendants F_2 'Excelsior' × 'Comandor', mutants V_2 'Comandor', and descendants F_2 'Olimp'; c) average fruit weight in mutants V_2 Comandor. The values of soluble dry matter (DM%) of the standard phenotype 'Comandor' were compared with the backcross descendants 'Comandor' and mutants V_2 'Comandor', emphasizing an increase from 15.6% in the standard phenotype to 18.46% in the backcross descendants, and 19.56% in the mutants V_2. An increase in soluble dry matter, compared with the standard phenotype 'Comandor', was also recorded in the descendants F_1 ♀Comandor × ♂Dacia, i.e. 16.29% on average. The mutants V_2 'Comandor' recorded an increased content in ascorbic acid-vitamin C, as well as increased average fruit weight, which showed that physical mutagenesis was an efficient method of improving some fruit quality traits.

The analysis on the genetic mechanism of the fruit shape heredity in the descendants F_1 of five genomic families emphasised three types of gene actions: no descendent segregation, 3:1 segregation, and 1:1 segregation. The non-segregated monohybrid descendants were ♀Comandor × ♂Dacia elongated fruit Aa × round fruit aa, and ♀Comandor × ♂77.3.52 BV elongated fruit Aa × elongated fruit Aa.

Table 4 Genetic variability induction of some quality characteristics in the descendants F_1, F_2, backcross, mutants V_2, and signification of differences from parents or standard phenotype. (Viorica Bălan and Valerica Tudor)

Genitors/Descendants	Dry matter (DM%)	Malic acid (g/%)	Vitamin C (mg/%)	Fruit weight (g)
F_1 ♀Excelsior x ♂Comandor	15.8	1.67	15.5	43.4
F_1-P_1xP_2	-1.89	-0.04	2.54/**	11.16/000
F_1-P_1	-4.0/000	0.45	1.58	11.16/000
F_1-P_2	+0.21	-0.53	3.5/***	11.16/000
F_1 ♀Comandor x ♂Excelsior	14.1	1.58	12.74	40.07
F_1-P_1xP_2	-3.59/000	-0.13	0.22	14.93/000
F_1-P_1	-1.49	-0.62	0.74	14.93/000
F_1-P_2	-5.7/000	0.36	-1.18	14.93/000
F_1 ♀Comandor x ♀Dacia	16.29	1.98	11.80	44.9
F_1-P_1xP_2	+0.98	0.16	-1.40	26.1/000
F_1-P_1	+1.68	0.22	-0.20	10.1/000
F_1-P_2	+0.27	0.54	-2.6/000	42.1/000
Backcross (B_2) Comandor x F_1 (♀Excelsior x ♀Comandor)	18.46	1.06	10.66	55.94
B_2-P_2 Comandor	+2.87/**	1.14/00	-1.34	+0.97
Mutants V_2 Comandor	19.56	0.99	19.56	58.37
Standard Comandor V_0	15.6	2.20	12.00	55
V_2-V_0	3.97/***	-1.21	7.56/***	3.37/***
F_1Olimp x NJA19	19.56	1.10	8.74	69.50
F_1-P_1 x P_2	+5.38/***	-0.81	-0.79	6.07/000
F_1-P_1	+3.0/***	0.10	-1.42	3.36/* * *
F_1-P_2	+7.76/***	-1.52	-0.16	15.5/000
F_2 Olimp	17.78	1.06	12.25	62.26
F_2Olimp-P_1Olimp	+1.22	0.04	2.09/*	3.88/000

The 1:1 segregation of the fruit shapes pointed to the descendant 'Goldrich' acting as a double recessive tester, and confirmed the heterozigotic nature of the parent 'Excelsior' as illustrated by the mutual monohybridisations ♀ExcelsiorAa × ♂ComandorAa and ♀ComandorAa × ♂ExcelsiorAa.

Based on these results, the following conclusions can be summed up:

- Controlled hybridisation, backcross, and physical gene mutation were efficient methods to improve fruit quality.
- Transgressions of dry substance and vitamin C were revealed in apricot descendants F_1.
- There were positive non-linear genetic correlations between the content in soluble dry matter and vitamin C.
- The heredity of the fruit shape was dominant, with segregation 3:1 in the combination of ♀elongated fruit (Aa) x ♂elongated fruit (Aa), and segregation 1:1 in the combination of ♀elongated fruit (Aa) x ♂round fruit (aa).

BIOTECHNOLOGY OF APRICOT TREE IN ROMANIA

Micropropagation

Culture initiation

The reaction to micropropagation is genotype and explant type dependent, according to many research teams results (Butic-Keul *et al*. 2004; Corneanu *et al*. 2006; Pérez-Tornero *et al*. 1999; Pérez-Tornero *et al*. 2006; Rogalski *et al*. 2003).

In Romania, young shoots from the following cultivars were used for micropropagation: 'Best of Hungary', 'Favorit', 'Mamaia', 'Excelsior' and 'Comandor', hybrids: progeny F_2 'Excelsior' × 'Comandor' and rootstocks: 'Stella' and 'Goldcot', from which apex, meristems, leaves and microcuttings were sampled (**Table 5**). The aseptic method of the biological material differed according to genotype and laboratory. The general scheme of sterilization was: washing in water, dipping into ethanol 70-95%, 10-60 sec; dipping into sterilizing agent (Domestos 20%, NaOCl 0.8-4%, $HgCl_2$ 0.3%), 10-20 min, three washes in sterile distilled water (**Table 1**). For culture initiation, MS (Murashige and Skoog 1962) and QL (Quoirin and Lepoivre 1977) media were tested. The culture mediums were supplied with different hormone balances and bioactive unconventional substances: DDW (30 ppm deuterium content) and magnetic fluids (**Table 2**). A multiple emulsion was used as a magnetic fluid. In multiple emulsions, the magnetic part was formed by iron oxides FeO and Fe_2O_3, in a ratio of 1:1 (magnetite), which was obtained by coprecipitation in an alcaline medium and stabilised with oleic acid (Minea *et al*. 2003). The medium was solidified with agar (7%), pH = 5.6-5.8. The culture vessels were maintained at 24-26°C, 16 h photoperiod, white light (Osram L58 w/30) at a PPFD of 35 μmol m^{-2} s^{-1}.

The explants that gave the best results concerning viability, as well as future evolution, were the apices and apical meristems. Similar results were obtained by Pérez-Tornero *et al*. (2006) who also observed that the survival of the explants was higher when axillary shoots instead of meristems were used for the culture introduction. In the case of young leaves and microcuttings, the shoots viability was low (under 20%), and total necrosis of the explants was observed 20 days after culture initiation. Shoot development and the elongation process were dependent on the genotype, as well as on the phytohormone balance of the culture medium (**Table 6**).

In the cultivars 'Best of Hungary', 'Favorit' and 'Mamaia' (Butic-Keul *et al*. 2004), the best results were obtained on the MS medium + 14.9 μM/l 2 iP (N^6-2-isopentenyl adenine) + 0.5 μM/l IBA + 0.26 μM/l GA_3 (gibberelic acid) + 56.8 μM/l vitamin C + 54.3 μM/l adenine sulphate, the length of the obtained shoots being 10.6-19.6 mm. In the rootstocks 'Stella' and 'Goldcot', better development was noticed on the basal QL medium supplied with 2.2-4.4 μM BA + 0.5 μM NAA + 0.02 μM GA_3, in comparison with the basal medium MS with the same phytohormone supplement, the regeneration percentage being 19.7-21.6% (Popa *et al*. 2005). By comparing the reaction to micropropagation of the cultivars 'Excelsior' and 'Comandor' with their hybrid progeny F_2, Corneanu *et al*. (2006) pointed out that the heterosis effect was also manifested *in vitro*, while the hybrid had the best results as far as the main shoot elongation and the basal caulogenesis process were concerned. The authors emphasised the specificity of the reaction, depending on the genotype × culture medium interaction, observation sustained also by Pérez-Tornero and Burgos (2000a) in their studies on the micropropagation of the cultivars 'Bulida', 'Helena', 'Canino', 'Lorna'. Corneanu *et al*. (2006) observed improved results when the culture medium was prepared with DDW, as the shoot elongation process and the foliar organogenesis were significantly increased.

According to Pérez-Tornero and Burgos (2000a), MS is the worst medium for some sensitive genotypes (e.g. all plants died within six weeks in the cultivar 'Bulida', while in 'Currot' and 'Helena' explants showed hyperhydricity symptoms, due to the excessive ammonium content of the MS medium) in comparison with QL or modified WPM media. In opposition, the cultivars tested in Romania: 'Best of Hungary', 'Favorit', 'Mamaia', 'Excelsior', 'Comandor' and their F_2 progeny reacted very well on the MS medium and no vitrification processes were observed.

Secondary basal shooting process was dependent on the genotype, as most authors emphasised (Butic-Keul *et al*. 2004; Corneanu *et al*. 2006). In some cultivars on the initiation medium mentioned above, 1-2 basal shoots ('Best of Hungary', 'Favorit', 'Mamaia') were obtained, in others ('Excelsior', 'Comandor') no caulogenesis took place while, in the hybrid F_2 ♀Excelsior × ♂Comandor), 3-6 basal shoots/explant were obtained on the medium prepared with

Table 5 Asepsization methods in *P. armeniaca*. (Mihaela Corneanu and Viorica Bălan)

Genotype	Biological Material	Aseptization methods	Laboratory	Reference
H_1	Immature seeds	Ethanol 95%	Research Station for Fruit-Tree Growing Baneasa	Bălan *et al.* 1999
H_2				
H_3				
H_4				
H_5				
H_6				
'Best of Hungary'	Shoots	Ethanol 70% -10 sec.	University Babes-Bolyai Cluj Napoca	Butic-Keul *et al.* 2004
'Favorit'		Domestos 20% -15 min.		
'Mamaia'				
'Stella'	Shoots	Ethanol 70% -60 sec.	Research Station for Fruit-Tree Growing Băneasa	Popa *et al.* 2005
'Goldcot'		NaOCl 0.8% -20 min		
'Excelsior'	Shoots	NaOCl 4.0% -10 min.	University of Craiova	Corneanu *et al.* 2006
'Comandor'		$HgCl_2$ 0.3% 10 min.		
♀Excelsior x ♂Comandor				

Table 6 Results obtained in *in vitro* culture initiation in *Prunus armeniaca* (cultivars, hybrids) in Romania. (Mihaela Corneanu)

Genotype	Explant	Optimum culture medium	Results	References
H_1	IM	H basal; MS modified; LP modified	G	Bălan *et al.* 1999
H_2				
H_3				
H_4		LP modified		
H_5				
H_6				
'Best of Hungary'	A	MS + 1.0 mg/l iP + 0.1 mg/l IBA + 0.1 mg/l GA_3 + 10 mg/l vitamine C + 10.0 mg/l adenine sulphate	C, E, R	Butic-Keul *et al.* 2004
'Favorit'		MS + 1.0 mg/l iP + 0.1 mg/l IBA + 0.1 mg/l GA_3 + 10 mg/l vitamin C + 10.0 mg/l adenine sulphate	C, E, R	
'Mamaia'		MS + 1.0 mg/l iP + 0.1 mg/l IBA + 0.1 mg/l GA_3 + 10 mg/l vitamine C + 10.0 mg/l adenine sulphate	C, E	
		MS + 1.0 mg/l iP + 0.1 mg/l IBA + 0.1 mg/l GA_3 + 10 mg/l vitamine C	R	
'Stella'	AM	LP + 2.2 – 4.4 µM/l BAP + 0.5 µM/l NAA + 0.02 µM/l GA_3	C	Popa *et al.* 2005
'Goldcot'				
'Excelsior'	AM	MS + 1.0 mg/l BAP + 0.1 mg/l NAA	C, E	Corneanu *et al.* 2006
'Comandor'		MS + 2.0 mg/l BAP + 2.0 mg/l IBA + 0.1 mg/l GA_3		
♀Excelsior x ♂Comandor		MS + 1.0 mg/l BAP + 0.1 mg/l NAA (prepared with DDW)		

Explant type: IM – immature embryo; A- apex; AM – apical meristem
Culture medium: MS modified; LP modified: ½ macroelements and iron; double microelements
Results: G – embryo germination; C – caulogenesis; E – shoot elongation; R - rhizogenesis

Table 7 The effect of the culture medium, deuterium-depleted water (DDW) and explant size on the main biometrical characters in hybrid progeny F_2 ♀Excelsior x ♂Comandor (Fisher's Test) (Corneanu *et al.* 2006).

Character	Fisher's Test 1- subculture medium; 2- DDW; 3- explant size					
	1	2	3	1 x 2	2 x 3	1 x 2 x 3
Shoot length	22.90***	0.60	356.97***	21.85***	6.89*	8.29***
No of leaves/explant	1.93	7.38**	87.34***	3.75**	5.03*	3.12**
Secondary shoot number	2.34*	21.51***	20.34***	1.52	5.13*	2.55*

Table 8 Results obtained in *in vitro* subculture in *Prunus armeniaca* (inter- and intraspecific hybrids) in Romania. (Mihaela Corneanu)

Genotype	Explant	Optimum culture medium*	Results	References
H_1	Germinated embryos	H basal; MS modified; LP modified	P; LS	Bălan *et al.* 1999
H_2		H basal; MS modified; LP modified	P; LS	
H_3		H basal; MS modified; LP modified	P; LS	
H_4		MS modified; LP modified	P	
H_5		MS modified; LP modified	P	
H_6		LP modified	P	
♀Excelsior x	Neoformed shoots 1 mm	MS + 2.0 mg/l BAP + 2.0 mg/l IBA + 0.1 mg/l GA_3	E, CCE	Corneanu *et al.* 2006
♂Comandor	Neoformed shoots 3 mm		E, C	
(F_2)		MS + 0.1 mg/l BAP + 0.1 mg/l IBA + 0.1 mg/l GA_3 + 60 mg/l FM	E, R	

* Culture medium with best results
MS modified; LP modified: ½ macroelements and iron; double microelements
Results: R – rhizogenesis ; P – plantlets; LS – lateral shoots; E – shoot elongation; CCE – caulogenesis via embryogenic calli; C – caulogenesis

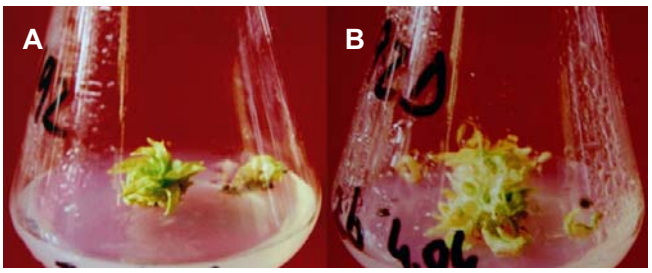

Fig. 5 The effect of DDW on caulogenesis process on *P. armeniaca*, F_2 hybrid ♀'Excelsior' × ♂'Comandor'. (**A**) MS + 1 mg/l BAP + 0.1 mg/l NAA. (**B**) MS + 1 mg/l BAP + 0.1 mg/l NAA prepared with DDW.

DDW (**Fig. 5**). DDW exercised an action of protection, both at the DNA and telomere level, which assured the chromosome integrity. But the telomer was partly lost with each cell division, therefore the division number characteristic to a cell was different (Hayfick, cited by Goodall 2003), depending on the genotype and probably on the tissue. The increase in the cell multiplication rate was limited by the telomer integrity. When the value (the division number characteristic to the genotype) was surpassed, cell divisions became abnormal, either resulting in aneuploid cells or cell division stopped. The knowledge of this concept, as well as the use of DDW in culture medium preparation, can be a way of improving the *in vitro* multiplication rate of the explants.

Subculture

The neoformed shoots must be transferred (subculture) on a fresh medium after 30-45 days; after this period, apex necrosis occurs at a high rate, a fact noticed by other authors in the *Prunus* species (Scaltsoyiannis *et al*. 1998); Balla and Vértesy 1999; Pérez-Tornero *et al*. 2000a).

In the experiments performed by Corneanu *et al*. (2006), the *in vitro* neoformed shoots of different size (3 mm, 4 leaves; 1 mm, 2 leaves) were transferred on eight variants of MS basal medium supplied with 0.44-8.9 µM BA + 0.5-9.8 µM IBA + 0.3 µM GA_3. The analysis of the effect of the subculture medium, initiation medium and explant type, pointed out the significance of each factor, as well as their interaction (Fisher's test) on the growth, differentiation and dedifferentiation processes. The main shoot elongation was very significantly influenced by the phytohormone balance, as well as by the explant size, a fact proved both by the Fisher's test and a very significantly positive correlation

between the shoot length and IBA quantity (r = +0.3374). The best results (shoot length = 20.5 ± 0.2 mm, 45 days) were obtained on the MS medium + 8.9 μM BA + 9.8 μM IBA + 0.3 μM GA_3. Organogenesis in the leaves was significantly stimulated in the medium variants where the auxin: cytokinin ratio favoured the latter. Caulogenesis at the shoot base was significantly influenced both by the phytohormone balance and the presence of DDW in the initiation culture medium, as well as by the explant size (**Table 7**). The highest number of shoots/explant was recorded in small shoots (1 mm) (8-12 shoots/explant), on the culture medium MS 8.9 μM BA + 9.8 μM IBA + 0.3 μM GA_3, originating from a medium prepared with DDW. This finding proves that DDW has a long term effect, having an important role in tissue rejuvenation. Knowing the effect of different controllable factors on the explant development allows their modellation in order to obtain the best results (**Table 8**).

Rhizogenesis

Obtaining strong rooted plantlets is a condition to carry out a succesful acclimatisation process. Most authors observed that a reduced concentration to 2/3 -1/2 basal medium salts improved the rhisogenesis process (Balla and Vértesy 1999; Kamali *et al*. 2006). Some authors recomended an induction period in the darkness for certain genotypes (Pérez-Tornero *et al*. 2000a, 2006); however, this might produce chlorosis and shoot necrosis, fact confirmed by Koubouris and Vasilakakis (2006) in the cultivar 'Babecou'.

In some genotypes, the rhisogenesis process can be obtained even in the initiation culture. Butic-Keul *et al*. (2004) obtained rooted plantlets on the same medium used for culture initiation, but the reaction to the culture medium was genotype-specific. The highest number of roots was obtained in the cultivars 'Best of Hungary' and 'Favorit' on MS + 4.9 μM 2 iP + 0.5 μM IBA + 0.26 μM GA_3 + 56.8 μM vitamin C + 54.3 μM adenine sulphate, while the cultivar 'Mamaia' rooted better in the absence of adenine sulphate. The number of neoformed roots in all the three genotypes was low (1.1-1.6 roots/explant) due to the low auxin content, as the culture medium was originally conceived to promote caulogenesis. Rhizogenesis occurred as a secondary process.

In order to induce rhizogenesis in the hybrid progeny F_2 ♀Excelsior × ♂Comandor, Corneanu (2006) supplemented the culture medium (80% MS) with phytohormones (0.44 μM BA + 0.5 μM IBA + 0.3 μM GA_3) and different concentrations of magnetic fluid (0-200 mg/l MF). Roots were obtained on all the medium variants supplied with magnetic fluid, but in a concentration of 60 mg/l the number of roots/explant was maximum (4.6 ± 0.2), while shoot elongation showed a correspondingly positive reaction (20-24 mm growth of the transferred shoots in 45 days). In the control variant (non-MF medium), no rooting process was observed and the shoots length presented a significant negative difference in comparison with the variant MF (7-10 mm). No caulo- or callogenesis at the shoot base was recorded in any experimental variant. These findings are in accordance with the previous ones obtained by Corneanu *et al*. in other species: *Aloe arborescens* (1994), *Fragaria ×annanasa* (1995), *Aztekium riitteri* (1996a), *Mammillaria duwei* (1996b), *Drosera rotundifolia* (1998), *Coryphantha elephantidens* (2000), *Prunus avium* (2004a), *Robinia pseudoacacia* (2004b) as a result of culture medium supplementation with magnetic fluid.

Immature embryo culture and seedling acclimatisation

The *in vitro* culture of immature embryos is an efficient method of rescuing the embryos resulting from interspecific hybridisation, as they frequently abort due to the genetic incompatibility between the embryo and endosperm.

In order to assure viable progeny of some interspecific hybrids, namely *P. armeniaca* × *P. persicum* (H_3) and *P. persicum* × *P. armeniaca* (H_1, H_2, H_4, H_5 and H_6), Bălan *et al*. (1999) used culture immature embryos *in vitro* and obtained acclimatized plantlets (**Table 8**).

To initiate the *in vitro* embryo culture, immature embryos (1-10 mm) were used as explants, harvested 6-7 weeks after pollination, interspecific hybridation progenies ♀*P. armeniaca* (*P.a*) *x* ♂*P. persica* (*P.p*), ♀*P.p* × ♂*P.a* (Bălan *et al*. 1999): H_1 – ♀*P.p* × ♂*P.a* (♀Garden Delight × ♂B19/20); H_2 – ♀*P.p* × ♂*P.a* (♀Prios Magdalena × ♂Dacia); H_3 – ♀*P.a* × ♂*P.p* (♀Olimp × ♂PI 132030); H_4 – ♀*P.p* × ♂*P.a* (♀Michigan × ♂B4/73); H_5 – ♀*P.p* × ♂*P.a* (♀Sweet Gold × ♂Favorit); H_6 - *P.p* × ♂*P.a* (♀Platycarpa × ♂Dacia). To rescue immature embryos, three variants of hormone-free culture media were tested: H basal (Theobald and Hough 1960), MS modified and QL modified (double microelement quantity, half macroelements and iron quantities). In the embryo culture, the test tubes were maintained at 16°C in the darkness, until germination started, then transferred to 22-25°C with 16 h photoperiod.

As with neoformed shoot subculture, the explant size was as important as the culture medium composition. For the successful germination of embryos used as explants, they should be >4 mm in size, otherwise an *in ovulo* culture for 1-2 weeks is recommended before excision. This observation is in accordance with Burgos and Ledbetter (1993) who found that embryos between 5 and 9 mm germinated and developed into plants in a significantly higher percentage that the ones in more mature stages.

The hybrids H_1, H_2, H_3 reacted favourably in all the three variants of the culture mediums, resulting in 100% germination, while the hybrids H_4, H_5, H_6 recorded modest results (16-18%) on LP medium; H and MS mediums were inadequate, inducing germination inhibition. The mediums used for culture initiation were not always the best for plantlet development. A reduction to half the macroelements and iron, and the doubling of microelements stimulated embryo germination and plant development. The lower salts concentration improved rhizogenesis and subsequent plant growth after acclimatisation. The resulting plantlets were acclimatised in three steps: uncovering the test tube for 5 days (in the culture room), maintaining them for 10 days in the test tube with distilled water and then transferring them into pots and providing high humidity. 54% of the hybrid plantlets H_1, H_2, H_3 developed lateral shoots, with high number of leaves on short stems, proving the success of acclimatisation.

CONCLUDING REMARKS

In order to develop future breeding strategies, genetic engineering and the DNA technology may merge with other non-conventional methods, such as biotechnology (somaclonal variation and stress resistance). For successful research, several things must be taken into consideration, among which increasing knowledge of the apricot genotype at the molecular level and the high expressions of inserted genes.

In the future, the studies based on molecular genetics and biotechnologies will be associated with biodiversity, and will employ combined research methods, such as: traditional hybridisation, backcross, mutagenesis, inbreeding, and unconventional genetic transformation. It is noteworthy that this strategy is already applied in some European countries: France, Italy, and Spain.

ACKNOWLEDGEMENTS

For the long-term support of our research, we would like to express our gratitude to the following: Prof. Dr. Doc. Teofil Crăciun (Professor of Genetics, University of Agronomic Sciences and Veterinary Medicine Bucharest); Prof. Dr. Doc.Vasile Cociu ("Gheorghe Ionescu-Şişeşti" Romanian Academy of Agricultural and Forestry Sciences); Prof. Dr. Petre Raicu (Professor of Genetics, University of Agronomic Sciences and Veterinary Medicine Bucharest); Prof. Dr. Ioan Florea Dumitru (Professor of Molecular

Genetics, University of Agronomic Sciences and Veterinary Medicine Bucharest); Prof. Dr. Lucian Gavrilă (Professor of Genetics, University of Agronomic Sciences and Veterinary Medicine Bucharest); Ms. Cristina Florea (biologist, National Programme Director in the Romanian Ministry of Research); Ms. Elena Nistor (teaching assistant, Foreign Languages Department of the University of Agronomic Sciences and Veterinary Medicine Bucharest).

Many thanks to: Dr. Maria Oprea (Senior Researcher, plant pathology and plant protection, Plant Protection Research Institute, Bucharest); Mrs. Elena Popa (biochemistry researcher, Research and Development Station for Fruit-Tree Growing Băneasa, Bucharest); Dr. Nicolae Branişte (Senior Researcher, genetics and genetic resources preservation, Research Institute for Fruit-Tree Growing Piteşti).

Also, many thanks to: Prof. Dr. L.F. Hough (Rutgers University, USA); Senior Researcher J.M. Couranjou (INRA France); Senior Researcher R. Monet (Research Centre -Bordeaux, France); Senior researcher J.M. Audergon (INRA Montfavet, France; Coordinator of the ISHS apricot-tree working group); Prof. Dr. D. Bassi (Milan University, Italy); Prof. Dr. R. Guerriero (University of Pisa, Italy); Senior Researcher C. Fideghelli (Director of the Fruit-tree Growing Research Institute - Rome, Italy); Senior Researcher L. Burgos (CEBAS-CSIC Murcia, Spain); Senior Researcher J. Egea (CEBAS-CSIC Murcia, Spain).

And, last but not least, our deepest gratitude to our patient families.

REFERENCES

Albuquerque N, Burgos L, Egea J (2006) Variability in cultivar characteristics as factors influencing productivity in apricot. *Acta Horticulturae* **701**, 267-269

Audergon JM, Castelain C, Morvan G, Chastelliere MG (1988) Apricot varietal sensibility and genetic variability to apricot chlorotic leaf roll disease. *Acta Horticulturae* **235**, 205-215

Audergon JM (1995) Variety and breeding, apricot culture. *Acta Horticulturae* **384**, 35-44

Audergon JM, Asins MJ, Guerierro R, Vitti R, Monteleone P, Bartolini S, Laghezali MD, Mamouni A, Mlika MD, Hellali R, Ben Mimoun M, Krichen L, Gulcan R, Paydas S, Albagnac G, Bureau S, Gouble B, Grotte M, Reich M, Legave JM, Audergon JM, Lambert P, Blanc A, Richard JC, Clauzel G (2006) Prospection, characterisation and assessment of apricot genetic resources in the Mediterranean region for the production in arid and semi-arid areas. *Acta Horticulturae* **701**, 263-266

Audergon JM, Giard A, Lambert P, Blanc A, Gilles F, Signoret V, Richard JC, Albagnac G, Bureau S, Gouble B, Grotte M, Reich M, Legave JM, Clauzel G, Dicenta F, Scortichini M, Simeone AM, Guerierro R, Vitti R, Monteleone P, Bartolini S, Martins JMS, Tsiantos J, Psallidas P (2006) Optimisation of apricot breeding by a joint conventional and molecular approach applied to the main agronomic traits. *Acta Horticulturae* **701**, 317-320

Badenes ML, Moustafa TA, Martinez-Calvo J, Llacer G (2006) Resistance to Sharka trait in a family of self-pollination of 'Lito' apricot cultivar. *Acta Horticulturae* **701**, 381-384

Baicu T, Săvescu A (1986) Sisteme de combatere integrată a bolilor şi dăunatorilor pe culture. Integrated pest and disease control systems according to crops. Ceres Publishing House, Bucharest, 264 pp

Bailey C, Hough LF (1977) Apricots. In: Janick J, Moore JN (Eds) *Advances in Fruit Breeding*, Purdue University Press, West Lafayette, Indiana, pp 367-383

Bailey CH, Kotowski S, Hough LF (1983) Estimate of chilling requirements of apricot selections. *Acta Horticulturae* **121**, 99-102

Balla I, Vertesy J (1999) *In vitro* culture of Hungarian apricot (*Prunus armeniaca L*) varieties. *Acta Horticulturae* **560**, 395-398

Barlow NWB (1980) The relationship between leaf size and shoot length in apple. *Journal of the American Society of Horticultural Science* **3**, 279-283

Bassi D (1990) *Germoplasma di albicocco* – Viagio di studio effetuato nella Republica Populare Cinese dal 2 al 26 juglio 1990 nell ambito agli accordi di cooperatione scientifica tra il CNR e la CAAS (personal report)

Bassi D, Negri P (1991) Ripening date and fruit traits in apricot progenies. *Acta Horticulturae* **293**, 133-140

Bassi D, Bellini E, Guerriero R, Monastra F, Pennone F (1995) Apricot breeding in Italy, Apricot Culture. *Acta Horticulturae* **384**, 47-54

Bassi D (1999) Apricot culture: present and future. *Acta Horticulturae* **488**, 35-42

Bassi D, Audergon JM (2006) Apricot breeding: update and perspectives. *Acta Horticulturae* **701**, 279-294

Bassi D, Bartolini S, Viti R (2006) Recent advances on environmental and physiological challenges in apricot growing. *Acta Horticulturae* **717**, 23-32

Bălan V, Oprea M, Drăgoescu E, Ivaşcu A (1985) Resistance of some apricot varieties hybrids to *Altemaria tenuissima*. Acta *Horticulturae* **192**, 231-238

Bălan V, Oprea M, Ivaşcu A (1989) The variability of field resistance against pathogens agents *Monilia laxa*, *Stigmina carpophillum* and *Cytospora cincta* in some hybrids. *Acta Horticulturae* **293**, 203-210

Bălan V, Ivaşcu A (1989) Resistance to frost and wintering of some apricot varieties with different geographical origin under Romanian plain conditions. *Acta Horticulturae* **293**, 331-340

Bălan V (1991) Cercetări privind variabilitatea genetică la cais cu privire specială la adaptabilitate şi calitate. Research on the genetic variability of the apricot-tree with special focus on adaptability and quality, PhD Thesis, University of Agronomic Sciences and Veterinary Medicine Bucharest, Romania, 247 pp

Bălan V, Stoian E, Stancu T, Ivaşcu A (1995) Breeding for diseases resistance in apricot problems and prospects. *Acta Horticulturae* **384**, 103-110

Bălan V (1995) Utilization of induced mutations in apricot breeding. *Acta Horticulturae* **384**, 231-236

Bălan V, Stoian E (1995) Susceptibility of apricot cultivars to Plum-pox virus in Romania. *Acta Horticulturae* **384**, 384-388

Bălan V, Ivaşcu A, Popa E (1995) Aptitude of several genitors to transmit chemical fruit traits and the vigour degree in apricot breeding programme. *Acta Horticulturae* **384**, 73-78

Bălan V, Ivaşcu A (1995) Genetic resources at apricot and peach in Romania. In: Schmidt H, Kellerhals M (Eds) *Progress in Temperate Fruit Breeding*, Eucarpia Fruit Breeding Section. Meeting Held at Wadenswil/Einsiedeln, Switzerland, August 3, 1993, Kluver Academic Publishers, Boston, pp 439-447

Bălan V (1999) Cumulus of positive characteristics of different apricot parental phenotypes and the way to transmitting in apricot hybrids descendants. *Acta Horticulturae* **488**, 257-266

Bălan V, Ivaşcu A, Toma S, Costea G (1999) Studies on immature embryos in *in vitro* culture of interspecific hybrids from the genus *Prunus*. *Acta Horticulturae* **488**, 557-559

Bălan V, Popa E, Bădescu V, Mihai R, Cerbu E (1999) Biochemical changes detected in different apricot varieties artificially inoculated with *Cytospora cincta* Sacc. *Acta Horticulturae* **488**, 661-666

Bălan V, Oprea M, Toma S (1999) Reaction of apricot cultivar from national collection to *Monilinia laxa* Lev. (Aderh.) inoculum. *Acta Horticulturae* **488**, 667-670

Bălan V, Tudor V, Petrişor C (2006a) Providing the quality features variability of apricot descendants: F_1, F_2, back-cross and V_2. *Acta Horticulturae* **701**, 175-178

Bălan V, Tudor V, Petrişor C (2006b) Maintenance of biodiversity of apricot tree phenotypes in Romania. *Acta Horticulturae* **701**, 199-206

Bălan V, Petrişor C, Lazăr V, Popescu M, Vlaicu I (2006) Chromaticity differences in evaluation of fruit quality of some apricot genotypes for fresh consumption. *Acta Horticulturae* **701**, 565-570

Benedikova D (2006) Apricot breeding in Slovak Republic for fruit quality and resistance to disease – new Slovak apricot varieties created by RBS Vesele. *Acta Horticulturae* **701**, 377-380

Bertazzoli A, Rivaroli S (2006) A trade flows analysis of fresh apricots: The European Markets. *Acta Horticulturae* **717**, 281-286

Bordeianu T, Constantinescu N, Stefan N (1967) *Pomologia Republicii Populare Romîne*. *Fruit-tree Growing in the Popular Republic of Romania* (Vols 1-3), Romanian Academy Publishing House, Bucharest, 756 pp

Brunton JG, Carillo A, Cos J, Sanchez PG, Montiel (2006) The apricot situation in the region in Murcia. *Acta Horticulturae* **717**, 193-196

Bureau S, Gouble B, Grotte M, Audergon JM, Albagnac G (2006) Variability of volatile aroma composition in apricot fruits. *Acta Horticulturae* **717**, 327-332

Bureau S, Reich M, Marfisi C, Audergon JM, Albagnac G (2006) Application of Fourier-transform infrared (FT-IR) spectroscopy for the evaluation of quality traits in apricot fruits. *Acta Horticulturae* **717**, 347-350

Burgos L, Ledbetter CA (1993) Improved efficiency in apricot breeding: Effects of embryo development and nutrient media on in vitro germination and seedlings establishment. *Plant Cell, Tissue and Organ Culture* **35**, 217-222

Burgos L (1995) Preliminary results of an inheritance study of genetic incompatibility in apricot, Apricot Culture. *Acta Horticulturae* **192**, 85-89

Butic-Keul A, Zapartan M, Deliu C (2004) Regenerarea *in vitro* si micropropagarea la cais. *In vitro* regeneration and micropropagation in apricot. *Proceedings of 15th National Symposium of Plant Tissue Culture: Physiopathology of the plant cell in vitro culture*, Daya, Satu Mare, pp 128-135

Butnaru G, Terteac D, Potentz I (1999) Magnetic fluids improving effect in *in vitro* regenerates in hipogravity. *Journal of Magnetism and Magnetic Materials* **201**, 435-439

Butnaru G, Ştefănescu I, Rogobete S, Titescu G (2001) Deuterium depleted water effects on plants behaviour. Proceedings of 2nd European Meeting on Environmental Chemistry, Dijon, France, 203-208

Butnaru G, Baciu A, Ştefănescu I, Titescu G, Împuşcătoiu D, Sărac I (2004) The action of different types of water on *in vitro* organogenesis in *Chrysanthemum indicum* L. *Proceedings of 3rd Congress "Water – a miracle"*, Constanţa, Vol **1**, 55-56

Carter MV, Moller WJ (1977) Eutypa canker and dieback of apricot, *OEPP Bulletin* **7**, 85-93

Ceapoiu N (1968) *Metode Statistice Aplicate în Experienţele Agricole şi Biolo-*

gice. *Statistical Methods Applied to Agricultural and Biological Experiments*, Agro-forestry Publishing House, Bucharest, 550 pp

Ceapoiu N (1980) *Evoluţia Speciilor*. *Evolution of Species*, Romanian Academy Publishing House, Bucharest, 480 pp

Ceapoiu N, Negulescu F (1983) *Genetica şi Ameliorarea Rezistenţei Plantelor*. *Disease Resistance Genetics and Improvement of Plants*, Romanian Academy Publishing House, Bucharest, 538 pp

Chang WF (1984) Relationship of seed germination and respiration during stratification with cultivar chilling requirements in peach. *Journal of the American Society of Horticultural Science* **109**, 42-45

Cociu V (1969) Breeding and study programme for fruit trees, strawberry and other berries between 1970 and 1980. *Theoretic and Applied Genetics* **6**, 470-492

Cociu V (1981) Cîteva aspecte ale zonării şi microzonării la pomi fructiferi şi arbuşti. Some issues of fruit-tree and bush variety zoning and microzoning. *Scientific Papers* 9, ICPP Mărăcineni, Piteşti, pp 9-14

Cociu V, Hough LF (1985) Germplasm of apricots and some suggestions for its use. Apricot culture and decline. *Acta Horticulturae* **192**, 291-296

Cociu V, Bumbac E, Bălan V, Hough LF (1985) Promising apricots hybrids with early and very early ripening. *Acta Horticulturae* **192**, 313-322

Cociu V, Oprea S (1989) *Metode de Cercetare în Pomicultură*. *Research Methods in Fruit-Tree Breeding*, Dacia Publishing House, Cluj-Napoca, 122 pp

Cociu V (1990) *Soiurile Noi, un Factor de Progress in Pomicultură*. *New Varieties, a Factor of Progress in Fruit-Tree Growing*, Ceres Publishing House, Bucharest, 188 pp

Cociu V (2006) 50 years of apricot genetic breeding in Romania. *Acta Horticulturae* **701**, 355-358

Corneanu GC (1989) *Radio-Susceptibilitatea Comparativă a Plantelor*. *Elemente de Radio-Biologie a Plantelor*. *Compared Radio-Susceptibility in Plants*. *Elements of Plant Radio-Biology*, Ceres Publishing House, Bucharest, 225 pp

Corneanu M, Corneanu G, Bădică C, Minea R, Bică D, Vékas L (1994) *In vitro* organogenesis at *Aloe arborescens* (Liliaceae). *Revue Roumain de Biologie, Biologie Végétale* **39** (1), 45 - 52

Corneanu M, Corneanu GC, Bădică C, Bică D, Minea R, Cosmulescu SN, Neculae L (1995) *In vitro* regeneration of the senescent or partial vitrified plants on the culture media supplied with magnetic fluids. *Genetics and Evolutionism* **2**, 51-57

Corneanu M, Maiuru G, Minea R (1996a) *In vitro* multiplication and acclimatisation in *Aztekium ritteri* (Fam. *Cactaceae*). *Acta Botanica Horti Bucurestiensis 1994-1995*, 175-180

Corneanu M, Corneanu G, Ebata J, Furukawa H., Bronzetti G, Bică D, Minea R, Gabor L (1996b) Organogenesis process in *Mammillaria duwei* (Cactaceae) depending on culture media composition. IPPS in Bulgaria – Second Scientific Conference "Propagation of Decorative Plants" (Razmnegenesis na Dekorativni Rasteniia), Sofia, Lesotehniceski Universitet Ed., 35 – 41

Corneanu M, Corneanu GC, Glodeanu E, Gabor L, Minea R, Bică D, Morariu VV, Bădică C, Hănescu V (1998) Medium culture composition and organogenesis processes in *Drosera rotundifolia*. *Acta Horticulturae* **457**: 109-114.

Corneanu M, Corneanu GC, Hănescu V, Gabor L, Minea R, Frangopol C (2000) The effect of the interaction magnetic fluids – X-rays on the *in vitro* micropropagation at *Coryphantha elephantidens* (Lem.) Lem. *Propagation of Ornamental Plants* **4**, 50-57

Corneanu M, Mîndrilă G, Corneanu GC, Cristea C, Atyim P, Minea R (2004a) The influence of humic acids and magnetic fluids on shoot elongation and *in vitro* rooting processes in *Prunus avium* L. *USAMV-CN Bulletin, Series Animal Science and Biotehnology* **60**, 313-318

Corneanu M, Mîndrilă G, Corneanu GC, Cristea C, Atyim P, Neţoiu C, Bică D (2004b) *In vitro* micropropagation in *Robinia pseudoacacia* var. *Oltenica*. *Proceedings XXXIV ESNA Annual Meeting*, Mondograf, Novi Sad, pp 231-234

Corneanu M, Tudor V, Corneanu CG, Gamaneci G, Ştefănescu I (2006a) The effect of genotype and depleted deuterium water on *in vitro* organogenesis in apricot (*Prunus armeniaca* L.). *Proceedings of 15th National Symposium of Plant Tissue Culture: The Conservation of Plant Vitroculture*, Alma Mater, Sibiu, pp 115-130

Corneanu M, Corneanu CG, Cristea C, Băbeanu C, Roşca A, Ştefănescu I, Mîndrilă G (2006b) The effects of the depleted deuterium water on *in vitro* organogenesis processes in *Robinia pseudoacacia* var. *oltenica*. *Revue de Cytologie et Biologie Végétales - Le Botaniste* **28**, 236-245

Costes E, Fournier D, Audergon JM, Legave JM, Clauzel G (2006) Architectural diversity of apricot trees: which morphological characters can be used to classify cultivars? *Acta Horticulturae* **701**, 105-111

Couranjou J (1975) L'amelioration genetique de l'abricotier. *INRA Publications* **387**, **388**, **407**

Couranjou J (1989) Main genetic results from a study of an apricot semidiallel. *Acta Horticulturae* **293**, 87-94

Couvillon CA, Hendershott CH (1974) A characterisation of the "after rest" period of flower buds from two peach cultivars of different chilling requirements. *Journal of the American Society of Horticultural Science* **99**, 25-26

Crăciun T, Tomozei I, Coles N, Nasta A (1978) *Genetica*. *Genetics*, Didactic and Pedagogic Publishing House, Bucharest, 623 pp

Crăciun T (1981) *Genetica Plantelor Horticole*. *Genetics of Horticultural Plants*, Ceres Publishing House, Bucharest, 537 pp

Crăciun T (1987) *Geniul Genetic şi Cultura Plantelor*. *Genetic Genius and Plant Breeding*, Ceres Publishing House, Bucharest, 265 pp

Crăciun T, Crăciun LL (1989) *Dicţionar de Biologie*. *Dictionary of Biology*, Albatros Publishing House, Bucharest, 467 pp

Decourtye L (1967) Etude de quelques caracters a controle genetique simple chez le pommier (*Malus* sp.) et le poirier (*Pyrus communis*). *Annales de Amelioration des Plantes* **17**, 243-265

Dejampour J, Zeinalabedini M (2006) Determination of some vegetative and bloom characteristics of some local apricots in Azarbaijan (Iran) ecological conditions. *Acta Horticulturae* **717**, 63-66

Dicenta F, Pérez-Campoy PJ, Martínez-Gómez P, García-Brunton J, Botella MA (1999) Natural spread of Sharka disease in fruit-tree orchards in Murcia (Spain). *Acta Horticulturae* **488**, 775-778

Dicenta F, Rubio M, Martinez-Gomez P (2006) Susceptibility to Sharka (Plum-pox potyvirus) in *Prunus mandshurica* × *Prunus armeniaca* seedlings. *Acta Horticulturae* **701**, 223-225

Dorobanţu N, Molea I, Voican V (1986) *Lucrări Practice de Fiziologia Plantelor*. *Practical Works in Plant Physiology*, Nicolae Bălcescu Agronomic Institute Publishing House, Faculty of Horticulture, 136 pp

Dosba F, Lansac M, Audergon JM, Maison P, Massonie G (1988) Tolerance to Plum-pox virus in apricot. *Acta Horticulturae* **235**, 275-281

Egea J, Burgos L, Martinez-Gomez P, Dicenta F (1999) Apricot breeding for sharka resistance at CEBAS-CSIC, Murcia (Spain). *Acta Horticultu-rae* **488**, 153-157

El-Kady S, Hevesi M, Sule S, Klement Z (1986) Pathological and serological separation of some *Pseudomonas syringae* p.v. *syringae* strains isolated from apricot, sour cherry and pepper hosts. *Acta Horticulturae* **192**, 193-204

Erez A, Lavee S (1971) The effect of climatic conditions on dormancy development of peach buds temperature. *Journal of the American Society of Horticultural Science* **96**, 711-714

Erez A, Couvillon GA, Hendershott CH (1979) The effect of cycle length on chilling negation by high temperatures in dormant peach leaf buds. *Journal of the American Society of Horticultural Science* **104**, 573-576

Friundlund PR (1979) Incompatibility between apricot and *Prunus tomentosa* seedlings. *Fruit Varieties Journal of the American Pomological Society* **33**, 90

Garrett CME (1979) Screening *Prunus* rootstocks for resistance to bacterial canker caused by *Pseudomonas mors prunorum*. *Journal of the American Society of Horticultural Science* **3**, 189-193

Geuna F, Bassi D, Failla O, Mignani I (2006) Use of morphological and AFLP markers assess possible synonymy between apricot accessions. *Acta Horticulturae* **701**, 215-218

Ghelfi R, Lucchi M (2006) Apricot production in Italy: Value chain in the domestic and international markets. *Acta Horticulturae* **717**, 265-270

Gilreath PR, Bouchanam DW (1981) Rest prediction for low chilling "Sungold" nectarine. *Journal of the American Society of Horticultural Science* **106**, 189-193

Giulivo G, Nicotra A, Roselli G (1983) Ruolo ed obiectivi del miglioramento genetico in frutticolutra. Nuove aequisizioni del miglioramento genetico italiano e scelte varietali in frutticoltura 2. *Quaderno ISOI* **83**, Centro operativo ortofrutticolo Ferrara

Goodall KB (2003) In search of the fountain of youth - preliminary analysis of deuterium's role in DNA degradation. Available online: www.slwater.com/Fof4-DDWpdf, 15 pp

Guerriero R (1984) ICAPI promettenti selezioni di albicocco. Informatore Agrario. Nuove aquisizioni del miglioramente genetico italiano e scelte varietali in frutticoltura 2, *Guaderno IFSOI* **83**, Centro operativo ortofrutticolo Ferrara, 5 pp

Guerriero R, Indiogine S, Scalabrelli G (1985) Influence on relations between bud and mother plant on changes in peach bud dormancy. *Acta Horticulturae* **173**, 113-122

Guerriero R, Indiogine SE, Scalabrelli G (1985) The effect of cyclic and constant temperatures in fulfilling the chilling requirement of two apricot cultivars. *Acta Horticulturae* **192**, 41-48

Guerriero R, Monteleone R, Marocco F (1995) Distribution of main fruit and trees traits in some apricot progenies, Apricot Culture and Decline. *Acta Horticulturae* **192**, 79-83

Guerriero R, Monteleone P, Viti R (2006) Evaluation of end of dormancy in several apricot cultivars according to different methodological approaches. *Acta Horticulturae* **701**, 99-103

Guerriero R, Monteleone P, Iacona C (2006) Apricot breeding in Pisa: some new selections for Italian growers. *Acta Horticulturae* **701**, 341-346

Guerriero R, Lomi F, D'Onofrio C (2006) Influence of some agronomic and ecological factors on the constancy of expression of some descriptive characters included in the UPOV apricot descriptor list. *Acta Horticulturae* **717**, 51-54

Guerriero R, Viti R, Bartolini S, Iacona C (2006) Parents for spring frost tolerance in apricot. *Acta Horticulturae* **717**, 153-156

Ham H (2006) Preliminary study on the effect of climate on colour development of two apricot (*Prunus armeniaca*) cultivars. *Acta Horticulturae* **717**,

381-384
Hansche P, Hesse C, Beres V (1972) Estimates of genetic environmental effects on several traits in peach. *Journal of the American Society of Horticultural Science* **97**, 76-79
Hansche P, Beres W (1980) Genetic remodeling offrait and nut trees to facilitate cultivars improvement. *Horticultural Sciences* **15**, 710-715
Hansche P (1986) Heritability offrait quality traits in peach and nectarine breeding stocks dwarfed by the dw gene. *Horticultural Sciences* **21**, 1193-1195
Hansche PE, Hesse GO, Beres V (1975) Inheritance of fruit size, soluble solids and ripening date in *Prunus domestica* cv. *Journal of the American Society of Horticultural Science* **5**, 522-524
Hansen P, Ryngo K (1979) Translocation and metabolism of carbohydrate fraction of ^{14}C–photosynthesis in "Frendi" prune, *Prunus domestica*. *Journal of the American Society of Horticultural Science* **104**, 622-625
Hatch AH, Walker DR (1969) Rest intensity of dormant peach and apricot leaf buds as influenced by temperature cold hardiness and respiration. *Journal of the American Society of Horticultural Science* **94**, 304-307
Ionică M, Bălan V, Stoian E (1990) Cercetări privind agentul de tip micoplasmă, izolat în Romania din pomi de cais în decline. Research on the mycoplasma-type agent isolated from declining apricot. *Annals of Cereals and Technical Plants Research Institute Fundulea* **XXIII**, SC Agris - Redacția revistelor agricole SA Fundulea, pp 29-33
Kamali K, Majidi E, Zarghami R, Arvin MJ (2006) Differences in micropropagation of vegetative rootstock (GF677) and other almond seed genotypes. *Acta Horticulturae* **726**, 199-200
Karayannis I (1988) Susceptibility of apricot cultivars to Plum-pox virus in Greece. *Acta Horticulturae* **235**, 271-275
Karayannis I, Mainou A, Stylianidis D, Thonidis T, Karayannis NI, Tsaftaris A (2006) Resistant to Sharka disease (PPV) apricot hybrids of high quality, selected in Greece. *Acta Horticulturae* **701**, 337-340
Klement K (1977) Apricot apoplexy. *EPPO Bulletin* **7**, 7-9
Koubouris G, Vasilakakis M (2006) Improvement of *in vitro* propagation of apricot cultivar 'Bebecou'. *Plant Cell, Tissue and Organ Culture* **85**, 173-180
Krska B, Oukropek I, Audergon JM, Polak J, Kominek P (2006) Evaluation of resistance of apricot progeny (VestarxSEO) to Plum-pox virus. *Acta Horticulturae* **701**, 313-316
Kuebemen EA, Wallace DH, Ludford PM (1979) Photosynthetic measurements of field grown dry beans and their relation to selection for yield. *Journal of the American Society of Horticultural Science* **104**, 480-482
Lachkar A, Mlika M (2006) New apricot varieties selected from the Tunisian breeding programme. *Acta Horticulturae* **717**, 189-192
Lapins KO (1983) Mutation breeding. In Moore JN, Janick J (Eds) *Methods in Fruit Breeding*, Purdue University Press, West Lafayette, 74-99
Layne REC (1980) Harogem apricot. *Fruit Varieties Journal of the American Pomological Society* **34**, 20
Legave JM, Fournier D, Costes E (2006) Genotype × location interactions on architectural and floral traits in apricot tree. *Acta Horticulturae* **717**, 33-36
Lespinasse Y, Lespinasse JM, Ganne B (1985) Inheritance of two agronomical characters in the apple tree (*Malus pumila* Mill): Compact type habit and fruit colour. *Acta Horticulturae* **159**, 34-47
Lilleland O (1935) Growth study of the apricot fruit. *Journal of the American Society of Horticultural Science* **33**, 237-245
Lilleland O (1935) Growth study of the apricot tree II – The effect of temperature. *Journal of the American Society of Horticultural Science* **33**, 269-279
Lloyd G, McCown B (1981) Commercially –feasible micropropagation of mountain laurel, *Kalmia latifolia*, by use of shoot tip culture. *Proceedings International Plant Propagation Society* **30**, 421-427
Loschnig J, Passecker F (1954) *Die Marille (Aprikose) und thre Kultur*, Osterreichischer Agrarverlag, Wien, 398 pp
Loukas M, Pontikis CA (1985) Pollen isozyme polymorphism in types of *Pistacia vera* and related species. *Journal of the American Society of Horticultural Science* **54**, 95-102
Manganaris AG, Alston FH (1989) Glutamate oxaloacetate transminase izoenzymes in apple cultivars and rootstocks. *Journal of the American Society of Horticultural Science* **64**, 9-15
Margarian AA, Marutian SA, Michaelian VM (1986) Nitrogen metabolism in apricot as a function of mineral nutrition. *Acta Horticulturae* **192**, 35-40
Marino G (1989) Isolation and culture of apricot (*Prunus armeniaca* L) protoplasts: initial results. *Acta Horticulturae* **293**, 391-394
Marino G, Bertazza G, Magnanini E, Altan DA (1993) Comparative effects of sorbitol and sucrose as main carbon energy sources in micropropagation of apricot. *Plant Cell Tissue and Organ Culture* **34**, 235-244
Mănescu C, Baciu E, Cosmin S (1975) *Combaterea Biologică în Pomicultură. Biological Control in Pomology*, Ceres Publishing House, Bucharest, 227 pp
McLean IB, Rasmussen HP (1980) Graphic display of quantitative and qualitative characters association in roses. *Journal of the American Society of Horticultural Science* **5**, 625-628
Mehlenbacker SA, Hough LP (1986) Progress in apricot breeding in New Jersey. *Acta Horticulturae* **192**, 167-175
Mencarelli F, Bellincontro A, Forniti R, Vizovitis K, Botondi R, Valentini M, Sequi P, DiNatale C, Basile B, Romano R (2006) Factors affecting the apricot quality for the consumer with special attention to the use of 1-MCP and of NDT for detection of bruising. *Acta Horticulturae* **717**, 315-320
Minea R, Tamaș A, Corneanu M, Corneanu CG (2003) The utilisation of multiple emulsion with magnetic fluid content in biological cultures. *Annals of West University of Timisoara, Series Chemistry* **12**, 17-21
Mircetich MS (1981) Phytophora root and crown rot of apricot trees. *Acta Horticulturae* **121**, 385-395
Mittermayer F (2006) The apricots market - An EU perspective. *Acta Horticulturae* **717**, 261-264
Monet R (1967) Contribution a l'etude genetique du pecher. *Annales de l'Amelioration des Plantes* **17**, 5-11
Monet R, Bastard Y (1971) Contribution a l'etude du controle genetique du quelques caracteres morfologique chez le pecher. *Annales de l'Amelioration des Plantes* **22**, 399-403
Monet R, Bastard Y (1971) Resistance au gel et evolution physiologique des bourgeons floreaux du pecher. *Annales de l'Amelioration des Plantes* **27**, 717-728
Monet R, Bastard Y (1971) Physiologie vegetale. *C.R. Academie des Science Paris Serie S*, 2317-2319
Monet R (1977) Amélioration du pecher par la voie sexuée; exposé d'une méthode. *Annales d'Amelioration des Plantes* **27**, 223-234
Monet R, Bastard Y (1982) Estimation du coefficient de régression enfant/parent de quelques caractères du pêcher dans le cas de familles issues d'autofécondations. *Agronomie* **2**, 347-358
Moore JN (1979) Pomology research and production in Romania and Poland. Fruit varieties. *Journal of the American Pomological Society* **33**, 70-73
Morvan G, Castelain C, Arnoux M (1985) Prospective for the control of apricot chlorotic leaf roll, a mycoplasma disease by cross protection. *Acta Horticulturae* **192**, 167-175
Morvan G (1988) The epidemiology of Plum-pox virus in the apricot orchards of southern France: Description of computer tools and main observation. *Acta Horticulturae* **235**, 263-271
Muleo R, Remorini D, Iacona C, Guerriero R, Massai R (2006) Cultivar-specific adaptation of growth and photosynthetic activity in developing apricot dense canopies. *Acta Horticulturae* **717**, 55-58
Murashige T, Skoog F (1962) A revised medium for rapid growth and bioassay with tobacco tissue cultures. *Physiologia Plantarum* **15**, 473-497
Németh M (1986) *Virus, Mycoplasma and Rickettsia Diseases of Fruit Trees*, Martinus Nijhoff Publishers, The Netherlands, 840 pp
Nicotra A, Conte L, Moser L, Fantechi P, Barbagiovanni I, Corazza ML, Vitale S, Magnotta A (2006) Breeding programme for *Monilinia laxa* resistance on apricot. *Acta Horticulturae* **701**, 307-311
Nyujto F, Németh M, Koller M (1985) Investigation on the resistance to Plum-pox virus disease of the apricot variety "Cegledi Bibor Kajszi C 244". *Acta Horticulturae* **192**, 159-166
Okie WR (1983) Rootstocks for cherry, plum and apricot, present and future. *Fruit Varieties Journal of the American Pomological Society* **37**, 15-23
Olgun A, Adanacioglu H (2006) Production and marketing of organic dried apricot and the tendencies of apricot producers for the future in Turkey: Case study of Malatya. *Acta Horticulturae* **717**, 271-280
Ozturk K, Olmez HA, Guloglu U, Kuden A (2006) Evaluation of the resistance of some apricot varieties growing in Malatya to winter hardiness and late spring frost. *Acta Horticulturae* **701**, 247-251
Paunovic SA, Plazinic R (1976) Ispitanje nasledivanje u Kaisije (*Prunus armeniaca*) u F1 generaciji. *Prestampano iz iugoslavensky vocarstava* **37-38**, Cacak
Paunovic SA, Plazinic R, Orgasonovic D, Lyufic M (1983) The influence of the parent cultivars on obtaining late blooming apricot hybrids. *Acta Horticulturae* **121**, 275-282
Paunovic SA, Plazinic R (1983) The breeding and introduction of new apricot selections. *Acta Horticulturae* **121**, 235-244
Paunovic SA, Padzarevic P, Kojonic R (1985) Knlonska seleksja I izbor najboljih autohtonic kajsija injenik podloga. *Prestampano iz iugoslavensky vocarstava* **71-72**, Cacak
Paunovic SA (1986) Thirty-five years of apricot breeding and clonal selections of apricot cvs and rootstocks. *Acta Horticulturae* **192**, 299-306
Paydas S, Eti S, Gülcan R, Derin K, Yilmaz KU (2006) *In vitro* investigations on pollen quality, production and self incompatibility of some apricot varieties in Malatya – Turkey. *Acta Horticulturae* **701**, 75-80
Pedryc A, Korbuly J, Sardi E (2006) Relationship between sugar composition of the buds and frost tolerance in apricot cultivars. *Acta Horticulturae* **701**, 57-62
Pena A (1986) *Genetică Horticolă – Manual de Procedură Pentru Lucrări de Laborator*. *Horticultural Genetics – Procedure Manual for Laboratory Works*, Nicolae Bălcescu Agronomic Institute Publishing House, Bucharest, 160 pp
Pennone F, Abbate V (2006) Apricot breeding in Caserta: new perspectives of apricot growing in Southern Italy. *Acta Horticulturae* **717**, 157-162
Pérez-Tornero O, Burgos L, Egea J (1999) Introduction and establishment of apricot *in vitro* through regeneration of shoots from meristem tips. *In Vitro Cell. The International Journal of Developmental Biology* **35**, 249-253
Pérez-Tornero O, Burgos L (2000a) Different mediums requirements for micropropagation of apricot cultivars. *Plant Cell, Tissue and Organ Culture* **63**, 133-141
Pérez-Tornero O, Lopez JM, Egea J, Burgos L (2000b) Effect of basal me-

dia and growth regulators on the *in vitro* propagation of apricot (*Prunus armeniaca* L) cv. Canino. *Journal of Horticultural Science and Biotechnology* **75**, 283-286

Pérez-Tornero O, Lopez JM, Burgos L (2006) Influence of explant type (meristem vs. axillary shoots on the introduction and establishment *in vitro* of four apricot cultivars. *Acta Horticulturae* **717**, 229-232

Petrişor C, Bălan V, Lazăr V, Tudor V (2006) Evolution of colour during maturation of different Romanian apricot cultivars. *Acta Horticulturae* **717**, 369-372

Poessel JL, Faurobert M, Loonis M, Corre MN, Olivier G, Restier V, Audergon JM, Masse M (2006) Physiological and genetic studies on apricot/ *Prunus* rootstocks graft compatibility. *Acta Horticulturae* **701**, 87-93

Popa G, Bălan V, Ivaşcu A, Plocon C (2005) Studies on the suitable *in vitro* culture conditions to micropropagation of some apricot and peach rootstock /in Romanian/ Proceedings of 14th National Symposium of Plant Tissue Culture: Vitrocultures in cormophytae, experimental models in biology research, Bion, Satu Mare, pp 133-137

Quoirin M, Lepoivre P (1977) Etude de milieux adaptes aux cultures *in vitro* de *Prunus*. *Acta Horticulturae* **78**, 437-442

Radovet-Salinski D, Cachita-Cosma D, Blidar CF, Beles D (2004) The influence of low deuterium water (87.5 ppm D) on hyperhidric Coleus blumei Benth vitrocultures. Proceedings of 3rd Congress "Water – a miracle". Constanţa **1**, 59-60

Ramming DW (1980) Apricot cultivar situation in North America. *Fruit Varieties Journal of the American Pomological Society* **34**, 70-74

Reffatti E, Osler R, Loi N, Carraro L, Benetti V, Tomasi A, Vindimiari ME (1985) An attempt in progress to eradicate Plum-pox. *Acta Horticulturae* **235**, 291-297

Renaud R (1980) Mutagenese artificielle sur le prunier d'ente. Caracteres agronomiques de deux mutants selections. *INRA Publication* **546**

Richardson A, Seeley S, Walker D (1974) A model for estimating the completion of rest for "Redhaven" and "Elberta" peach trees. *Journal of the American Society of Horticultural Science* **9**, 331-332

Rishbeth Y (1964) Stump infection by basidiospores of *Armillaria mellea*. *British Mycological Society* **47**, 460

Rodrigo J, Julian C, Herrero M (2006) Spring frost damage in buds, flowers and developing fruits in apricot. *Acta Horticulturae* **717**, 87-88

Rogalski M, Antunes de Moraes LK, Felisbino C, Crestani L, Guerra MP, Lima da Silva A (2003) Acclimatization of micropropagated *Prunus* sp. rootstock. *Revista Brasileira de Fruticultura* **25**, 279-281

Romero C, Llacer G, Badenes ML, Pedryc A (2006) Relationship among apricot cultivars from Hungary and a South European pool determined by SSR markers. *Acta Horticulturae* **701**, 233-239

Rozsnyay ZD (1977) Cytospora, canker and decline dieback of apricots. *OEPP Bulletin* **17**, 69-80

Rozsnyay ZD (1983) The appearance of *Eutypa armeniacae* (Hansford) carter on apricot and grape in Hungary. *Acta Horticulturae* **121**, 397-400

Ruiz D, Campoy JA, Egea J (2006) Chilling requirements of apricot varieties. *Acta Horticulturae* **717**, 67-70

Salesses G, Bonnet A (1988) Cytogenetic study of hybrids between hazelnut varieties carrying a translocation in heterozygous state. *Cytologia* **5**, 407-413 (in French)

Sansavini S, Costa G, Marangoni B, Bordini R (1974) Sei anni di osservazioni su due cultivar e dodici portinnesti di albicocco, Instituto Coltivazioni di Arboree, Universita di Pisa. *Rivista di Ortoflorofrutticultura Italiana* **4**, 286-303

Sansavini S, Bassi D, Grandi M, Pirazzini P, Montevecchi P, Lunati U, Cavicchi C (1988) Le cultivar di albicocco in Emilia-Romagna. III contributo. *Rivista di Frutticoltura* **6**, 41-47

Săvulescu T, Săvulescu O (1959) *Tratat de Patologie Vegetală. Treatise on Plant Pathology* (Vol 1), Romanian Academy Publishing House, Bucharest, 485 pp

Scalabrelli G, Couvillon GA (1985) Influenza della temperatura e del tipo di gemme sul termine della dormienza nel pesco as "Redhaven". *Acta Horticulturae* **192**, 157-165

Scaltsoyiannis A, Iliev I, Moulalis D, Passayiannes G, Tsoulpha P, Tsaksira M (1998) Rejuvenation and micropropagation of wild cherry trees (*Prunus avium* L.). Plant Breeding and Genetics for Agriculture that is Friendly to the Environment. Proceedings of the 7th PanHellenic Congress, Heraklion, Crete, pp 272-280

Sesan T, Oprea M (1999) Influence of antagonistic micromyceta from phyllosphere on the main pathogens of apricot-tree. *Acta Horticulturae* **488**, 705-710

Sjujka-Lacza J (1985) Data on the morphology and anatomy of *Prunus armeniaca* L. *Acta Horticulturae* **192**, 9-19

Smith C, Mollendorf L (1999) Apricot (*Prunus armeniaca* L.) production and breeding in South Africa. *Acta Horticulturae* **488**, 119-124

Snir I (1983) Chemical dormancy breaking of red raspberry. *Journal of the American Society of Horticultural Science* **18**, 710-713

Spiegel-Roy P, Alston FH (1979) Chilling and post dormant heat requirement as selection criteria for late flowering pears. *Journal of the American Society of Horticultural Science* **54**, 115-120

Strada GD, Pennone F, Fideghelli C, Monastra F, Cobianchi D (1989) Monografia di cultivar di albicocco. Istituto Sperimentale per la Frutticoltura, Roma, 257 pp

Struss D, Ahmad R, Aman M, Southwick SM (2006) Identifying cultivars and genetic diversity of apricot by molecular markers. *Acta Horticulturae* **701**, 253-256

Suranyi D (1985) The role of ecological factors affecting the fruit thinning of apricot. *Acta Horticulturae* **192**, 73-81

Szalay L, Papp J, Pedryc A, Szabo Z (2006) Diversity of apricot varieties based on traits determining winter hardiness and early spring frost tolerance of floral buds. *Acta Horticulturae* **701**, 131-134

Theobald WL, Hough LF (1960) The relationship between stages of peach embryo development and seedling growth and survival. *Proceedings of the American Society for Horticultural Science* **75**, 163-170

Topor E, Burtoiu MC (2006) New apricot selections with very early ripening maturity obtained under Romanian conditions. *Acta Horticulturae* **701**, 367-369

Trandafirescu M, Teodorescu G (2006) Behaviour of some apricot and hybrids from national collection to *Monilinia laxa* (Aderh et Ruhl) Honey infection. *Acta Horticulturae* **701**, 371-375

Tzoneva E, Tzonev R (1999) Pomological peculiarities of native Japanese Ansu and Mume cultivars and some interspecific hybrids. *Acta Horticulturae* **488**, 233-235

Vanderzwet T, Otto WA, Westwood MN (1975) Variability in degree of fire blight resistance within and between pyrus species, interspecific hybrids and seedling progenies. *Euphytica* **23**, 295-304

Wang Yu-Zhu, Liu Qi-Zhi (2006) Apricot germplasm resources in China. *Acta Horticulturae* **701**, 181-189